Realtime and Embedded Specification for Java

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The Realtime and Embedded Specification for Java (RTSJ) is under development within the Java Community Process (JCP) by the members of the JSR-282 Expert Group (EG). This group, was lead by TimeSys Inc. Corporation, but has been taken over by aicas GmbH.

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Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

The goal of the *Real-Time Specification for Java* (`RTSJ`) is to support the use of Java technology in embedded and realtime systems. It provides a specification for refining the *Java Language Specification* and the *Java Virtual Machine Specification* and for providing an extended Application Programming Interface that facilitates the creation, verification, analysis, execution, and management of realtime Java programs such as control and sensor applications.

The Java Virtual Machine and the Java Language were conceived as a portable environment for desktop and server applications. The emphasis has been on throughput and responsiveness. These are characteristics obtainable with time-sharing systems. For this conventional Java environment, it is more important that each task makes progress, than that a particular task completes within a predefined time slot.

In a realtime system, the system tries to schedule the most critical task that is ready to run first. This task runs either until it is finished, or it needs to wait for some event or data, or a more critical task is released or a more critical task becomes schedulable after waiting for its event or data.

Realtime scheduling is commonly done with a priority preemptive scheduler, where tasks that have short deadlines are given higher priority than tasks that have longer deadlines. The programmer is responsible for encoding some notion of task importance to priorities. The goal is to see that all tasks finish within their deadlines. Scheduling analysis, such as Rate Monotonic Analysis, can be used to help achieve this goal.

Many realtime systems have nonrealtime components, so it is desirable to be able to combine realtime and nonrealtime tasks in a single system. Realtime tasks are then given preference over nonrealtime tasks. For Java, this means that realtime tasks must be scheduled before threads with conventional Java priorities (1–10). Being able to synchronize between tasks, both realtime and conventional Java threads, imposes additional requirements.

Providing realtime semantics and the additional programming interfaces required is a core part of this specification. This led the original specification to provided special memory areas to avoid the use of garbage collection; however, the availability of various techniques for realtime garbage collection has changed the state of practice since `RTSJ` Version 1.0. Though still part of the specification, these special memory areas are no longer central to it. Realtime scheduling and priority inversion avoidance

for synchronization are the core of providing realtime response. These are provided through refinements to the core Java semantics and with additional classes.

Realtime tasks can be modeled both with realtime threads and with event handlers. Realtime threads are much the same as conventional Java threads except for how they are scheduled. Event handlers encapsulate a bit of work that is done every time some event occurs. Events are referred to as asynchronous because they generally occur independent of program flow. Thus, a periodic timed event is considered to be an asynchronous event, but scheduled periodically. Event handling provides a less resource intensive means of writing control applications because the underlying thread mechanism can be shared between event handlers. Deadline analysis is also somewhat simpler because the end of the work to be done is well bounded. Event handling is ideal for periodic tasks and responding to external impulses. The specification provides both paradigms.

Though realtime is necessary for many control tasks, it is not sufficient. A significant part of the `RTSJ` API addresses communication with the outside world through devices and signals. This makes it possible to write control applications without resorting to JNI, thereby maintaining the integrity and safety that Java offers.

Since not all applications need all aspects of the specification, there are now modules to suite the major application scenarios. This should make it easier for conventional JVM providers to include basic specification facilities without negatively impacting their core application domains, but still be compatible with hard realtime implementations. The goal is to make the transition between conventional JVMs and realtime JVMs easier.

1.1 Guiding Principles

Providing a coherent semantics and a set of programming interfaces requires some guiding principles around which to organize the `RTSJ`. The following principles delimit the scope of the `RTSJ` and its compatibility requirements with conventional Java. They ensure that conventional Java code can be run with realtime Java code on a single Java virtual machine.

1.1.1 Applicability Across Java Environments

The `RTSJ` shall not include specifications that restrict its use to a particular Java environment, such as a particular versions of the Java Development Kit, an Embedded Java Application Environment, or a Java Edition, beyond the natural development of the Java language.

1.1.2 Backward Compatibility

The `RTSJ` shall not prevent existing, properly written, conventional Java programs from executing on implementations of the `RTSJ`.

1.1.3 Write Once, Run Anywhere

The RTSJ should recognize the importance of "Write Once, Run Anywhere", but it should also recognize the difficulty of achieving WORA for realtime programs and not attempt to increase or maintain binary portability at the expense of predictability. Hence, the goal should be "Write Once Carefully, Run Anywhere Conditionally".

1.1.4 Current Practice vs. Advanced Features

The RTSJ should address current realtime system practice as well as allow future implementations to include advanced features.

1.1.5 Predictable Execution

The RTSJ shall hold predictable execution as first priority in all trade-offs; this may sometimes be at the expense of typical general-purpose computing performance measures.

1.1.6 No Syntactic Extension

In order to facilitate the job of tool developers, and thus to increase the likelihood of timely implementations, the RTSJ shall not introduce new keywords or make other syntactic extensions to the Java language.

1.1.7 Allow Variation in Implementation Decisions

Implementations of the RTSJ may vary in a number of implementation decisions, such as the use of efficient or inefficient algorithms, trade-offs between time and space efficiency, inclusion of scheduling algorithms not required in the minimum implementation, and variation in code path length for the execution of byte codes. The RTSJ should not mandate algorithms or specific time constants for such, but require that the semantics of the implementation be met and where necessary put limits on execution time complexity. The RTSJ offers implementers the flexibility to create implementations suited to meet the requirements of their customers.

1.1.8 Interoperability

It should be possible to implement all aspects of the RTSJ on a conventional JVM with the exception that realtime response and pointer assignment rules would not necessarily be guaranteed. This should ease the transition between conventional and realtime programming and aid functional testing on a conventional JVM. The API should support modules for this as well.

1.2 Areas of Enhancement

Each guiding principle has had a direct effect on the development of the specification. These pricples are reflected in the following aspects of the realtime refinements and ad-

ditional classes in the specification. Their enumeration should aid the understanding of the rest of the specification.

1.2.1 Thread Scheduling and Dispatching

Portability dictates the specification of at least one standard realtime scheduler, but in light of the significant diversity in scheduling and dispatching models and the recognition that each model has wide applicability in the diverse realtime systems industry, the specification provides an underlying scheduling infrastructure that can be extended to use other algorithms for scheduling realtime Java threads and event handlers.

To accommodate current practice, the `RTSJ` shall require a base scheduler in all implementations. The required base scheduler will be familiar to realtime system programmers. It is a priority preemptive, first-in-first-out, scheduler. Since most realtime systems also support round-robin scheduling, a round-robin scheduler shall also be supplied. For compatibility with conventional Java implementations, both schedulers shall use priorities above the conventional Java priorities (1–10).

The specification is constructed to allow implementations to provide unanticipated scheduling algorithms. Implementations will enable the programmatic assignment of parameters appropriate for the underlying scheduling mechanism as well as provide any necessary methods for the creation, management and termination of realtime Java threads. In the current specification, any other thread, scheduling, and dispatching mechanism may be bound to an implementation; however, there should be enough flexibility in the thread scheduling framework to enable future versions of the specification to build on this release.

1.2.2 Memory Management

Automatic memory management is a particularly important feature of the Java programming environment. The specification enables, as far as possible, the job of memory management to be implemented automatically by the underlying system and not intrude on the programming task. Many automatic memory management algorithms, also known as garbage collection (GC), exist, and many of those apply to certain classes of realtime programming styles and systems. In an attempt to accommodate a diverse set of GC algorithms, the specification defines a memory allocation and reclamation paradigm that

- is independent of any particular GC algorithm,
- requires the VM to precisely characterize its GC algorithm's effect on the preemption of realtime Java tasks, and
- enables the allocation and reclamation of objects outside of any interference by any GC algorithm.

1.2.3 Synchronization and Resource Sharing

Logic often requires exclusive access to resources, and realtime systems introduce an additional complexity: the need to minimize priority inversion and hence the

excessive delay of more critical tasks. The least intrusive specification for enabling realtime safe synchronization is to require that implementations of the Java keyword `synchronized` use one or more algorithms that prevent priority inversion among realtime Java tasks that share the serialized resource. In addition, the specification provides other data passing mechanisms to minimize the need for synchronization.

1.2.4 Asynchronous Event Handling

Realtime systems typically interact closely with the real world. With respect to the execution of logic, the real world is asynchronous; therefore, the specification includes efficient mechanisms for programming disciplines that would accommodate this inherent asynchrony. The `RTSJ` has a general mechanism for asynchronous event handling. This specification provides classes that represent things that can happen and logic that executes when those things happen. The execution of the logic is scheduled and dispatched by the `RTSJ` runtime.

1.2.5 Task Interruption

Sometimes, the real world changes so drastically (and asynchronously) that the current point of logic execution should be immediately, efficiently, and safely ended, and control should be transferred to another point of execution. The `RTSJ` provides a mechanism which extends Java's interrupt and exception handling mechanisms to enable applications to programmatically change the locus of control of another Java task. This mechanism may restrict this asynchronous transfer of control to logic specifically written with the assumption that its locus of control may asynchronously change. Due to the inherent susceptibility to deadlock, the `Thread.stop` method cannot be used for this.

1.2.6 Raw Memory Access

Accessing device memory is not in and of itself a realtime issue; however, many realtime systems require it for providing realtime control of a system. This requires an API providing programmers with byte-level access to physical device registers, whether in main memory or in some I/O space. This API must be as efficient as possible, since such access is often under tight time constraints.

1.2.7 Physical Memory Access

Some systems provide memory areas that differ in important aspects, such as time to read or write data and its persistence. Being able to take advantage of these areas can have an impact on performance. This specification enables their efficient use.

1.2.8 Modularization

Not all applications require all aspects of the specification. In fact, having a core set of the APIs presented is useful for conventional Java programming and aids overall interoperability. To this end, the specification provides a core set of APIs and a

few optional modules as well as semantics for use in conventional JVMs that do not offer realtime guarantees. This should enable implementations to be optimized for particular use cases and enable conventional Java environments to be used to help develop code that can be more easily shared between realtime and conventional systems.

Chapter 2

Overview

The RTSJ comprises several areas of extended semantics. These areas are discussed in approximate order of their relevance to realtime programming. The semantics and mechanisms of each topic—threads and scheduling, synchronization, asynchrony, clocks and timers, memory management, device access and raw memory, system options, and exceptions—are all crucial to the acceptance of the RTSJ as a viable real-time development platform. Further details, exact requirements, class documentation, and rationale for these extensions are given in subsequent chapters.

2.1 Threads and Scheduling

One of the concerns of realtime programming is to ensure the timely and predictable execution of sequences of machine instructions. Various scheduling schemes name these sequences of instructions differently, for example, thread, task, module, or block. In Java, this computation is executed in the context of a thread. Since Java threads were designed for fair execution[1] rather than predictable execution, the RTSJ introduces the concept of a *schedulable*. These are the objects managed by the base scheduler: `RealtimeThread` and its subclasses and `AsyncBaseEventHandler` and its subclasses. `RealtimeThread` is a specialization of Java's `Thread`.

Timely execution of schedulables means that the programmer can determine, by analysis of the program, testing the program on particular implementations, or both, whether particular threads will always complete execution before a given timeliness constraint. This is the essence of realtime programming: the addition of temporal constraints to the correctness conditions for computation. For example, for a program to compute the sum of two numbers, it may no longer be acceptable to compute only the correct arithmetic answer but the answer must be computed within a particular time interval. Typically, temporal constraints are deadlines expressed in either relative or absolute time.

The term *scheduling* (or *scheduling algorithm*) refers to the production of a sequence (or ordering) for the execution of a set of schedulables (a *schedule*). This schedule attempts to optimize a particular metric (a metric that measures how well

[1] Actually, neither the Java Virtual Machine Specification[6] nor the Java Language Specification[5] defines how Java threads should be scheduled, but most implementations, including the reference implementations, use some sort of fair scheduling.

the system is meeting the temporal constraints). A *feasibility analysis* determines if a schedule has an acceptable value for the metric. For example in hard realtime systems, the typical metric is "number of missed deadlines" and the only acceptable value for that metric is zero. So called soft realtime systems use other metrics, such as *mean tardiness*, and may accept various values for the metric in use.

Many systems, including most conventional Java implementations, use thread priority to guide the determination of a schedule. Priority is typically an integer associated with a thread; these integers convey to the system the order in which the threads should execute. The generalization of the concept of priority is *execution eligibility*. The term *dispatching* refers to that portion of the system which selects the thread with the highest execution eligibility from the pool of threads that are ready to run.

In current realtime system practice, the assignment of priorities is typically under programmer control as opposed to under system control. As a base scheduler for realtime tasks, the `RTSJ` provides preemptive priority-based first-in-first-out (FIFO) scheduler, which also leaves the assignment of priorities to programmer control. It also provides a priority-based round-robin (RR) scheduler. Most realtime operating systems (RTOS) are also based on priority preemptive scheduling and support both FIFO and RR scheduling.

The `RTSJ` defines a number of classes with names of the form `<string>Parameters` such as `ReleaseParameters`, which provide parameters for resource management. An instance of one of these parameter classes holds a particular resource-demand characteristic for one or more schedulables. For example, the `PriorityParameters` subclass of `SchedulingParameters` contains the execution eligibility metric of the base and round-robin schedulers, i.e., a priority. At some time (construction-time or later when the parameters are replaced using setter methods), instances of parameter classes are bound to a schedulable. The schedulable then assumes the characteristics of the values in the parameter object. For example, a `PriorityParameters` instance with its priority set to the value representing the highest priority available on a system is bound to a schedulable, then that schedulable will assume the characteristic that it will execute whenever it is ready in preference to all other schedulables (except, of course, those also with the same priority).

The `RTSJ` provides implementers with the flexibility to install arbitrary scheduling algorithms in an implementation of the specification. This is to support the widely varying requirements of the realtime systems industry with respect to scheduling. Use of the Java platform may help produce code written once but able to be executed on many different computing platforms. The `RTSJ` contributes to this goal, but the rigors of realtime systems detract from it. The `RTSJ`'s rigorous specification of the required priority scheduler is critical for portability of time-critical code, but the `RTSJ` permits and supports platform-specific schedulers which are not necessarily portable.

2.2 Synchronization

If the computation in each thread were independent of the computation in all other threads, scheduling alone would be enough to ensure timeliness; however, this is

usually not the case. Threads often need to communicate with one another or share data. Resources must be shared as well. Two threads cannot read different data from the disk at the same time nor write data to a disk at the same time. They cannot send a message to another machine at the same time. They cannot update the same in-memory data at the same time. One thread may have to wait for another thread to get the data it needs. Just as in a normal system, synchronization is required. In a realtime system, this synchronization must not prevent other threads from completing their tasks on time.

2.2.1 Priority Inversion

The additional concern for synchronization in a realtime system, as opposed to a conventional system, is that blocking can cause the wrong thread to run first. A high priority thread can be blocked by a low priority thread that is vying for the same resource. A priority queue can be used to ensure that a highest priority thread goes first, when more than one thread is waiting to enter a synchronized block, but this is not always sufficient.

Consider a single processor system with three threads, t_1, t_2, and t_3, where t_1 has the highest priority and t_3 has the lowest priority. It is possible that t_2 can prevent t_1 from running by preempting t_3. This is called priority inversion. It occurs when t_1 is blocked by attempting to acquire a lock that is held by thread t_3 and t_3 is preempted by t_2. When t_2 does run, it may prevent t_3 from running indefinitely, thereby keeping t_1 blocked past its deadline.

What is needed is a mechanism the ensure that, while t_1 is waiting on a resource in use by t_3, thread t_3 runs before all threads with a priority less than that of t_1.

2.2.2 Priority Inversion Avoidance

Two of the most common mechanisms for avoiding priority inversion are priority inheritance and priority ceiling emulation (a.k.a. highest locker protocol). Both of these boost the priority of a thread holding the lock in order to prevent a noncontending thread from transitively blocking a higher priority thread which is waiting for the same lock. The difference is how high the priority is raised and when. Both take effect when a thread is in a `synchronized` section of code.

The first mechanism is the default behavior for `synchronized` blocks and methods. It applies to all code running within the implementation, not just to `schedulables`. The priority inheritance protocol is a well-known algorithm in the realtime scheduling literature and it has the following effect. When thread t_1 attempts to acquire a lock that is held by a lower-priority thread t_3, then t_3's priority is raised to that of t_1 as long as t_3 holds the lock (and recursively if t_3 is itself waiting to acquire a lock held by an even lower-priority thread).

The specification also provides a mechanism by which the programmer can override the default system-wide policy, or control the policy to be used for a particular monitor, provided that policy is supported by the implementation. The second mechanism, priority ceiling emulation protocol, can be set using this mechanism. It is also a well-known algorithm in the literature. The following three points provide a

somewhat simplified description of its effect.

1. A monitor is given a “priority ceiling" when it is created; the programmer should choose at least the highest priority of any thread that could attempt to enter the monitor.
2. As soon as a thread enters synchronized code, its (active) priority is raised to the monitor's ceiling priority. If, through programming error, a thread has a higher base priority than the ceiling of the monitor it is attempting to enter, then an exception is thrown.
3. On leaving the monitor, the thread has its active priority reset. In simple cases it will set be to the thread's previous active priority, but under some circumstances (e.g. a dynamic change to the thread's base priority while it was in the monitor) a different value is possible.

In addition, threads and asynchronous event handlers waiting to acquire a resource must be released from highest to lowest priority (in priority order). This applies to processors as well as to synchronized blocks. If schedulables with the same priority are possible under the active scheduling policy, such schedulables are awakened in FIFO order. This is exemplified in the following scenarios.

1. Threads waiting to enter synchronized blocks are granted access to the synchronized block in priority order.
2. A blocked thread that becomes ready to run is given access to a processor in priority order.
3. A thread whose priority is explicitly set by itself or another thread is given access to a processor in priority order.
4. A thread that performs a yield will be given access to the processor after waiting for threads of the same priority to be given a processor.
5. Threads that are preempted in favor of a thread with higher priority may be given access to a processor at any time as determined by a particular implementation. The implementation is required to provide documentation stating exactly the algorithm used for granting such access.

In any case, there needs to be a fixed upper bound on the time required to enter a synchronized block for an unlocked monitor.

2.2.3 Execution Eligibility

Since an implementation of the `RTSJ` may provide schedulers other than priority-based schedulers, the notion of priority can be generalized to execution eligibility. Execution eligibility defines a partial ordering over all tasks for determining which task should run before which other tasks. Execution eligibility may be determined dynamically. For example, earliest deadline first (EDF) scheduling determines execution eligibility ordering by the order of the next deadlines for each of its tasks. The notion of priority, as described above, can be generalized to execution eligibility to integrate other schedulers into an `RTSJ` implementation.

2.2.4 Wait-Free Queues

While the RTSJ requires that the execution of schedulables which do not access the heap must not be delayed by garbage collection on behalf of lower-priority schedulables, an application can cause such a schedulable to wait for garbage collection by synchronizing using an object shared with a heap-using thread or schedulable. The RTSJ provides wait-free queue classes to provide protected, nonblocking, shared access to objects accessed by both regular Java threads and schedulables, which do not access the heap.

2.3 Asynchrony

Since a realtime system must be able to react to the outside world, the system needs to be able to change its execution flow asynchronously to the current execution. All external signals, whether interrupts, messages, or timed events, are asynchronous with respect to ongoing computation. This means that computation must be both startable and stoppable based on external stimuli.

2.3.1 Asynchronous Events

Asynchronous event provide a means of starting computation based on external stimuli. The asynchronous event facility is based on two classes: `AsyncBaseEvent` and `AsyncBaseEventHandler`. An `AsyncBaseEvent` object represents something that can happen, like a POSIX signal, a hardware interrupt, or a computed event like an airplane entering a specified region. When one of these events occurs, which is indicated by the `fire()` method being called, the associated instances of `AsyncBaseEventHandler` are scheduled and the `handleAsyncEvent()` methods are invoked, thus the required logic is performed. Also, methods on `AsyncBaseEvent` are provided to manage the set of instances of `AsyncBaseEventHandler` associated with the instance of `AsyncBaseEvent`.

An instance of an `AsyncBaseEventHandler` can be thought of as something similar to a thread. When an event fires, the associated handlers are scheduled and the `handleAsyncEvent()` methods are invoked. What distinguishes an `AsyncBaseEvent-Handler` from a simple `Runnable` is that an `AsyncBaseEventHandler` has associated instances of `ReleaseParameters`, `SchedulingParameters` and `MemoryParameters` that control the actual execution of the handler once the associated `AsyncBaseEvent` is fired. When an event is fired, the handlers are executed asynchronously, scheduled according to the associated `ReleaseParameters` and `SchedulingParameters` objects, in a manner that looks like the handler has just been assigned to its own thread. It is intended that the system can cope well with situations where there are large numbers of instances of `AsyncBaseEvent` and `AsyncBaseEventHandler` (tens of thousands), since the number of fired (in progress) handlers is expected to be much smaller.

There are specialized forms of `AsyncBaseEvent`: `AsyncEvent`, `AsyncLongEvent`, and `AsyncObjectEvent` for events that are stateless, carry a `long` payload, and carry an `Object` payload, respectively. They are matched by specialized forms

of AsyncBaseEventHandler: AsyncEventHandler, AsyncLongEventHandler, and AsyncObjectEventHandler. Most external events are stateless, but sometimes it is helpful to be able to receive some information about the event or pass some data with the event. The Long and Object variants enable this and the RealtimeSignal takes advantage of it.

Another specialized form of an AsyncEvent is the Timer class, which represents an event whose occurrence is driven by time. There are two forms of Timers: the OneShotTimer and the PeriodicTimer. Instances of OneShotTimer fire once, at the specified time. Periodic timers fire initially at the specified time, and then periodically according to a specified interval.

Timers are driven by Clock objects. There is a special Clock object, Clock.getRealtimeClock(), that represents the realtime clock. The Clock class may be extended to represent other clocks, which the underlying system might make available (such as an execution-time clock of some granularity).

2.3.2 Asynchronous Transfer of Control

Many event-driven computer systems that tightly interact with external physical systems (e.g., humans, machines, control processes, etc.) may require mode changes in their computational behavior as a result of significant changes in the actual real-world system. It simplifies the architecture of a system when a task can be programmatically terminated when an external physical system change causes its computation to be superfluous. Without this facility, a thread or set of threads have to be coded so that their computational behavior anticipates all of the possible transitions among possible states of the external system. When the external system makes a state transition, the changes in computation behavior can be managed by an oracle that terminates a set of threads required for the old state of the external system, and invokes a new set of threads appropriate for the new state of the external system. Since the possible state transitions of the external system are encoded only in the oracle and not in each thread, the overall system design is simpler.

There is a second requirement for a mechanism to terminate some computation, where a potentially unbounded computation needs to be done in a bounded period of time. In this case, if that computation can be executed with an algorithm that is iterative, and produces successively refined results, the system could abandon the computation early and still have usable results. The RTSJ supports aborting a computation by a signal from another thread or by the expiration of a timer with a feature termed Asynchronous Transfer of Control (ATC).

An example of the second case is processing compressed video for a human controller. The system knows that a new frame must be produced at a constant update frequency. The cost of each iteration is highly variable and the minimum required latency to terminate the computation and receive the last consistent result is much less than the mean cost and bound of an iteration. Therefore, using ATC for interrupting a computation to capture an intermediate result at the expiration of a known time bound is a convenient programming style. Of course, there are other kinds of programming tasks that may also benefit from ATC.

The RTSJ's approach to ATC uses asynchronous interruptions and exceptions,

and is based on several guiding principles covering methodology, expressiveness, semantics, and pragmatic concerns.

2.3.2.1 Methodological Principles

1. A method must explicitly indicate its susceptibility to ATC, i.e., it is asynchronously interruptible. Since legacy code or library methods might have been written assuming no ATC, by default ATC must be turned off (more precisely, must be deferred as long as control is in such code).
2. Even if a method allows ATC, some code sections must be executed to completion and thus ATC is deferred in such sections. These ATC-deferred sections are synchronized methods, synchronized statements, catch clauses, and static initializers.
3. Code that responds to an ATC does not return to the point in the schedulable where the ATC was triggered; that is, an ATC is an unconditional transfer of control. Resumptive semantics, which returns control from the handler to the point of interruption, are not needed since they can be achieved through other mechanisms (in particular, an `AsyncEventHandler`).

2.3.2.2 Expressibility Principles

1. A mechanism is needed through which an ATC can be explicitly triggered in a target schedulable. This triggering may be direct (from a source thread or schedulable) or indirect (through an asynchronously interrupted exception).
2. It must be possible to trigger an ATC based on any asynchronous event including an external happening or an explicit event firing from another thread or schedulable. In particular, it must be possible to base an ATC on a timer going off.
3. Through ATC it must be possible to abort a realtime thread but in a manner that does not carry the dangers of the `Thread` class's `stop()` and `destroy()` methods.

2.3.2.3 Semantic Principles

1. When ATC is modeled by exception handling, there must be some way to ensure that an asynchronous exception is only caught by the intended handler and not, for example, by an all-purpose handler that happens to be on the propagation path.
2. Nested ATCs must work properly. For example, consider two, nested ATC-based timers and assume that the outer timer has a shorter time-out than the nested, inner timer. When the outer timer times out while control is in the nested code of the inner timer, then the nested code must be aborted (as soon as it is outside an ATC-deferred section), and control must then transfer to the appropriate `catch` clause for the outer timer. An implementation that either handles the outer time-out in the nested code, or that waits for the longer (nested) timer, is incorrect.

2.3.2.4 Pragmatic Principles

1. There should be straightforward programming idioms for common cases such as timer handlers and realtime thread termination.
2. When code with a time-out completes before the timer's expiration, the timer needs to be automatically stopped and its resources returned to the system.

2.3.3 Asynchronous Realtime Thread Termination

A special case of stopping a particular computation is stopping a thread. Earlier versions of the Java language supplied mechanisms for achieving these effects: in particular the methods `stop()` and `destroy()` in class `Thread`. However, since `stop()` could leave shared objects in an inconsistent state, `stop()` has been deprecated. The use of `destroy()` can lead to deadlock, e.g., when a thread is destroyed while it is holding a lock, and although it was not deprecated until version 1.5 of the Java specification, its usage has long been discouraged. A goal of the `RTSJ` was to meet the requirements of asynchronous thread termination without introducing the dangers of the `stop()` or `destroy()` methods.

The `RTSJ` accommodates safe asynchronous realtime thread termination through a combination of the asynchronous event handling and the asynchronous transfer of control mechanisms. To create such a set of realtime threads consider the following steps:

1. make all of the application methods of the realtime thread asynchronously interruptible;
2. create an oracle[2] which monitors the external world by setting up an asynchronous event with a number of asynchronous event handlers, which is fired when an appropriate mode change;
3. have the handlers call `interrupt()` on each of the realtime threads affected by the change; then
4. after the handlers call `interrupt()`, have them create a new set of realtime threads appropriate to the current state of the external world.

The effect of the event is to cause each interruptible method to abort abnormally by transferring control to the appropriate catch clause. Ultimately the `run()` method of the realtime thread will complete normally.

This idiom provides a quick but orderly clean up and termination of the realtime thread.

2.4 Clocks, Time, and Timers

Realtime systems require a high resolution notion of time. Both very small units and very long periods of time must be uniformly representable, a range that is not even representable with a `long` value. Furthermore, a time can represent an absolute value, usually represented as some absolute fixed point in time plus an offset, or it can represent an interval of time. The time classes defined in Chapter 9 support a `long`s worth of seconds and another integer for nanoseconds.

[2]Note, the oracle can comprise as many or as few asynchronous event handlers as appropriate.

2.5 Memory Management

The Java language is designed around automatic memory management, in particular garbage collection. Unfortunately, though garbage collection is a functional safety and security feature, conventional garbage collectors interrupt the normal flow of control in a program. Therefore, garbage-collected memory heaps had been considered an obstacle to realtime programming due to the potential for unpredictable latencies introduced by the garbage collector. Though conventional collectors still have these drawbacks, there are now realtime collectors that can be used for hard realtime application. Still, the `RTSJ` provides an alternative to garbage collection for systems which require it, either because they do not have a garbage collector or deterministic garbage collector, or require heap partitioning for some other reason. Extensions to the memory model, which support memory management in a manner that does not interfere with the ability of realtime code to provide deterministic behavior, are provided to support these alternatives. This goal is accomplished by providing memory areas for the allocation of objects outside of the garbage-collected heap for both short-lived and long-lived objects. In order to provide additional separation between the garbage collector and schedulables which do not require its services, a schedulable can be marked to indicate that it never accesses the heap.

2.5.1 Memory Areas

The `RTSJ` introduces the concept of a memory area. A memory area represents an area of memory that may be used for allocating objects. Some memory areas exist outside of the heap and place restrictions on what the system and garbage collector may do with objects allocated within. Objects in some memory areas are never garbage collected; however, the garbage collector must be capable of scanning these memory areas for references to any object within the heap to preserve the integrity of the heap.

There are four basic types of memory areas:

1. Heap memory represents an area of memory that is the heap. The `RTSJ` does not change the determinant of lifetime of objects on the heap. The lifetime is still determined by visibility.
2. Immortal memory represents an area of memory containing objects that may be referenced without exception or garbage collection delay by any schedulable, specifically including realtime threads and asynchronous event handlers configured to not have access to the heap.
3. Scoped memory provides a mechanism for managing objects that have a lifetime defined by their scope. It is akin to, but more general than, allocating objects on the thread stack.
4. Physical memory allows objects to be created within specific physical memory regions that have particular important characteristics, such as memory that has substantially faster access.

2.5.2 Heap Memory

Heap memory is the memory area used by Java by default. It is garbage collected and the access time to objects in this area are not guaranteed unless the implementation supports realtime garbage collection. The `RTSJ`, as with conventional Java, supports only one Heap in a system. Multiple heaps are only practical in one of two configurations: the heaps are completely independent of one another or there are subsidiary heaps from which a program may not store references in the main heap. In other words, the subsidiary heaps can reference the main heap but not vice versa. Currently, the `RTSJ` does not address these cases.

2.5.3 Immortal Memory

`ImmortalMemory` is a memory resource shared among all schedulable objects and threads in an application. Objects allocated in `ImmortalMemory` are always available to extraheap threads and asynchronous event handlers without the possibility of a delay for garbage collection.

2.5.4 Scoped Memory

The `RTSJ` introduces the concept of scoped memory. A memory scope is used to give bounds to the lifetime of any objects allocated within it. When a scope is entered, every use of `new` causes the memory to be allocated from the active memory scope. A scope may be entered explicitly, or it can be attached to a schedulable which will effectively enter the scope before it executes the object's `run()` method.

The contents of a scoped memory are discarded when no object in the scope can be accessed. This is done by a technique similar to reference counting the scope. A conforming implementation might maintain a count of the number of external references to each memory area. The reference count for a `ScopedMemory` area would be increased by entering a new scope through the `enter()` method of `MemoryArea`, by the creation of a schedulable using the particular `ScopedMemory` area, or by the opening of an inner scope. The reference count for a `ScopedMemory` area would be decreased when returning from the `enter()` method, when the schedulable using the `ScopedMemory` terminates, or when an inner scope returns from its `enter()` method. When the count drops to zero, the finalize method for each object in the memory would be executed to completion. Reuse of the scope is blocked until finalization is complete.

Scopes may be nested. When a nested scope is entered, all subsequent allocations are taken from the memory associated with the new scope. When the nested scope is exited, the previous scope is restored and subsequent allocations are again taken from that scope.

Because of the lifetimes of scoped objects, it is necessary to limit the references to scoped objects, by means of a restricted set of assignment rules. A reference to a scoped object cannot be assigned to a variable from an outer scope, or to a field of an object in either the heap or the immortal area. A reference to a scoped object may only be assigned into the same scope or into an inner scope. The virtual machine

must detect illegal assignment attempts and must throw an appropriate exception when they occur.

For cases where the usage of memory does not follow a stack discipline, in particular code that uses the producer-consumer pattern, a special variant of scoped memory is provided. This variant `PinnableMemory` has the same semantics as `LTMemory` except that a task can "pin" the memory, thereby keeping it open, even when no task is in the area. One task can fill the memory, put a reference in its portal, and then pass it on to another task to consume the data therein. Thus one does not have to have a dummy task to hold a pinned area open while it is passed from producer to consumer.

The flexibility provided in choice of scoped memory types enables the application to use a memory area that has characteristics that are appropriate to a particular syntactically defined region of the code.

2.5.5 Physical Memory Areas

In many cases, systems needing the predictable execution of the `RTSJ` will also need to access various kinds of memory at particular addresses for performance or other reasons. Consider a system in which very fast static RAM was programmatically available. A design that could optimize performance might wish to place various frequently used Java objects in the fast static RAM. The `PhysicalMemoryRegion` and `PhysicalMemoryFactory` classes provide the programmer this flexibility. The programmer would construct a physical memory object on the memory addresses occupied by the fast RAM.

2.5.6 Budgeted Allocation

The `RTSJ` also provides limited support for providing memory allocation budgets for schedulables using memory areas. Maximum memory area consumption and maximum allocation rates for individual schedulable objects may be specified when they are created.

2.6 Device Access and Raw Memory

The `RTSJ` defines classes for programmers wishing to directly access physical memory from code written in the Java language. The `RawMemory<Size>` types, where `<Size>` is one of `Byte`, `Short`, `Long`, `Float`, or `Double`, define methods that enable the programmer to construct an object that represents a vector of consecutive positions in memory where the `Size` represents a primitive numerical data type, i.e., byte, short, int, long, float, and double repectively. Access to the physical memory is then accomplished through `get<Size>()` and `set<Size>()` methods of that object. No semantics other than the `set<Size>()` and `get<Size>()` methods are implied. On the other hand, the `PhysicalMemoryRegion` and `PhysicalMemoryFactory` classes enable programmers to construct an object that represents a range of physical memory addresses. When this object is used as a `MemoryArea` other objects can be

constructed in the physical memory using the new keyword as appropriate. Factories can be used to create the desired type of both physical and raw memory.

2.6.1 Raw Memory Access

An instance of `RawMemory` models a range of physical memory locations as a fixed sequence of elements of a given size. The elements correspond to Java primitive types. For objects that access more than a single physical address, elements can be accessed through offsets from the base, where the offset is measured in multiples of the element size, not necessarily the byte offset in memory.

The `RawMemory` interface enables a realtime program to implement device drivers, memory-mapped registers, I/O space mapped registers, flash memory, battery-backed RAM, and similar low-level hardware.

A raw memory area cannot contain references to Java objects. Such a capability would be unsafe (since it could be used to defeat Java's type checking) and error prone (since it is sensitive to the specific representational choices made by the Java compiler).

2.7 System Options

POSIX defines some convenient interfaces for interacting with the system. These interactions include catching keyboard interrupts, user-to-process signaling, and interprocess signaling. Many realtime operating systems support this POSIX signal interface. For this reason, the `RTSJ` provides a POSIX signal interface. Though many of the features POSIX signals provide are also available on most other operating systems, the specification does not require the POSIX signal interface to be emulated on these other platforms. Thus they are optional in the sense that they are only required on systems that directly support POSIX signals.

2.8 Resource Enforcement

Since the Java language and runtime provide support for dynamic code loading, additional safeguards are necessary for using those features with realtime scheduling. It is quite easy to lock up a system with improperly design or implemented code that uses run to completion semantics that is provided by this specification. It is also more difficult to properly dimension a system that dynamically loads code. Therefore, an API for resource enforcement is provided for building robust frameworks for dynamic realtime systems.

2.9 Exceptions

Aside from several new exceptions, the `RTSJ` provides a new interface for using exceptions without creating ephemeral objects and some new treatment of exceptions surrounding asynchronous transfer of control.

Using exceptions is resource intensive, since a new exception is allocated for each throw. This is particularly a problem for scoped memory, since scopes may need to be sized much larger than otherwise necessary to hold exceptions and their stack traces. Additionally, the information they contain cannot be propagated beyond the scope in which they are allocated. To better support scoped, immortal, and physical memory, a new class of throwable has been included: `StaticThrowable`. Exceptions and Errors which implement this interface are not thrown in the usual manner, but with a style that does not require memory to be allocated at all.

Asynchronous transfer of control can cause the exception that triggered it to be propagated even when it is caught but the underlying interrupt is not cleared. The system rethrows the exception once the catch is finished. This is necessary since the Java exception hierarchy is poorly designed: there is no common base class for checked exceptions, so application code often contains a catch for `Exception` when only checked exceptions need to be caught. Even the JVM specification wording is awkward on this point, where a checked exception is an exception that is not a subclass of `RuntimeException` and an error is a throwable that is not a subclass of `Exception`.

2.10 Summary

The `RTSJ` refines the semantics of threads, scheduling, synchronization, memory management, and exceptions and adds features to support realtime threads, realtime scheduling, configuring synchronization, handling asynchrony, representing time, clocks and timers, additional methods for memory management, device access and raw memory, system options. These features and semantic refinements to the Java language and virtual machine have been outlined above, but the description does not constitute a definition for them. In other words, it is not normative. The normative chapters follow.

Chapter 3

General Requirements

The RTSJ is both an Application Programmer Interface (API) and a refinement of the semantics of the Java virtual machine. Both aspects are necessary to produce a programming environment conducive to programming realtime systems. Most realtime systems require features that go beyond simply being able to react within a defined time bounds, they must also respond to something and take action thereon. Therefore, the ability to interact with the external environment is a necessary part of a realtime specification.

There are many applications that can benefit from the API and semantic refinements of the Java runtime environment that have been described above. Not every application requires all parts, so some flexibility of implementation is necessary. Therefore the RTSJ is divided into a core package and three optional packages. Furthermore, it also provides for different usage modes to support both development and deployment.

Finally, the vast majority of realtime systems are also embedded systems. The constraints of such system must also be considered. The specification begins with the overall requirements of these concerns.

3.1 Definitions

Code — Program text written in the Java programming language.

Java Language — A programming language defined through the Java Community Process.

Heap — An area of memory for allocating data structures (objects) defined by the Java Language.

Extraheap Memory — An area of memory for allocating data structures (objects) other than the heap defined by the Java Language.

Thread — An instance of the `java.lang.Thread` class.

Realtime Thread — An instance of the `javax.realtime.RealtimeThread` class.

Java Thread — An instance of java.lang.Thread class, but does not extend the `javax.realtime.RealtimeThread` class.

Heapless Realtime Thread — An instance of the `javax.realtime.RealtimeThread` class that must not access the heap.

Event Handler — An instance of the `javax.realtime.AsyncBaseEventHandler`

class.

Schedulable — Any object that is of type `Schedulable`, and is recognized as a dispatchable entity by the required schedulers. The required schedulers' set of schedulables comprises instances of `RealtimeThread` and `AsyncBaseEventHandler`. Other schedulers may support a different set of schedulables, but this specification only defines the behavior of the required schedulers so the term schedulable should be understood as "schedulable by the base scheduler."

Task — Any object that represents computation, including schedulables and Java threads and instances of Schedulable.

Garbage Collection — A processes that reclaims memory on the heap that is no longer reachable by the application program. It may be accomplished through a dedicated set of threads or be distributed throughout the application.

3.2 Semantics

This specification is a contract between the specification implementer and the user who writes a program to run on an implementation. To be able to support both implementation and use, many chapters provide additional rationale to help both the implementer and the user understand the intention behind the normative text. The remainder of this specification, including this chapter, is normative, except for the introductory text in each chapter and the sections named Rationale.

3.2.1 Base Requirements

The base requirements of this specification are as follows.

1. Except as specifically required by this specification, any implementation shall fully conform to a Java platform configuration.
2. Any implementation of this specification shall implement all classes and methods in the base module of this specification.
3. Except as noted in this chapter, all classes and methods in an implemented module shall be implemented.
4. The `javax.realtime` package and its subpackages shall contain no public or protected classes or methods not included in this specification.
5. A realtime JVM implementation shall not be implemented in a way that permits unbounded priority inversion in any scheduling interaction it implements.
6. All methods defined under `javax.realtime` can safely be used concurrently by multiple threads unless otherwise documented.
7. Static final values, as found in `AperiodicParameters`, `SporadicParameters`, `RealtimeSystem`, and `PriorityScheduler`, shall be implemented such that their values cannot be resolved by a conformant Java compiler (Java source to byte code).

Many aspects of this specification set a minimum requirement, but permit latitude in its implementation. For instance, the required priority scheduler requires at least 28 consecutively numbered realtime priorities. It does not, however, specify the numeric values of the maximum and minimum realtime priorities. Implementations

are encouraged to offer as many realtime priority levels immediately above the conventional Java priorities as they can support.

Except where otherwise specified, when this specification requires object creation, the object is created in the current allocation context.

3.2.2 Modules

The original `RTSJ` specification was conceived, with the exception of some optional features, as a monolith specification. This has inhibited the adoption of the `RTSJ` beyond the hard realtime community, because some of the features were considered to have an overly negative impact on overall JVM performance. Version 2.0 addresses this by breaking the specification into modules.

Modules provide a means of grouping related functionality together in a way that promotes maximal adoption for various implementation classes. A conventional JVM may simply implement the Core Module API, without providing any realtime guarantees at all, thereby providing programmers with the benefits of features such as asynchronous event programming as an alternative to conventional threading. A hard realtime implementation could implement all modules to provide the maximal flexibility and functionality to the realtime programmer. Both would benefit from easier migration of code to realtime systems.

Every `RTSJ` implementation shall provide the Core Module functionality, but all other modules are optional. The optional modules are the Device Module, the Alternative Memory Areas Module and the POSIX Module. In addition, there are a couple of optional features as well. This gives the implementers some choice over which modules and features to include and which not.

3.2.2.1 Core Module

The Core Module adds the concepts of processor affinity, threads with realtime scheduling, and asynchronous event handling. This includes the notion of executing code at a given time interval, providing a much more stable response than using `sleep` in a loop. These features should have no impact on the overall performance of a system that implements them, but enrich the programming modules available to the programmer. The classes and interfaces required in this module are all in package `javax.realtime` and are listed below.

- `AbsoluteTime` (Section 9.3.1.1)
- `ActiveEvent` (Section 8.3.1.1)
- `ActiveEventDispatcher` (Section 8.3.2.1)
- `Affinity` (Section 6.3.3.1)
- `AffinityPermission` (Section 16.2.2.1)
- `AperiodicParameters` (Section 6.3.3.2)
- `AsyncBaseEvent` (Section 8.3.2.2)
- `AsyncBaseEvent` (Section 8.3.2.2)
- `AsyncBaseEventHandler` (Section 8.3.2.3)
- `AsyncBaseEventHandler` (Section 8.3.2.3)
- `AsyncEvent` (Section 8.3.2.4)
- `AsyncEventHandler` (Section 8.3.2.5)

- AsyncLongEvent (Section 8.3.2.6)
- AsyncLongEventHandler (Section 8.3.2.7)
- AsyncObjectEvent (Section 8.3.2.8)
- AsyncObjectEventHandler (Section 8.3.2.9)
- BackgroundParameters (Section 6.3.3.3)
- BoundAsyncEventHandler (Section 8.3.2.10)
- BoundAsyncLongEventHandler (Section 8.3.2.11)
- BoundAsyncObjectEventHandler (Section 8.3.2.12)
- BoundSchedulable (Section 6.3.1.1)
- ConfigurationParameters (Section 5.3.2.1)
- CoreMemoryPermission (Section 16.2.2.2)
- EnclosedType (Section 11.3.1.1)
- FirstInFirstOutParameters (Section 6.3.3.4)
- FirstInFirstOutReleaseRunner (Section 8.3.2.13)
- FirstInFirstOutScheduler (Section 6.3.3.5)
- GarbageCollector (Section 16.2.2.3)
- HeapMemory (Section 11.3.2.1)
- HighResolutionTime (Section 9.3.1.2)
- ImmortalMemory (Section 11.3.2.2)
- MemoryArea (Section 11.3.2.3)
- MemoryParameters (Section 11.3.2.4)
- MinimumInterarrivalPolicy (Section 6.3.2.1)
- MonitorControl (Section 7.3.1.1)
- PerennialMemory (Section 11.3.2.5)
- PeriodicParameters (Section 6.3.3.6)
- PhasingPolicy (Section 5.3.1.1)
- PriorityCeilingEmulation (Section 7.3.1.2)
- PriorityInheritance (Section 7.3.1.3)
- PriorityParameters (Section 6.3.3.7)
- PriorityScheduler (Section 6.3.3.8)
- QueueOverflowPolicy (Section 6.3.2.2)
- RealtimePermission (Section 16.2.2.4)
- RealtimeSecurity (Section B.2.2.29)
- RealtimeSystem (Section 16.2.2.5)
- RealtimeThread (Section 5.3.2.2)
- RealtimeThreadGroup (Section 6.3.3.9)
- RelativeTime (Section 9.3.1.3)
- Releasable (Section 8.3.1.2)
- ReleaseParameters (Section 6.3.3.10)
- ReleaseRunner (Section 8.3.2.14)
- RoundRobinParameters (Section 6.3.3.11)
- RoundRobinScheduler (Section 6.3.3.12)
- RTSJModule (Section 16.2.1.1)
- Schedulable (Section 6.3.1.2)
- Scheduler (Section 6.3.3.13)
- SchedulingParameters (Section 6.3.3.14)

- `SchedulingPermission` (Section 16.2.2.6)
- `SizeEstimator` (Section 11.3.2.6)
- `SporadicParameters` (Section 6.3.3.15)
- `Subsumable` (Section 8.3.1.3)
- `TaskPermission` (Section 16.2.2.7)
- `TimePermission` (Section 16.2.2.8)
- `WaitFreeReadQueue` (Section 7.3.1.4)
- `WaitFreeWriteQueue` (Section 7.3.1.5)

All throwables defined in the `RTSJ` are also in the `javax.realtime` package:

- `AlignmentError` (Section 17.2.2.1)
- `ArrivalTimeQueueOverflowException` (Section 17.2.2.2)
- `CeilingViolationException` (Section 17.2.2.3)
- `ConstructorCheckedException` (Section 17.2.2.4)
- `DeregistrationException` (Section 17.2.2.5)
- `EventQueueOverflowException` (Section 17.2.2.6)
- `ForEachTerminationException` (Section 17.2.2.7)
- `IllegalAssignmentError` (Section 17.2.2.8)
- `IllegalTaskStateException` (Section 17.2.2.9)
- `InaccessibleAreaException` (Section 17.2.2.10)
- `LateStartException` (Section 17.2.2.11)
- `MemoryAccessError` (Section 17.2.2.13)
- `MemoryInUseException` (Section 17.2.2.14)
- `MemoryScopeException` (Section 17.2.2.15)
- `MemoryTypeConflictException` (Section 17.2.2.16)
- `MITViolationException` (Section 17.2.2.12)
- `OffsetOutOfBoundsException` (Section 17.2.2.17)
- `POSIXInvalidSignalException` (Section 17.2.2.18)
- `POSIXInvalidTargetException` (Section 17.2.2.19)
- `POSIXSignalPermissionException` (Section 17.2.2.20)
- `ProcessorAffinityException` (Section 17.2.2.21)
- `RangeOutOfBoundsException` (Section 17.2.2.22)
- `RegistrationException` (Section 17.2.2.23)
- `ResourceLimitError` (Section 17.2.2.24)
- `ScopedCycleException` (Section 17.2.2.25)
- `SizeOutOfBoundsException` (Section 17.2.2.26)
- `StaticCheckedException` (Section 17.2.2.27)
- `StaticError` (Section 17.2.2.28)
- `StaticIllegalArgumentException` (Section 17.2.2.29)
- `StaticIllegalStateException` (Section 17.2.2.30)
- `StaticOutOfMemoryError` (Section 17.2.2.31)
- `StaticRuntimeException` (Section 17.2.2.32)
- `StaticSecurityException` (Section 17.2.2.33)
- `StaticThrowable` (Section 17.2.1.1)
- `StaticThrowableStorage` (Section 17.2.2.34)
- `StaticUnsupportedOperationException` (Section 17.2.2.35)
- `ThrowBoundaryError` (Section 17.2.2.36)

- `UninitializedStateException` (Section 17.2.2.37)
- `UnsupportedPhysicalMemoryException` (Section 17.2.2.38)
- `UnsupportedRawMemoryRegionException` (Section 17.2.2.39)

3.2.2.2 Alternative Memory Areas Module

The Alternative Memory Areas Module provides an alternative to a single heap with garbage collection model for memory management. Most of the facilities are centered around providing an alternative to garbage collection, but facilities for providing what memory to use for Java objects is also addressed. The classes required in this module are all in package `javax.realtime.memory` and are listed below.

- `ClassAllocation` (Section 11.4.1.1)
- `LTMemory` (Section 11.4.4.1)
- `MemoryAreaType` (Section 11.4.3.1)
- `PhysicalMemoryCharacteristic` (Section 11.4.2.1)
- `PhysicalMemoryFactory` (Section 11.4.4.2)
- `PhysicalMemoryRegion` (Section 11.4.4.3)
- `PhysicalMemorySelector` (Section 11.4.4.4)
- `PinnableMemory` (Section 11.4.4.5)
- `ScopedConfigurationParameters` (Section 11.4.4.6)
- `ScopedMemory` (Section 11.4.4.7)
- `ScopedMemoryParameters` (Section 11.4.4.8)
- `StackedMemory` (Section 11.4.4.9)

3.2.2.3 Control Module

Conventional Java provided a single exception for asynchronous control flow change: the `ThreadDeath` error. This is thrown when `Thread.stop()` is called. Unfortunately, throwing `ThreadDeath` is not thread safe, so it has been deprecated. This module provides an alternative that is thread safe. It is optional because support for this module requires significant changes to the VM. The classes required are all in the package `javax.realtime.control` and are listed below.

- `AsynchronousControlGroup` (Section 12.3.2.1)
- `AsynchronouslyInterruptedException` (Section 12.3.2.2)
- `Interruptible` (Section 12.3.1.1)
- `Timed` (Section 12.3.2.3)

3.2.2.4 Device Module

The Device Module provides a low level interface for interacting with the real world. Though realtime control systems need this kind of interaction, other systems can benefit from it as well. Data collection, that is not time critical, is a good example. For instance, monitoring the temperature or humidity in a room could be done easily with off-the-self hardware using this module. The classes required in this module are all in the package `javax.realtime.device` and are listed below.

- `DirectMemoryBufferFactory` (Section 13.3.2.1)
- `DirectMemoryByteBuffer` (Section 13.3.1.1)

- `DirectMemoryRegion` (Section 13.3.2.2)
- `Happening` (Section 13.3.2.3)
- `HappeningDispatcher` (Section 13.3.2.4)
- `InterruptCeilingEmulation` (Section 13.3.2.5)
- `InterruptDescriptor` (Section 13.3.2.6)
- `InterruptInheritance` (Section 13.3.2.7)
- `InterruptMasking` (Section 13.3.2.8)
- `InterruptServiceRoutine` (Section 13.3.2.9)
- `InterruptUnmaskable` (Section 13.3.2.10)
- `RawByte` (Section 13.3.1.2)
- `RawByteReader` (Section 13.3.1.3)
- `RawByteWriter` (Section 13.3.1.4)
- `RawDouble` (Section 13.3.1.5)
- `RawDoubleReader` (Section 13.3.1.6)
- `RawDoubleWriter` (Section 13.3.1.7)
- `RawFloat` (Section 13.3.1.8)
- `RawFloatReader` (Section 13.3.1.9)
- `RawFloatWriter` (Section 13.3.1.10)
- `RawInt` (Section 13.3.1.11)
- `RawIntReader` (Section 13.3.1.12)
- `RawIntWriter` (Section 13.3.1.13)
- `RawLong` (Section 13.3.1.14)
- `RawLongReader` (Section 13.3.1.15)
- `RawLongWriter` (Section 13.3.1.16)
- `RawMemory` (Section 13.3.1.17)
- `RawMemoryFactory` (Section 13.3.2.11)
- `RawMemoryRegion` (Section 13.3.2.12)
- `RawMemoryRegionFactory` (Section 13.3.1.18)
- `RawShort` (Section 13.3.1.19)
- `RawShortReader` (Section 13.3.1.20)
- `RawShortWriter` (Section 13.3.1.21)

3.2.2.5 POSIX module

The POSIX module provides access to functionality particular to POSIX systems. In particular, it addresses POSIX signals and POSIX realtime signals. This module is optional, but an implementation of this standard on a POSIX platform should provide it. Implementations on platforms that are not POSIX compliant may provide it. The classes in this module are in the package `javax.realtime.posix` and are listed below.

- `RealtimeSignal` (Section 14.3.1.1)
- `RealtimeSignalDispatcher` (Section 14.3.1.2)
- `Signal` (Section 14.3.1.3)
- `SignalDispatcher` (Section 14.3.1.4)

3.2.2.6 Resource Enforcement

The Resource Enforcement Module provides API for limiting the amount of a given resource can be used by a given group of tasks. The specification supports managing CPU and memory resources. It takes advantage of an extended thread group concept provided below as an organizational feature for resource management. In combination with class loaders and security management, one has powerful tools for building a robust dynamic realtime system. This module is also optional.

- `BackingStoreConstraint` (Section 15.3.1.1)
- `HeapConstraint` (Section 15.3.1.2)
- `ImmortalConstraint` (Section 15.3.1.3)
- `ProcessingConstraint` (Section 15.3.1.4)
- `ResourceConstraint` (Section 15.3.1.5)

3.2.3 Optional Features

Even with modules, it is difficult to eliminate all optional features. These features are either not easy to implement on all platforms or have the potential to cause a significant performance overhead. Therefore, an application cannot depend on them to be present in every implementation. However, if an optional facility is implemented, the application may rely on it to behave as specified here. Those extensions are illustrated in Table 3.1.

Table 3.1: `RTSJ` Options

Allocation-rate enforcement on heap allocation	Enables the application to limit the rate at which a schedulable creates objects in the heap.
Interrupt service routine	Provides first level interrupt processing in Java.

In implementations where heap allocation rate enforcement is supported, it shall be implemented as specified. If heap allocation rate enforcement is not supported, the allocation rate attribute of `MemoryParameters` shall be checked for validity but otherwise ignored by the implementation.

First level interrupt handling can only be supported in certain contexts, such as in kernel space and in a device driver context in user space on systems that support this feature. Normally user space programs cannot handle interrupts directly. The class should be present in every system that implements the device module, but in implementations that do not support first level interrupt handling, the `InterruptServiceRoutine.register` should always throw an `UnsupportedOperationException`.

Extensions to this specification are allowed, but shall not require changes to the public interfaces defined in the `javax.realtime` package tree in particular and the `java` and `javax` package trees in general.

3.2.4 Deprecated Classes

Classes and methods that have been deprecated as of this specification are not part of any module, but may be implemented by a full `RTSJ` implementation. The following

classes are deprecated:

- `AsynchronouslyInterruptedException` (Section B.2.2.6)
- `DuplicateFilterException` (Section B.2.2.8)
- `ImmortalPhysicalMemory` (Section B.2.2.11)
- `ImportanceParameters` (Section B.2.2.12)
- `Interruptible` (Section B.2.1.1)
- `LTMemory` (Section B.2.2.13)
- `LTPhysicalMemory` (Section B.2.2.14)
- `NoHeapRealtimeThread` (Section B.2.2.18)
- `PhysicalMemoryManager` (Section B.2.2.22)
- `PhysicalMemoryTypeFilter` (Section B.2.1.2)
- `POSIXSignalHandler` (Section B.2.2.20)
- `ProcessingGroupParameters` (Section B.2.2.25)
- `RationalTime` (Section B.2.2.26)
- `RawMemoryAccess` (Section B.2.2.27)
- `RawMemoryFloatAccess` (Section B.2.2.28)
- `ScopedMemory` (Section B.2.2.35)
- `Timed` (Section B.2.2.38)
- `UnknownHappeningException` (Section B.2.2.39)
- `VTMemory` (Section B.2.2.41)
- `VTPhysicalMemory` (Section B.2.2.42)

They are documented fully in Chapter B.

3.2.5 Implementation types Allowed

As described in Section 3.2.2, the `RTSJ` now has modules. Every implementation, except one supporting `Safety Critical Java`, must implement the Core module. Each module provided by an implementation must be provided in full. None of the classes of an unimplemented module should be present. Only an implementation of this specification exclusively used for supporting `Safety Critical Java` may subset classes and packages herein, but must implement the methods and classes defined in that specification[1].

3.2.5.1 Realtime Deployment Implementation

A realtime deployment implementation must support all semantics described herein necessary for deterministic programming. In addition to implementing the core module, a realtime deployment implementation must have a realtime garbage collector or implement the alternative memory areas module. All other modules are optional.

The minimum scheduling semantics that must be supported in all implementations of the `RTSJ` are fixed-priority preemptive scheduling with support for at least 28 unique priority levels[2]. Fixed priority means that the system does not change the priority of any `Schedulable` except, temporarily, for priority inversion avoidance. Priority change is under control of the application.

[1] The `Safety Critical Java` has its own module (package) that extends APIs supported by the `RTSJ`, but all of its realtime functionality are implemented using `RTSJ` classes.

[2] This does not mean that each deployment must have all 28 priorities active

What the RTSJ precludes by this statement is scheduling algorithms for realtime priorities which change thread priorities according to policies for optimizing throughput. An implementation may not increase the priority of a thread that has been receiving few processor cycles because of higher priority threads (aging) or other so-called fair scheduling algorithms. Fair scheduling operations are also prohibited. These types of algorithms are reserved for conventional Java thread priorities. This does not prohibit an application from implementing other realtime schedulers, such as earliest deadline first, which use underlying OS priorities to support an application meeting its deadlines.

The 28 priority levels are required to be unique to preclude implementations from using fewer priority levels of underlying systems to implement the required 28 by simplistic algorithms (such as lumping four RTSJ priorities into seven buckets for an underlying system that only supports seven priority levels). It is sufficient for systems with fewer than 28 priority levels to use more sophisticated algorithms to implement the required 28 unique levels as long as Schedulable behave as though there were at least 28 unique levels. (e.g. if there were 28 RealtimeThreads $(t_1, ..., t_{28})$ with priorities $(p_1, ..., p_{28})$, respectively, where the value of p_1 was the highest priority and the value of p_2 the next highest priority, etc., then for all executions of threads t_1 through t_{28} thread t_1 would *always* execute in preference to threads $t_2, ..., t_{28}$ and thread t_2 would *always* execute in preference to threads $t_3, ..., t_{28}$, etc.)

The minimum synchronization semantics that must be supported in all deployment implementations of the RTSJ are detailed in the section on synchronization below and repeated here. All deployment implementations of the RTSJ must provide an implementation of the synchronized primitive with default behavior that ensures that there is no unbounded priority inversion. Furthermore, this must apply to code if it is run within the implementation as well as to schedulables. Both the priority inheritance and the priority ceiling emulation protocols must be implemented, but priority inheritance is the default.

All instances of Schedulable waiting to acquire a resource must be queued in priority order. This applies to the processor as well as to synchronized blocks. When schedulables with the same exact priority are possible under the active scheduling policy, schedulables with the same priority are queued in FIFO order. Note that these requirements apply only to the required scheduling policy and hence use the specific term "priority". In particular,

1. schedulables waiting to enter synchronized blocks are granted access to the synchronized block in priority order;
2. a blocked schedulable that becomes ready to run is given access to the processor in priority order;
3. a schedulable whose execution eligibility is explicitly set by itself or another schedulable is given access to the processor in priority order;
4. a schedulable that performs a yield() will be given access to the processor after all other schedulables waiting at the same priority;
5. however, schedulables that are preempted in favor of a schedulable with higher priority may be given access to the processor at any time as determined by a particular implementation. The implementation is required to provide documentation stating exactly the algorithm used for granting such access.

Other realtime schedulers must provide and document similar algorithms to expedited schedulables with higher execution eligibility over those with lower execution eligibility.

The `RTSJ` does not require any particular garbage collection algorithm; however, every deployment implementation must either implement the alternate memory area module or have a realtime garbage collection. In the later case, the realtime limitations must be documented. All implementations of the `RTSJ` must support the class `GarbageCollector` and implement all of its methods.

Notwithstanding the above, a program that uses the `RTSJ` and is deployed as an executable, so that it does not provide general access to the virtual machine, but solely runs that program code, need only include the `RTSJ` methods and classes needed by the application.

3.2.5.2 Simulation Implementation

An implementation that chooses not to provide realtime guarantees, is termed a simulation implementation. Such an implementation does not need to provide the realtime characteristic described above, but does need to at least provide all the APIs of the core module. A simulation implementation can be a production system, but not for realtime applications. This enables a conventional JVM to make the base APIs available to a wider audience without changing its performance characteristics.

The following semantics are optional for an `RTSJ` implementation designed and licensed exclusively as a development tool.

1. The priority scheduler need not support fixed-priority preemptive scheduling or the priority inversion avoidance algorithms. This does not excuse an implementation from fully supporting the relevant APIs. It only reduces the required behavior of the underlying scheduler to the level of the scheduler in the Java specification extended to at least 28 priorities.
2. No semantics constraining timing beyond the requirements of the Java specifications need be supported. Specifically, garbage collection may delay any thread without bound and any delay in delivering asynchronously interrupted exceptions (AIE) is permissible including never delivering the exception. Note, however, that if any AIE other than the generic AIE is delivered, it shall meet the AIE semantics, and all heap-memory-related semantics other than preemption remain fully in effect. Further, relaxed timing does not imply relaxed sequencing. For instance, semantics for scoped memory shall be fully implemented.
3. The `RTSJ` semantics that alter standard Java method behavior, such as the modified semantics for `Thread.setPriority` and `Thread.interrupt`, are not required for a development tool, but such deviations from the `RTSJ` shall be documented, and the implementation shall be able to generate a runtime warning each time one of these methods deviates from standard `RTSJ` behavior.

These relaxed requirements set a floor for `RTSJ` development system tool implementations. A development tool may choose to implement semantics that are not required.

3.3 Required Documentation

In order to properly engineer a realtime system, an understanding of the cost associated with any arbitrary code segment is required. This is especially important for operations that are performed by the runtime system, largely hidden from the programmer. An example of this is the maximum expected latency before the garbage collector can be interrupted.

The `RTSJ` does not require specific performance or latency numbers to be matched. Rather, to be conformant to this specification, an implementation must provide documentation regarding the expected behavior of particular mechanisms. The mechanisms requiring such documentation, and the specific data to be provided, will be detailed in the class and method definitions.

Each implementation of the `RTSJ` is required to provide documentation for several behaviors.

1. If schedulers other than the required first-in-first-out (FIFO) and round robin (RR) schedulers are available to applications, the behavior of these schedulers and their interaction with each other and the required schedulers as detailed in Chapter 6, Scheduling, shall be documented.
   (a) The documentation must define how its order of execution eligibility relates to that of the priority schedulers, where the order of execution eligibility of a priority scheduler is the priority order.
   (b) The list of classes whose instances constitute schedulables for the scheduler, unless that list is the same as the list of schedulables for the required schedulers, shall be included.
   (c) If there are restrictions on use of the scheduler from a context without heap access, such restrictions shall be documented as well.
2. A scheduler that cannot place a schedulable at the front of the queue for its active priority when it is preempted by a higher-priority schedulable must document such a deviation from the specification.
3. An implementation is required to document the granularity at which the current CPU consumption is updated for cost monitoring and cost enforcement, when the later is implemented.
4. The implementation shall fully document the behavior of any subclasses of `GarbageCollector`.
5. An implementation that provides any `MonitorControl` subclasses not detailed in this specification shall document their effects, particularly with respect to priority inversion control and which (if any) schedulers fail to support the new policy.
6. If on losing "boosted" priority due to a priority inversion avoidance algorithm, the schedulable is not placed at the front of its new queue, the implementation shall document the queuing behavior.
7. For any available scheduler other than the required schedulers, an implementation shall document how, if at all, the semantics of synchronization differ from the rules defined for the default `PriorityInheritance` monitor control policy.
   (a) It shall supply documentation for the behavior of the new scheduler with priority inheritance (and, if it is supported, priority ceiling emulation

protocol) equivalent to the semantics for the base priority scheduler found in the Synchronization chapter.

(b) If there are restrictions on use of the scheduler from an extraheap context, the documentation shall detail the effect of these restrictions for each `RTSJ` API.

8. The worst-case response interval from the firing of an `AsyncEvent`, due to a bound happening, to releasing an associated `AsyncEventHandler`, assuming no higher-priority schedulables are runnable, shall be documented for at least one reference architecture.
9. The interval between firing an `AsynchronouslyInterruptedException` at an ATC-enabled thread and first delivery of that exception (assuming no higher-priority schedulables are runnable) shall be documented for at least one reference architecture.
10. If cost enforcement is supported and the implementation assigns the cost of running finalizers for objects in scoped memory to any schedulable other than the one that caused the scope's reference count to drop to zero by leaving the scope, the rules for assigning the cost shall be documented.
11. If hard cost enforcement is supported and enforcement (blocked-by-cost-overrun) can be delayed beyond the enforcement time granularity, the maximum such delay shall be documented.
12. If the implementation of `RealtimeSecurity` is more restrictive than the required implementation, or has run-time configuration options, those features shall be documented.
13. For each supported clock, the documentation shall specify whether the resolution is settable, and if it is settable the documentation shall indicate the supported values.
14. If an implementation includes any clocks other than the required realtime clock, their documentation shall indicate in what contexts those clocks can be used. If they cannot be used in extraheap context, the documentation shall detail the consequences of passing the clock, or a time that uses the clock to a heapless schedulable.

3.4 Rationale

The embedded market, especially for safety critical applications, is quite sensitive to including code that is not needed by an application. Furthermore, different application domains have differing needs on API. Flexibility is needed to ensure that these diverse domains and requirements are met. Still, it is important to ensure that when a given function is needed, it is included as defined herein. It is also important that an open virtual machine deployment has a well-defined API set. This has required moving a few classes into a new package, so that the resulting modules will be consistent with the rules imposed by the JSR 376, the Java Platform Module System. The above modules and deployment rules provide both this flexibility and standardization.

Chapter 4

Realtime vs Conventional Java

Though compatibility with conventional Java (i.e., any Java runtime environments that implement the Java Virtual Machine Specification and the Java Language Specification but not the RTSJ) is the first concern of this specification, there are several cases where being able to meet realtime constraints requires a tightening of the semantics of the virtual machine and some subtle changes to the semantics of two key classes: `java.lang.Thread` and `java.lang.ThreadGroup`. These constraints and changes place additional requirements on scheduling, the memory model, and memory management. The specification additionally defines both an extension to thread for realtime scheduling and a new type of concurrent activity called an event handler; hence, the meaning of current thread has a different interpretation than in conventional Java. The term *task* is used when referring to any of these three types: conventional Java thread, realtime thread, and event handler.

Behaviors that may be different from conventional Java or may be surprising to developers of conventional Java applications under the RTSJ can be divided into three categories. The first category applies to conventional Java code that was not developed with the RTSJ in mind and does not use RTSJ features but runs under an RTSJ implementation. The second is conventional Java code that was not developed with the RTSJ in mind but is called by code developed for the RTSJ in an RTSJ implementation. The final category is Java code that was developed for the RTSJ and is being used in an RTSJ implementation.

The first category, conventional Java code running on an RTSJ implementation but not using any RTSJ features, may encounter the following behaviors that are not (necessarily) experienced under a conventional Java VM.

- Any object allocated in a static initializer that later becomes garbage may be unable to be collected by the VM. (See Section 11.2.7.)
- Some `Throwable`s, in particular those implementing `StaticThrowable`, which includes `StaticOutOfMemoryError`, thrown by an RTSJ VM in preference to `OutOfMemoryError`, have stack trace and message information which is valid only while the `Throwable` is in flight and in the thread which originally threw the `Throwable`. (See Section 17.1.)

The second category, conventional Java code that is running on an RTSJ implementation and in use by code that was developed for the RTSJ, may encounter the following differences in behavior.

- `IllegalAssignmentError` may be thrown in non `RTSJ`-aware classes when the Alternative Memory Management module (Chapter 11) is in use. (See Section 11.2.8.)
- Tasks in an `RTSJ` application might not be scheduled by a fair scheduler. The result is that there may be thread starvation unexpected by conventional Java applications. (See Section 6.2.1.)
- A call to `Thread.getPriority()` may return a priority higher than `Thread.MAX_PRIORITY`. (See Section 6.3.3.13.2.)
- Methods cannot rely on any thread local information when used in conjunction with asynchronous event handlers. This includes thread local data and calls to `Thread.currentThread()`. Hence, care must be taken when using thread identifiers to determine the identity of callers. (This is analogous to the use of `ThreadPool` in conventional Java.) (See Sections 8.2.1 and 8.3.2.5.)

The third and final category comprises behaviors exhibited by code designed for the `RTSJ` running on an `RTSJ` implementation that are departures from conventional Java semantics or may be otherwise surprising.

- Finally clauses in asynchronously interruptible methods are not executed during propagation of an `AsynchronouslyInterruptedException`. However, synchronized code is always ATC-deferred, and therefore monitor locks are released normally. (See Section 12.2.2.)
- Catch clauses that name `AsynchronouslyInterruptedException` (or its parent classes) will not automatically stop the propagation of AIEs. An `AsynchronouslyInterruptedException` must be explicitly cleared. (See Section 12.2.2.)
- Exceptions propagating into asynchronously interruptible regions of code will be lost if an `AsynchronouslyInterruptibleException` is pending. (See Section 12.2.2.)
- Subclasses of `AsynchronouslyInterruptibleException` indicated in the signature of a method do not indicate that the method is asynchronously interruptible. (See Section 12.2.2.)
- Catch clauses for `AsynchronouslyInterruptibleException` or its subclasses in asynchronously interruptible methods will not catch an AIE. (See Section 12.2.2.)
- A `Throwable` crossing a `MemoryArea` boundary might be transformed into a `ThrowBoundaryError`, and the original exception may be lost. (See Section 17.2.2.36 and the `enter` family of methods on `MemoryArea`.)

4.1 Definitions

Conventional Java — The language and runtime as defined by the "Java Language Specification[5]" and "Java Virtual Machine Specification[6]," without any realtime extensions.

Realtime Java — Conventional Java extended and refined according to this specification for programming realtime systems.

Fair Scheduling — A method of nonrealtime scheduling which tries to ensure that all tasks get a chance to run, thus preventing starvation. Tasks with a higher priority get a notionally larger share of execution time than lower priority tasks.

Tasks running at the same priority get notionally equal shares of the processor.

Happens-Before — The "Java Language Specification[5]" specifies the *happens-before* relationship as "If one action happens-before another, then the first is visible to and ordered before the second." See the specification for the implications of this relationship.

Priority — An indication of the relative scheduling eligibility of a task. A task with a higher priority is scheduled before a task with a lower priority. The priority assigned to a task is not necessarily the one used for scheduling, since priority avoidance and cost enforcement mechanisms may transiently override it. See Base Priority in Section 6.1 and Active Priority in Section 7.1.

Task — A conventional Java thread or an `RTSJ Schedulable`.

4.2 Semantics

The refinements and changes to the semantics of the Java runtime environment and classes shall not affect the functional correctness of Java code written for a conventional Java implementation when running on a Java runtime environment which implements this specification. There may be changes in the relative timing of threads, but these should not violate the conventional Java specifications. The use of some `RTSJ` features with code written for a conventional Java implementation may, however, cause unexpected behaviors. This is particularly true when using alternate memory areas, asynchronous transfer of control, and thread local memory in conjunction with unbound asynchronous event handlers.

4.2.1 Scheduling

How tasks are scheduled in a realtime system is quite different from what one expects in a conventional Java virtual machine. For compatibility, this means that there must be a domain where conventional Java threads are scheduled in a familiar way and another domain that supports realtime scheduling. This separation is done in part via task priority.

Tasks running with the conventional ten priorities defined in Java should be scheduled as expected. Unfortunately, in order to ease the porting of Java to different environments, the scheduling of conventional Java threads is underspecified in [5]. This has been resolved in practice to avoid surprising the programmer by providing some sort of fair scheduling for these threads, i.e, scheduling that at least prevents task starvation, but may also try to balance CPU availability across threads. For tasks running in these priorities, an implementation of this specification shall provide some notion of fair scheduling between tasks with priority between one and ten inclusive.

Realtime threads and event handlers need a stronger notion of prioritization than conventional Java threads, so this specification requires the implementation of two priority-preemptive schedulers, one with run to completion (or next suspension point) and one with round-robin semantics. Priorities above the conventional ten priorities are used for these schedulers, and the interactions of the two schedulers are well-defined. Multithreaded code that runs with the priority-preemptive scheduler

(or any other realtime scheduler) is more prone to deadlock or starvation than code run with fair scheduling. The changes to `Thread` and `ThreadGroup` are to support this realtime scheduling.

1. The semantics of set and get methods for priority in `Thread` differ for realtime threads.
2. The `ThreadGroup` class's behavior differs with respect to realtime threads.
3. The behavior of the `ThreadGroup`-related methods in `Thread` differ when they are applied to realtime threads.

Code running at realtime priorities can also starve tasks scheduled on the conventional Java scheduler, possibly indefinitely.

4.2.1.1 Priority

The methods `setPriority` and `getPriority` in `java.lang.Thread` are `final`. The realtime thread classes are consequently not able to override them and modify their behavior to suit the requirements of the `RTSJ` scheduler. To bring the `java.lang.Thread` class in line with its realtime subclasses, the semantics of the `getPriority` and `setPriority` methods must be modified.

4.2.1.1.1 Setting Priority

The `setPriority` method has the following additional requirements.

1. Use of `Thread.setPriority()` shall not affect the correctness of the priority inversion avoidance algorithms controlled by `PriorityCeilingEmulation` and `PriorityInheritance`. Changes to the base priority of a realtime thread as a result of invoking `Thread.setPriority()` are governed by semantics from Chapter 7 on *Synchronization*.
2. Conventional Java threads may not use `setPriority` to apply the expanded range of priorities defined by this specification.
3. When `setPriority` is called on a realtime thread, that thread's `SchedulingParameters` are set to `null` and the thread is scheduled as if it were a Java thread.

4.2.1.1.2 Getting Priority

The `getPriority` method has the following additional requirements.

1. When called on a conventional Java thread, its assigned priority is returned even if it has a higher priority than what would be allowed by conventional Java. It may be higher only when set with an instance of `SchedulingParameters` through a scheduler.
2. When called on a realtime thread with `null SchedulingParameters`, a value in the conventional Java priority range is returned.
3. When called on a realtime thread (t) with `PriorityParameters`, `getPriority` behaves effectively as if it included the following code snippet:

```
1    ((PriorityParameters)t.getSchedulingParameters()).getPriority
         ();
```

4. When the scheduling parameters are of a type other than `PriorityParameters`, a `ClassCastException` is thrown.

All supported monitor control policies must apply to Java threads as well as to all schedulables.

4.2.1.2 Thread Groups

Conventional Java provides thread groups as a means of managing groups of threads. Since the `RTSJ` provides additional classes for encapsulating control flow under the umbrella of `Schedulable`, it makes sense to have facilities for managing groups of these as well. The `RTSJ` provides an extension of `ThreadGroup` for this called `RealtimeThreadGroup`.

Every instance of `ThreadGroup` holds a reference to every member thread and every subgroup instance of `ThreadGroup`, as well as a reference to its parent group. This is problematic under the `RTSJ`, since realtime threads may be allocated in scoped memory. Rather than making complicated changes to the semantics of `ThreadGroup` (and, in particular, its `enumerate` methods), the `RTSJ` requires that no `ThreadGroup` or Java thread is allocated in scoped memory, and that no thread allocated in `ScopedMemory` is referenced by a `ThreadGroup`. Instances of `RealtimeThreadGroup` are instead used for these purposes, and an alternative to `enumerate` is provided on `RealtimeThreadGroup` in the form of a visitor.

Realtime thread groups, i.e., instances of `RealtimeThreadGroup`, a subclass of `ThreadGroup`, are designed to be able to reference threads, schedulables, and other realtime thread groups, even when they are in scoped memory. These are only reachable using a visitor with a lambda expression. Consequently schedulables and realtime thread groups are not part of any thread group and will hold a realtime thread group reference as their parent thread group. This requires that the thread group of the main thread is also a schedulable group, so that schedulables and schedule groups can be created from the main thread.

In order for this to work in a transparent manner, the following rules must hold.

1. An instance of `ThreadGroup` that is not an instance of `RealtimeThreadGroup` cannot contain any instances of `Schedulable`.
2. In an `RTSJ` implementation, both the `ThreadGroup` at the root of the `ThreadGroup hierarchy` and the `ThreadGroup` to which the initial thread belongs must be instances of `RealtimeThreadGroup`.
3. Calls to `RealtimeThreadGroup.enumerate(Thread[])` and `RealtimeThreadGroup.enumerate(Thread[], boolean)` only return Java threads.
4. Calls to `RealtimeThreadGroup.enumerate(ThreadGroup[])` and `RealtimeThreadGroup.enumerate(ThreadGroup[], boolean)` only return threads groups and realtime thread groups allocated in heap and immortal memory.
5. A Java thread (not a realtime thread) that is created from a realtime thread or bound asynchronous event handler without an explicit thread group and that is not assigned a thread group by the security manager, inherits the realtime thread group of its creator, when that group is allocated in heap or immortal memory; otherwise an `IllegalAssignmentError` is thrown.
6. The thread group of a Java thread that is created from an unbound asynchronous event handler without an explicit thread group and that is not assigned

a thread group by the security manager, is assigned to the realtime thread group of the handler's dispatcher, when that dispatcher's realtime thread group is allocated in heap or immortal memory; otherwise an `IllegalAssignmentError` is thrown.

7. A thread group cannot be created in scoped memory. The constructor shall throw an `IllegalAssignmentError`.
8. Setting a maximum priority on a realtime thread group, either explicitly or via its parent with a thread group specific method, has no influence on the schedulables in that group.
9. Except as specified previously, realtime threads and bound asynchronous event handlers have the same `ThreadGroup` membership rules as their parent `Thread` class.

4.2.1.3 Current Thread

In Java, the currently executing thread can always be determined by calling the static method `Thread.currentThread()`. In the `RTSJ`, there are two types of schedulable entities: threads and asynchronous event handlers. The latter may be mapped dynamically by the realtime Java virtual machine onto the underlying thread model. The method `Thread.currentThread()`, when called from an unbound asynchronous event handler, will return the thread that is being used as the current execution engine for that event handler. The program should not rely on this being constant for the lifetime of the program. It can rely on it being constant for the current *release* of the handler (see 6.1 for the definition of a *release*). It is not recommended that the program perform any operations on this underlying thread as it may have an impact beyond that of the current event handler. This also means that thread local memory cannot be relied on when used with unbound event handlers, because data saved in one release may not be available in the next release.

4.2.2 InterruptedException

The specification extends the use of the `InterruptedException` to support asynchronous transfer of control.

The interruptible methods in the standard libraries (such as `Object.wait`, `Thread.sleep`, and `Thread.join`) have their contract expanded slightly such that they will respond to interruption not only when the interrupt method is invoked on the current thread, but also, for schedulables, when executing within a call to `AIE.doInterruptible` and that AIE is fired where AIE is an instance of the `AsynchronouslyInterruptedException`. See Chapter 8 on Asynchrony.

4.2.3 Java Memory Model

Some aspects of the Java Memory Model must be tightened for this specification, in particular with regards to interactions with native code or when using the Device Module. A conforming implementation must ensure that volatile loads and stores, raw memory operations (see 13.2.1), and `DirectMemoryBufferFactory` fence methods are ordered to be consistent with respect to native code or hardware devices that

use platform-native memory coherency protocols to access raw memory or raw byte buffers shared with the virtual machine. In particular, all Java code that precedes a JNI call in the source *happens-before* the code executed during the JNI call, which *happens-before* all Java code that follows its return.

Though not specified for conventional Java, most implementations provide explicit fencing for JNI calls.

4.2.4 Memory Management

The specification provides for two means of managing memory: garbage collection and special memory areas. The latter are not collected by the garbage collector. Since memory allocated in Java is always in the heap, or at least appears to be, the initial allocation area is the heap. Furthermore, the allocation area can only be changed either by entering another memory area or by calling a method that explicitly causes allocation in another area. When the alternative memory areas module is not present, the conventional Java semantics for allocation prevails.

4.2.4.1 Memory Areas

Using a conventional class in a memory area other than a heap can result in unexpected behavior. This is particularly the case when a method of a class is called when the current allocation context is different from the allocation context in which the object was created; this can lead to exceptions. In general, memory areas other than the heap may become full much faster than expected, because objects that are no longer referenced will not be collected automatically.

A method that allocates an object or takes an object that was created in a different memory area and tries to assign it to a field of its associated object can fail. For example, creating a `List` on the heap and adding to it an object from a scoped memory area will most likely cause an exception. Although using other memory areas, such as scoped memory, is useful for helping to improve determinism, its use complicates the logic of application and library code.

On systems that support memory areas other than heap and do not support realtime garbage collection, some global resources must be put in immortal memory. System properties and their `String` values allocated during system initialization shall be allocated in immortal memory. For such a system, class objects should also be stored there. Though this avoids priority inversion with the garbage collector, it can cause higher memory use than expected.

4.2.4.2 Garbage Collection

Garbage collection is an important safety feature of the Java language and runtime environment. Unfortunately, the garbage collection process can interfere with a realtime program's ability to always meet its timing deadlines. This specification provides two main means of circumventing this problem: using a realtime garbage collector or using the memory area module as an alternative to garbage collection for realtime code. Additionally, an implementation may ignore the problem for an environment meant as a development system or for systems that choose not to

provide realtime guarantees. In any case, an implementation must document what realtime guarantees it gives and which methods it uses to do so.

4.2.4.3 Realtime Garbage Collections

Industrial realtime garbage collectors are available with varying approaches to providing realtime response. Though new collectors will undoubtedly be developed, all current ones use a variant of the mark-and-sweep algorithm. In all cases, the collectors are incremental: realtime response is obtained by limiting how much of a collection cycle is done each time the collector runs. Even on a multicore machine, the garbage collector must be incremental, because it must tolerate changes to the heap during garbage collection. Then CPU use is limited by tying the collector to one or more cores.

4.2.4.3.1 Thread-Based Collectors

A realtime thread-based collector is an incremental garbage collector that has its own thread of control and runs at intervals. In this case, the garbage collector needs to be scheduled to ensure that it runs often enough and long enough at each interval to recycle discarded objects fast enough to keep up with allocations. There should also be some maximum time after which the garbage collector can be interrupted.

4.2.4.3.2 Allocation-Based Collectors

A realtime allocation-based garbage collector does not have its own thread of control. Instead, some interval of garbage collection work is done at each allocation. This work is generally a function of the size of the object being allocated. This work becomes part of the execution time of the program. Again, there should be some maximum time after which the garbage collector can be interrupted.

4.2.4.3.3 Alternatives to Garbage Collection

This specification provides an alternative Memory Areas Module for managing memory without garbage collection. An implementation of this specification may provide realtime response by requiring applications to use that module instead of providing a realtime garbage collector. This means that all realtime threads would have to run above the priority of the garbage collector and all communication with conventional threads would have to use some nonblocking protocol.

4.2.4.3.4 Developer Implementation

An implementation that simply provides all the API but no realtime guarantee is also permitted. This is useful as a development environment. Also, many of the APIs are useful event in a conventional Java implementation.

4.3 Rationale

The threading model of conventional Java was never meant for realtime programming. Refinements to the virtual machine and new APIs are necessary to support the additional requirements of applications, which have tasks that must complete in a fixed amount of time. However, to ensure that any conventional Java program can run on a virtual machine or runtime that implements this specification requires careful consideration of each refinement to the Java programming model. Therefore, conventional Java APIs and semantics have been extended, rather than replaced, to facilitate compatibility with conventional Java runtime implementations.

Chapter 5

Realtime Threads

Conventional Java provides a thread class for its tasking model. Tasks can be run simultaneously by creating multiple threads, but they do not provide realtime scheduling semantics. For this, the specification provides a realtime thread class. This class provides for the creation of

- realtime threads that have more precise scheduling semantics than `java.lang.Thread`, and
- realtime threads that have no dependency on the heap.

The `RealtimeThread` class extends `java.lang.Thread`. The `ReleaseParameters`, `SchedulingParameters`, and `MemoryParameters` objects that can be passed to the `RealtimeThread` constructor provide the temporal and processor configuration of the thread to be communicated to the *scheduler*. `ProcessingConstraint` of the Resource Enforcement Module in package `javax.realtime.enforce` provides cost enforcement on groups of tasks. The `ConfigurationParameters` class defines, among other things, the size of Java's thread stack. The `PhasingPolicy` class defines the relationship between the threads start time and its first release time when the start time is in the past.

The `RTSJ` provides two types of objects that implement the `Schedulable` interface: *realtime threads and asynchronous event handlers*. This chapter defines the facilities that are available to realtime threads. In many cases, these functionalities are also available to asynchronous event handlers. In particular,

- the default scheduler must support the scheduling of both realtime threads and asynchronous event handlers;
- realtime threads and asynchronous event handlers are allowed to enter into memory areas and consequently they have associated scope stacks; and
- the flow of control of realtime threads and asynchronous event handlers are affected by the `RTSJ` asynchronous transfer of control facilities.

Where the semantics apply to both realtime threads and asynchronous event handlers, the term *schedulable* will be used.

5.1 Definitions

Exception — Both a mechanism of nonlocal transfer of control and a Java object which carried information about the cause of the control transfer.

Scheduler — A module that manages the execution of tasks, as well as detects deadline misses and monitoring costs.

5.2 Semantics

Instances of `RealtimeThread` have the same semantics as conventional Java threads except as noted below.

1. Garbage collection executing in the context of a Java thread must not in itself block execution of a schedulable with a higher execution eligibility that may not access the heap; however, application locks work as specified even when the lock causes synchronization between a heap-using thread and a schedulable that may not use the heap.
2. Each schedulable has an attribute which indicates whether an `AsynchronouslyInterruptedException` is pending. This attribute is set when a call to `RealtimeThread.interrupt()` is made on the associated realtime thread, when a call is made to the interrupt method in one of the family of asynchronous event handler classes, and when an asynchronously interrupted exception's `fire` method is invoked between the time the schedulable has entered that exception's `doInterruptible` method, and before it has return from `doInterruptible`. (See Chapter 8 on *Asynchrony*.)
3. A call to `Schedulable.interrupt()` generates the system's generic `AsynchronouslyInterruptedException`. (See Chapter 8 on *Asynchrony*.)
4. The `RealtimeThread.waitForNextRelease` method is for use by realtime threads that have periodic or aperiodic release parameters. In the absence of any deadline miss or cost overrun, or an interrupt, the method returns when the realtime thread's next period is due or the next release happens.
5. In the presence of a cost overrun or a deadline miss, the behavior of `waitForNextRelease` is governed by the thread's scheduler.
6. The first release time of a realtime thread is governed by the value of any `start` time in its associated `ReleaseParameter` object and the time at which the `RealtimeThread.start` method is called and the value of any `PhasingPolicy` parameter passed to it.
7. Instances of `RealtimeThread` may not be created with a thread group which is not an instance of `RealtimeThreadGroup`.
8. System-related termination activity (such as execution of finalizers for scoped objects in scoped memory areas that become unreferenced) triggered by termination of a realtime thread is not subject to cost enforcement or deadline miss detection.
9. The scheduling of a realtime thread is governed by its `SchedulingParameters` and its `Scheduler` unless set explicitly with method `setPriority(int)` in `java.lang.Thread`, which causes it to be treated as a conventional java thread until a new `SchedulingParameters` object is set.

5.2.1 Startup Considerations

For efficient system startup, it is sometimes necessary that the Java main thread and all internal system threads have a priority other than `Thread.NORM_PRIORITY`. The core module provides a property for this. When `javax.realtime.start.priority` is set, the initial and main Java threads start with the given priority; otherwise, the default of `Thread.NORM_PRIORITY` is used.

5.3 javax.realtime

5.3.1 Enumerations

5.3.1.1 PhasingPolicy

---

public enum PhasingPolicy

Inheritance

java.lang.Object
  java.lang.Enum<PhasingPolicy>
    PhasingPolicy

Description

This class defines a set of constants that specify the supported policies for starting a periodic thread or periodic timer, when it is started later than the assigned absolute time. The following table specifies the effective start time, that is, the first release time of a periodic realtime thread. The effective start time of a periodic timer is similar; where the first firing is equivalent to the first release, and a call to the constructor is equivalent to a call to `RealtimeThread.start()`.

Since RTSJ 2.0

5.3.1.1.1 Enumeration Constants

ADJUST_IMMEDIATE

```
public static final PhasingPolicy ADJUST_IMMEDIATE
```

Description

Indicates that a periodic thread started after the absolute time given for its start time should be released immediately with the next release one period later.

ADJUST_FORWARD

```
public static final PhasingPolicy ADJUST_FORWARD
```

Description

Indicates that a periodic thread started after the absolute time given for its start time should be released at the next multiple of its period from its start time.

Table 5.1: PhasingPolicy Effect on First Release of a RealtimeThread with PeriodicParameters

	ADJUST IMMEDIATE	ADJUST FORWARD	ADJUST BACKWARD	STRICT PHASING
RelativeTime	The time of start method invocation plus `start` time.	The time of start method invocation plus `start` time.	The time of start method invocation plus `start` time.	The time of start method invocation plus `start` time.
AbsoluteTime, earlier than call to `start`	Release immediately and set next release time to be at the time the start method was invoked plus `period`.	All releases before the time `start` is called are ignored. The first release is at the start time plus the smallest multiple of `period` whose time is after the time `start` was called.	The first release occurs immediately and the next release is at the start time plus the smallest multiple of `period` whose time is after the time `start` was called.	The `start` method throws an exception.
AbsoluteTime, later than call to `start`	First release is at time passed to `start`.	First release is at time passed to `start`.	First release is at time passed to `start`.	First release is at time passed to `start`.
Without Time	First release is at time of start method invocation	First release is at time of start method invocation	First release is at time of start method invocation	First release is at time of start method invocation

ADJUST_BACKWARD

```
public static final PhasingPolicy ADJUST_BACKWARD
```

Description

Indicates that a periodic thread started after the absolute time given for its start time should be released immediately with the next release at the next multiple of its period from its start time.

STRICT_PHASING

```
public static final PhasingPolicy STRICT_PHASING
```

Description

Indicates that a periodic thread started after the absolute time given for its start time should throw the `LateStartException` exception instead of being released.

5.3.1.1.2 Methods

---

values

Signature

```
public static javax.realtime.PhasingPolicy[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.PhasingPolicy
valueOf(String name)
```

Description

5.3.2 Classes

5.3.2.1 ConfigurationParameters

---

public class ConfigurationParameters

Inheritance

java.lang.Object
ConfigurationParameters

Interfaces

`Cloneable`
`Serializable`

Description

Configuration parameters provide a way to specify various implementation-dependent parameters such as the Java stack and native stack sizes, and to configure the statically allocated `ThrowBoundaryError` associated with a `Schedulable`.

Note that these parameters are immutable.

Since RTSJ 2.0

5.3.2.1.1 Constructors

ConfigurationParameters(int, int, int, int, int, long)

Signature

```
public
ConfigurationParameters(int messageLength,
                        int stackTraceDepth,
                        int classNameLength,
                        int methodNameLength,
                        int fileNameLength,
                        long[] sizes)
throws StaticIllegalStateException
```

Description

Creates a parameter object for initializing the state of a `Schedulable`. The parameters provide the data for this initialization. For `RealtimeThread` and bound versions of `AsyncBaseEventHandler`, the stack and message buffers can be set exactly, but for the unbound event handlers, the system cannot give any guarentees to allow thread sharing.

Parameters

`messageLength`—The size of the buffer, in units of `char`, for storing an exception message used by preallocated exceptions and errors thrown in the context of an instance of `Schedulable` which was created with `this` as its configuration parameters. The value `0` indicates that no message should be stored. The value of `-1` uses the system default and is the default when an instance of this class is not provided.

`stackTraceDepth`—The number of stack trace elements, reserved for use by preallocated exceptions and errors thrown in the execution context of the `Schedulable` object created with these parameters. The amount of space this requires is implementation-specific. The value `0` indicates that no stack trace should be stored. The value of `-1` uses the system default and is the default when an instance of this class is not provided.

`classNameLength`—The number of characters reserved in each frame for saving the full class name in a given stack trace frame.

`methodNameLength`—The number of characters reserved in each frame for saving the method signature in a given stack trace frame.

`fileNameLength`—The number of characters reserved in each frame for saving the file name in a given stack trace frame.

`sizes`—An array of implementation-specific values dictating memory parameters for `Schedulable` objects created with these parameters, such as maximum Java and native stack sizes. The `sizes` array will not be stored in the constructed object. The default is system dependent, and indicated by setting this parameter to `null` or by not providing an instance of this class.

JamaicaVM: not yet used.

ConfigurationParameters(long)

Signature

```
public
ConfigurationParameters(long[] sizes)
```

Description

Same as `ConfigurationParameters(int,int,int,int,int,long[])` with arguments `(0, 0, 0, 0, 0, sizes)`.

5.3.2.1.2 Methods

---

setDefault(ConfigurationParameters)

Signature

```
public static synchronized void
setDefault(ConfigurationParameters config)
```

Description

Set the parameters object to be used when none is provided for an instance of `Schedulable`.

Parameters

`config`—the new default parameter object. Setting to `null` restores the default values.

getDefault

Signature

```
public static synchronized javax.realtime.ConfigurationParameters
getDefault()
```

Description

Set the parameters object to be used when none is provided for an instance of `Schedulable`.

Returns

the default parameter object.

setDefaultRunner(ReleaseRunner)

Signature

```
public static synchronized void
setDefaultRunner(ReleaseRunner runner)
throws StaticIllegalArgumentException
```

Description

Sets the system default heap release runner.

Parameters

`runner`—The runner to be used when none is set. When `null`, the default release runner is set to the original system default.

getDefaultRunner

Signature

```
public synchronized javax.realtime.ReleaseRunner
getDefaultRunner()
```

Description

Gets the system default release runner.

Returns

a general runner to be used when none is set.

mayUseHeap

Signature

```
public boolean
mayUseHeap()
```

Description

Determines whether or not this `schedulable` may use the heap.

Returns

`true` only when this configuration may allocate on the heap and may enter the `Heap`.

getMessageLength

Signature

```
public int
getMessageLength()
```

Description

Obtain the size of the buffer dedicated to storing the message of the last thrown throwable in the context of instances of `Schedulable` created with these parameters. The value `0` indicates that no message will be stored.

Returns
reserved memory in units of `char`.

getStackTraceDepth

Signature

```
public int
getStackTraceDepth()
```

Description

Obtain the number of frames available for storing the stack trace of the last thrown throwable in the context of instances of `Schedulable` created with these parameters. The value `0` indicates that no stack trace will be stored.

Returns
reserved memory as number of frames to save.

getClassNameLength

Signature

```
public int
getClassNameLength()
```

Description

Obtain the maximum number of character available for storing class names in each stack trace frame.

Returns
reserved memory in units of `char`.

getMethodNameLength

Signature

```
public int
getMethodNameLength()
```

Description

Obtain the maximum number of character available for storing method signatures in each stack trace frame.

Returns
reserved memory in units of `char`.

getFileNameLength

Signature

```
public int
getFileNameLength()
```

Description

Obtain the maximum number of character available for storing file names in each stack trace frame.

Returns

reserved memory in units of `char`.

getSizes

Signature

```
public long[]
getSizes()
```

Description

Gets the array of implementation-specific sizes associated with `Schedulable` objects created with these parameters. *This method may allocate memory.*

Returns

a copy of the array of implementation-specific sizes or `null` when none are set.

5.3.2.2 RealtimeThread

---

public class RealtimeThread

Inheritance

java.lang.Object
  java.lang.Thread
    RealtimeThread

Interfaces

javax.realtime.BoundSchedulable
javax.realtime.AsyncTimable

Description

Class `RealtimeThread` extends `Thread` and adds access to realtime services such as advanced scheduling, affinity management, asynchronous transfer of control, and access to scope memory.

As with `java.lang.Thread`, there are two ways to create a `RealtimeThread`.

- Create a new class that extends `RealtimeThread` and override the `run()` method with the logic for the thread.
- Create an instance of `RealtimeThread` using one of the constructors with a `logic` parameter. Pass a `Runnable` object whose `run()` method implements the logic of the thread.

Every RealtimeThread is a member of a `RealtimeThreadGroup`, and it is not possible to add a RealtimeThread from within a regular ThreadGroup.

See Section RealtimeThreadGroup

5.3.2.2.1 Constructors

RealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, TimeDispatcher, RealtimeThreadGroup, Runnable)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               MemoryParameters memory,
               MemoryArea area,
               ConfigurationParameters config,
               TimeDispatcher dispatcher,
               RealtimeThreadGroup group,
               Runnable logic)
```

Description

Creates a realtime thread with the given characteristics and a specified `Runnable`. The realtime thread group of the new thread is inherited from its parent task unless `group` is set. The newly-created realtime thread is associated with the scheduler in effect during execution of the constructor.

Since RTSJ 2.0

Parameters

`scheduling`—The `SchedulingParameters` associated with `this` (And possibly other instances of `Schedulable`). When `scheduling` is `null` and the creator is a schedulable, `SchedulingParameters` is a clone of the creator's value created in the same memory area as `this`. When `scheduling` is `null` and the creator is a Java thread, the contents and type of the new `SchedulingParameters` object is governed by the associated scheduler.

`release`—The `ReleaseParameters` associated with `this` (and possibly other instances of `Schedulable`). When `release` is `null` the new `RealtimeThread` will use a clone of the default `ReleaseParameters` for the associated scheduler created in the memory area that contains the `RealtimeThread` object.

`memory`—The `MemoryParameters` associated with `this` (and possibly other instances of `Schedulable`). When `memory` is `null`, the new `RealtimeThread` receives `null` value for its memory parameters, and the amount or rate of memory allocation for the new thread is unrestricted, and it may access the heap.

`area`—The initial `MemoryArea` of this handler.

`config`—The `ConfigurationParameters` associated with `this` (and possibly other instances of `Schedulable`). When `config` is `null`, this `RealtimeThread` will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

`dispatcher`—The `TimeDispatcher` to use for realtime sleep and determining the period of a periodic thread.

`group`—The `RealtimeThreadGroup` of the newly created realtime thread or the parent's realtime thread group when null.

`logic`—The `Runnable` object whose `run()` method will serve as the logic for the new `RealtimeThread`. When `logic` is `null`, the `run()` method in the new object will serve as its logic.

Throws

`StaticIllegalArgumentException`—when the parameters are not compatible with the associated scheduler.

`IllegalAssignmentError`—when the new `RealtimeThread` instance cannot hold a reference to any of the values of `scheduling`, `release`, `memory`, or `group`, when those parameters cannot hold a reference to the new `RealtimeThread`, when the new `RealtimeThread` instance cannot hold a reference to the values of `area` or `logic`, when the initial memory area is not specified and the new `RealtimeThread` instance cannot hold a reference to the default initial memory area, and when the thread may not use the heap, as specified by its memory parameters, and any of the following is true:

- the initial memory area is not specified,
- the initial memory is heap memory,
- the initial memory area, scheduling, release, memory, or group is allocated in heap memory.
- when this is in heap memory, or
- logic is in heap memory.

`ScopedCycleException`—when `memory` is a scoped memory area that has already been entered from a memory area other than the current scope.

`StaticIllegalStateException`—when the `ThreadGroup` of the calling thread is not an instance of `RealtimeThreadGroup` and the argument is `null`.

RealtimeThread(SchedulingParameters, ReleaseParameters, ConfigurationParameters, Runnable)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               ConfigurationParameters config,
               Runnable logic)
```

Description

Creates a realtime thread with the given SchedulingParameters, ReleaseParameters, MemoryArea and a specified Runnable and default values for all other parameters.

This constructor is equivalent to RealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, TimeDispatcher, RealtimeThreadGroup, Runnable) with values scheduling, release, null, null, config, null, null, logic.

Since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters, ConfigurationParameters)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               ConfigurationParameters config)
```

Description

Creates a realtime thread with the given SchedulingParameters, ReleaseParameters and MemoryArea and default values for all other parameters.

This constructor is equivalent to RealtimeThread(scheduling, release, null, null, config, null, null, null).

Since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters, Runnable)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               Runnable logic)
```

Description

Creates a realtime thread with the given SchedulingParameters, ReleaseParameters and a specified Runnable and default values for all other parameters.

This constructor is equivalent to RealtimeThread(scheduling, release, null, null, null, null, null, logic).

Since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release)
```

Description

Creates a realtime thread with the given `SchedulingParameters` and `ReleaseParameters` and default values for all other parameters.

This constructor is equivalent to `RealtimeThread(scheduling, release, null, null, null, null, null, null)`.

RealtimeThread(SchedulingParameters, ReleaseParameters, TimeDispatcher)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               TimeDispatcher dispatcher)
```

Description

Creates a realtime thread with the given `SchedulingParameters`, `ReleaseParameters` and `TimeDispatcher` and default values for all other parameters. This constructor is equivalent to `RealtimeThread(scheduling, release, null, null, null, dispatcher, null, null)`.

Since RTSJ 2.0

RealtimeThread(SchedulingParameters)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling)
```

Description

Creates a realtime thread with the given `SchedulingParameters` and default values for all other parameters.

This constructor is equivalent to `RealtimeThread(scheduling, null, null, null, null, null, null, null)`.

RealtimeThread

Signature

```
public
RealtimeThread()
```

Description

Creates a realtime thread with default values for all parameters. This constructor is equivalent to `RealtimeThread(null, null, null, null, null, null, null, null)`.

5.3.2.2.2 Methods

currentRealtimeThread

Signature

```
public static javax.realtime.RealtimeThread
currentRealtimeThread()
throws ClassCastException
```

Description

Gets a reference to the current instance of `RealtimeThread`.

Calling `currentRealtimeThread` is permissible when control is in an `AsyncEventHandler`. The method will return a reference to the `RealtimeThread` supporting that release of the async event handler.

Throws

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

Returns

a reference to the current instance of `RealtimeThread`.

currentSchedulable

Signature

```
public static javax.realtime.RealtimeThread
currentSchedulable()
throws ClassCastException
```

Description

Gets a reference to the current instance of `Schedulable`. It behaves the same when the current thread is an instance of `java.lang.Thread`, but otherwise it produces an instance of `AsyncBaseEventHandler`.

Throws

`ClassCastException`—when the current execution context is that of a conventional Java thread.

Returns

a reference to the current instance of `Schedulable`.

getCurrentReleaseTime

Signature

```
public static javax.realtime.AbsoluteTime
getCurrentReleaseTime()
```

Description

Gets the absolute time of this thread's last release, whether periodic or aperiodic.

The clock in the returned absolute time shall be the realtime clock for aperiodic releases and the clock used for the periodic release for periodic releases.

Returns

the last release time in a new absolute time instance in the current memory area.

Since RTSJ 2.0

getCurrentReleaseTime(AbsoluteTime)

Signature

```
public static javax.realtime.AbsoluteTime
getCurrentReleaseTime(AbsoluteTime dest)
```

Description

Gets the absolute time of this thread's last release, whether periodic or aperiodic.

The clock in the returned absolute time shall be the realtime clock for aperiodic releases and the clock used for the periodic release for periodic releases.

Parameters

`dest`,—when not `null`, contains the last release time

Returns

the last release time in `dest`. When `dest` is `null`, create a new absolute time instance in the current memory area.

Since RTSJ 2.0

getCurrentConsumption(RelativeTime)

Signature

```
public static javax.realtime.RelativeTime
getCurrentConsumption(RelativeTime dest)
```

Description

Determines the CPU consumption for this release.

Parameters

`dest`,—when not `null`, contains the CPU consumption

Throws

`StaticIllegalStateException`—when the caller is not a `Schedulable`.

Returns

when `dest` is `null`, returns the CPU consumption in a `RelativeTime` instance created in the current execution context.

Since RTSJ 2.0

getCurrentConsumption

Signature

```
public static javax.realtime.RelativeTime
getCurrentConsumption()
```

Description

Determines the CPU consumption for this release.

Throws

`StaticIllegalStateException`—when the caller is not a `Schedulable`.

Returns

the CPU consumption in a `RelativeTime` instance created in the current execution context.

Since RTSJ 2.0

getCurrentMemoryArea

Signature

```
public static javax.realtime.MemoryArea
getCurrentMemoryArea()
```

Description

Gets a reference to the `MemoryArea` object representing the current allocation context. For a task that is not an instance of `Schedulable`, the result can only be heap or immortal memory.

Returns

a reference to the `MemoryArea` object representing the current allocation context.

sleep(HighResolutionTime)

Signature

```
public static void
sleep(HighResolutionTime<?> time)
throws InterruptedException,
       ClassCastException,
       StaticIllegalArgumentException
```

Description

A sleep method that is controlled by a generalized clock. Since the time is expressed as a `HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution available for the clock and even the quantity it measures depends on `clock`. The time base is the given `Clock`. The sleep time may be relative or absolute. When relative, then the calling thread is blocked for the amount of time given by `time`, and measured by `clock`. When absolute, then the calling thread is blocked until the indicated value is reached by

`clock`. When the given absolute time is less than or equal to the current value of `clock`, the call to sleep returns immediately.

Calling `sleep` is permissible when control is in an `AsyncEventHandler`. The method causes the handler to sleep.

This method must not throw `IllegalAssignmentError`. It must tolerate `time` instances that may not be stored in `this`.

Parameters

`time`—The amount of time to sleep or the point in time at which to awaken.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when `time` is `null`, when `time` is a relative time less than zero, or when the `Chronograph` of `time` is not a `Clock`.

suspend(HighResolutionTime)

Signature

```
public static void
suspend(HighResolutionTime<?> time)
throws ClassCastException,
       StaticIllegalArgumentException
```

Description

The same as `sleep(HighResolutionTime)` except that it is not interruptible.

Parameters

`time`—An absolute or relative time until which to suspend.

Throws

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when `time` is `null`, when `time` is a relative time less than zero, or when the `Chronograph` of `time` is not a `Clock`.

Since RTSJ 2.0

spin(HighResolutionTime)

Signature

```
public static void
spin(HighResolutionTime<?> time)
throws InterruptedException,
       ClassCastException,
       StaticIllegalArgumentException
```

Description

Similar to `sleep(HighResolutionTime)` except it performs a busy wait by polling on the `Chronograph` associated with `time` until `time` has been reached. Note that interaction with other tasks, scheduling considerations, and other effects may reduce the frequency of polling for long delays, so an application cannot assume that the associated `Chronograph` will be polled as quickly as possible.

Parameters

`time`—An absolute or relative time at which to stop spinning.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when `time` is `null`, or when `time` is a relative time less than zero.

Since RTSJ 2.0

spin(int)

Signature

```
public static void
spin(int nanos)
throws InterruptedException,
       ClassCastException,
       StaticIllegalArgumentException
```

Description

The same as calling `spin(HighResolutionTime)` with a relative time to the default realtime clock, zero milliseconds, and `nanos` nanoseconds, except no relative time object is necessary.

Parameters

`nanos`—A relative number of nanoseconds to wait.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when `nanos` is less than zero.

Since RTSJ 2.0

waitForNextRelease

Signature

```
public static boolean
waitForNextRelease()
throws StaticIllegalStateException,
       ClassCastException
```

Description

Causes the current realtime thread to delay until the next release. (See `release()`.) Used by threads that have a reference to either periodic or aperiodic `ReleaseParameters`. The first release starts when `this` thread is released as a consequence of the action of one of the `start()` family of methods. Each time this method is called it will block until the next release unless the thread is in a deadline miss condition. In that case, the operation of `waitForNextRelease` is controlled by this thread's scheduler. (See `PriorityScheduler`.)

Throws

`StaticIllegalStateException`—when `this` does not have a reference to a `ReleaseParameters` type of either `PeriodicParameters` or `AperiodicParameters`.

`ClassCastException`—when the current thread is not an instance of `RealtimeThread`.

Returns

either `false` when the thread is in a deadline miss condition or `true` otherwise. When a deadline miss condition occurs is defined by its thread's scheduler.

Since RTSJ 2.0

waitForNextReleaseInterruptible

Signature

```
public static boolean
waitForNextReleaseInterruptible()
throws InterruptedException,
       StaticIllegalStateException,
       ClassCastException
```

Description

Same as `waitForNextRelease()` except it can throw an interrupted exception

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it and the `ReleaseParameters.isRousable()` on its release parameters returns `true`.
An interrupt during `waitForNextPeriodInterruptible()` is treated as a release for purposes of scheduling. This is likely to disrupt proper operation of the periodic thread. The timing behavior of the thread is unspecified until the

state is reset by altering the thread's release parameters or the thread is no longer in a deadline miss state.

`StaticIllegalStateException`—when `this` does not have a reference to a `ReleaseParameters` type of either `PeriodicParameters` or `AperiodicParameters`.

`ClassCastException`—when the current thread is not an instance of `RealtimeThread`.

Returns

either `false` when the thread is in a deadline miss condition or `true` otherwise. When a deadline miss condition occurs is defined by its thread's scheduler.

Since RTSJ 2.0

subsumes(Schedulable)

Signature

```
public boolean
subsumes(Schedulable other)
```

Description

Returns

`true` when and only when this instance of `Schedulable` is more eligible than `other`.

Since RTSJ 2.0

getMemoryArea

Signature

```
public javax.realtime.MemoryArea
getMemoryArea()
```

Description

Obtains the initial memory area for this `RealtimeThread`. When not specified through the constructor, the default is a *reference* to the current allocation context when `this` was constructed.

Returns

a reference to the initial memory area for this thread.

Since RTSJ 1.0.1

getMemoryParameters

Signature

```
public javax.realtime.MemoryParameters
getMemoryParameters()
```

Description

Returns
a reference to the current `MemoryParameters` object.

getRealtimeThreadGroup

Signature

```
public javax.realtime.RealtimeThreadGroup
getRealtimeThreadGroup()
```

Description

Returns
a reference to the associated `RealtimeThreadGroup` object.

Since RTSJ 2.0

getConfigurationParameters

Signature

```
public javax.realtime.ConfigurationParameters
getConfigurationParameters()
```

Description

Returns
a reference to the associated `ConfigurationParameters` object.

Since RTSJ 2.0

getReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
getReleaseParameters()
```

Description

Gets a reference to the `ReleaseParameters` object for this schedulable.

Returns
a reference to the current `ReleaseParameters` object.

getScheduler

Signature

```
public javax.realtime.Scheduler
getScheduler()
```

Description

Returns

a reference to the associated `Scheduler` object.

getSchedulingParameters

Signature

```
public javax.realtime.SchedulingParameters
getSchedulingParameters()
```

Description

Returns

A reference to the current `SchedulingParameters` object.

release

Signature

```
public void
release()
```

Description

Generates a release for this `RealtimeThread`. The action of this release is governed by the scheduler. It may, for instance, act immediately, or be queued, delayed, or discarded. This method does not suspend itself and has a runtime complexity of `O(1)`.

Throws

`StaticIllegalStateException`—when `this` does not have a reference to a `ReleaseParameters` type of `AperiodicParameters`.

Since RTSJ 2.0

interrupt

Signature

```
public void
interrupt()
```

Description

Throws

`IllegalTaskStateException`—when `this` is not currently releasable, i.e., is disabled, not firable, its start method has not been called, or it has terminated.

Since RTSJ 2.0

isInterrupted

Signature

```
public boolean
isInterrupted()
```

Description

Returns

`true` when and only when the generic `AsynchronouslyInterruptedException` is pending.

Since RTSJ 2.0

deschedule

Signature

```
public void
deschedule()
```

Description

Performs any *deschedule* actions specified by this thread's scheduler, either immediately when in `waitForNextRelease()` or the next time the thread enters `waitForNextRelease()`.

Since RTSJ 2.0

reschedule

Signature

```
public void
reschedule()
throws IllegalTaskStateException
```

Description

Gets the thread to the blocked-for-next-release state. This causes the next event to release the thread and `waitForNextRelease` to return. Deadline miss and cost enforcement are re-enabled.

The details of the interaction of this method with `deschedule`, `waitForNextRelease` and `release` are dictated by this thread's scheduler.

Throws

`IllegalTaskStateException`—when the configured `Scheduler` and `SchedulingParameters` for this `RealtimeThread` are not compatible.

Since RTSJ 2.0

startPeriodic(PhasingPolicy)

Signature

```
public void
startPeriodic(PhasingPolicy phasingPolicy)
throws LateStartException,
       IllegalTaskStateException
```

Description

Starts the periodic thread with the specified phasing policy.

Parameters

`phasingPolicy`—The phasing policy to be applied when the start time given in the realtime thread's associated `PeriodicParameters` is in the past.

Throws

`javax.realtime.LateStartException`—when the actual start time is after the assigned start time and the phasing policy is `PhasingPolicy.STRICT_PHASING`.

`IllegalTaskStateException`—when the configured `Scheduler` and `SchedulingParameters` for this `RealtimeThread` are not compatible or the thread is does not have periodic parameters with an absolute start time.

Since RTSJ 2.0

start

Signature

```
public void
start()
throws StaticIllegalStateException
```

Description

Sets up the realtime thread's environment and starts it. The set up might include delaying it until the assigned start time and initializing the thread's memory area stack. (See `ScopedMemory`.) It is never legal to start a thread more than once. In particular, a thread may not be restarted once it has completed execution.

Throws

`StaticIllegalStateException`—when the configured `Scheduler` and `SchedulingParameters` for this `RealtimeThread` are not compatible.

`IllegalTaskStateException`—when the affinity of this RealtimeThread is not compatible with the affinity of the `RealtimeThreadGroup` it belongs.

`IllegalThreadStateException`—when the thread is already started.

Since RTSJ 2.0 adds new exceptions

getEffectiveStartTime

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStartTime()
```

Description

Equivalent to `getEffectiveStartTime(null)`.

Since RTSJ 2.0

getEffectiveStartTime(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStartTime(AbsoluteTime dest)
```

Description

Determines the effective start time of this realtime thread. This is not necessarily the same as the start time in the release parameters.

- When the release parameters' start time is relative, the effective start time is the time of the first release.
- When the release parameters' start time is an absolute time after start() is invoked, the effective start time is the same as the release parameters' start time.
- When the release parameters' start time is an absolute time before start() is invoked, the effective start time depends on the phasing policy.

The default is to set the effective start time equal to the time start() is invoked.

Returns

the effective start time in `dest`. When `dest` is `null`, returns the effective start time in an `AbsoluteTime` instance created in the current memory area.

Since RTSJ 2.0

getMinConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)
```

Description

Gets the minimum CPU consumption measured for any completed release of this schedulable.

Throws

`StaticIllegalStateException`—when the caller is not a `Schedulable`.

Returns

the minimum CPU consumption in `dest`. When `dest` is `null`, it returns the minimum CPU consumption in a `RelativeTime` instance created in the current memory area.

Since RTSJ 2.0

getMinConsumption

Signature

```
public javax.realtime.RelativeTime
getMinConsumption()
```

Description

Equivalent to `getMinConsumption(null)`.

Since RTSJ 2.0

getMaxConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption(RelativeTime dest)
```

Description

Gets the maximum CPU consumption measured for any completed release of this schedulable.

Throws

`StaticIllegalStateException`—when the caller is not a `Schedulable`.

Returns

the maximum CPU consumption in `dest`. When `dest` is `null`, it returns the maximum CPU consumption in a `RelativeTime` instance created in the current memory area.

Since RTSJ 2.0

getMaxConsumption

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption()
```

Description

Equivalent to `getMaxConsumption(null)`.

Since RTSJ 2.0

getDispatcher

Signature

```
public javax.realtime.TimeDispatcher
getDispatcher()
```

Description

Gets the dispatcher responsible for handling sleep requests issued by this thread

See Section Timable.getDispatcher()

Since RTSJ 2.0

mayUseHeap

Signature

```
public boolean
mayUseHeap()
```

Description

Determines whether or not this `schedulable` may use the heap.

Returns

`true` only when this `Schedulable` may allocate on the heap and may enter `HeapMemory`.

Since RTSJ 2.0

fire

Signature

```
public final void
fire()
```

Description

Used by the `Clock` infrastructure to cause a call to `waitForNextRelease` to return.

See Section AsyncTimable.fire()
Since RTSJ 2.0

awaken

Signature

```
public final void
awaken()
```

Description

Used by the `Clock` infrastructure to cause a call to `sleep` to return.

See Section Schedulable.awaken()
Since RTSJ 2.0

setMemoryParameters(MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setMemoryParameters(MemoryParameters memory)
```

Description

Parameters

`memory`—A `MemoryParameters` object which will become the memory parameters associated with `this` after the method call. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `memory` is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and `memory` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `memory`, or when `memory` cannot hold a reference to this schedulable instance.

Returns

`this`

Since RTSJ 2.0 returns itself

setReleaseParameters(ReleaseParameters)

Signature

```
public javax.realtime.Schedulable
setReleaseParameters(ReleaseParameters<?> release)
```

Description

Parameters

`release`—A `ReleaseParameters` object which will become the release parameters associated with this after the method call, and take effect as determined by the associated scheduler. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `release` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `release` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `release` or `release` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is running and the new release parameters are not compatible with the current scheduler.

Returns

`this`

Since RTSJ 2.0 returns itself

setScheduler(Scheduler)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler)
```

Description

Sets the reference to the Scheduler object. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`. If the `Schedulable` is running, its associated `SchedulingParameters` (if any) must be compatible with `scheduler`.

For an instance of `RealtimeThread`, the `Schedulable` is *running* when `RealtimeThread.start()` has been called on it and `RealtimeThread.join()` would block.

Parameters

`scheduler`—A reference to the scheduler that will manage execution of this schedulable. `Null` is not a permissible value.

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null`, or the schedulable's existing parameter values are not compatible with `scheduler`. Also when this schedulable may not use the heap and `scheduler` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `scheduler` or the current `Schedulable` is running and its associated `SchedulingParameters` are incompatible with `scheduler`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

`IllegalTaskStateException`—when `scheduler` has scheduling or release parameters that are not compatible with the new scheduler and this schedulable is running.

Returns

`this`

Since RTSJ 2.0 returns itself

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
             MemoryParameters memoryParameters)
```

Description

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Returns

`this`

Since RTSJ 2.0

setSchedulingParameters(SchedulingParameters)

Signature

```
public synchronized javax.realtime.Schedulable
setSchedulingParameters(SchedulingParameters scheduling)
```

Description

Parameters

`scheduling`—A reference to the `SchedulingParameters` object. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.). When the Affinity is not defined in `scheduling`, then the affinity that will be used is the one of the creating Thread. However, this default affinity will not appear when calling `getSchedulingParameters`, unless explicitly set using this method.

Throws

`StaticIllegalArgumentException`—when `scheduling` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `scheduling` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `scheduling` or `scheduling` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is active and the new scheduling parameters are not compatible with the current scheduler or when the task is

active and the affinity in `scheduling` is not a subset of the affinity of `this` object's `RealtimeThreadGroup` or when the task is active and the affinity in `scheduling` is invalid.

Returns
`this`

Since RTSJ 2.0, method returns a reference to `this`.

5.4 Rationale

Realtime programming requires a scheduling method radically different than what a conventional Java programmer would expect, but most other aspects of thread behavior are the same. Therefore, it is reasonable to model a realtime thread as an extension to a `java.lang.Thread`. The main additions needed are for scheduling control such as release control for asynchronous event handling. Here asynchronous includes periodic releases, since release is asynchronous with regards to the executing code.

The `RTSJ` platform's priority-preemptive dispatching model is very similar to the dispatching model found in the majority of commercial realtime operating systems. The `ReleaseParameters` and `MemoryParameters` provided to the `RealtimeThread` constructor provide a number of common realtime thread types, including periodic threads. However, conventional Java thread scheduling is supported. The realtime priorities are all above the conventional Java priorities to ensure the realtime threads take precedence over normal tasks.

The `MemoryParameters` class is provided with a may-use-heap option in order to enable time-critical schedulables to execute in preference to the garbage collector given appropriate assignment of execution eligibility when `false`. The memory access and assignment semantics of these heapless schedulables are designed to guarantee that the execution of such threads does not lead to an inconsistent heap state.

Chapter 6

Scheduling

Scheduling is a key differentiation between a conventional Java implementation and a realtime Java implementation. Whereas conventional Java implementations relies on some sort of fair scheduling, a realtime Java implementation must provide a realtime scheduler. In a realtime scheduler, ensuring that critical tasks finish on time is more important than overall throughput or fairness.

The scheduler required by this specification is fixed-priority preemptive with at least 28 unique priority levels. At least 28 must be supported by each implementation, but a deployment need not have all 28 active, when not needed by the application. It is represented by the class `FirstInFirstOutScheduler`, a subclass of `PriorityScheduler`, and is called the *base scheduler*. As the name implies, this scheduler does not time-slice threads at a given priority, but rather runs each to completion, so long as no higher priority thread becomes ready to run and no other processor is available for the higher priority thread. In that case, the current thread is preempted by the higher priority thread.

The schedulables required by this specification are denoted by the `Schedulable` interface and include the classes `RealtimeThread` and `AsyncBaseEventHandler` along with its subclasses. The base scheduler assigns processor resources according to the schedulables' release characteristics, execution eligibility, and processing constraint values. Subclasses of these schedulables are also schedulables and behave as these required classes.

The scheduler dispatches a schedulable, that is ready to run, on a CPU. Some systems, such as multicore systems, have more than one CPU to choose from. By default, a ready schedulable would be dispatched on the next available CPU; however, the specification provides an interface, `Affinity`, to control on which sets of CPUs a given schedulable may run.

An instance of the `SchedulingParameters` class contains values of execution eligibility, including affinity. A schedulable is considered to have the execution eligibility represented by the `SchedulingParameters` object currently bound to it. For implementations providing only the base scheduler, the scheduling parameters object is an instance of `PriorityParameters` (a subclass of `SchedulingParameters`).

An instance of the `ReleaseParameters` class or its subclasses, `PeriodicParameters`, `AperiodicParameters`, and `SporadicParameters`, contains values that define a particular release characteristic. A schedulable is considered to have the release

characteristics of a single associated instance of the `ReleaseParameters` class.

For a realtime thread, the scheduler defines the behavior of the realtime thread's `waitForNextRelease` methods. For all `Schedulables`, the scheduler monitors cost overrun and deadline miss conditions based on its release parameters. Release parameters also govern the treatment of the minimum interarrival time for sporadic schedulables.

The `ThreadGroup` class has special significance in an `RTSJ` implementation. As in conventional Java, the maximum priority of a thread is governed in part by its thread group, but the CPU affinity of a thread is also governed by its thread group along with the `Affinity` class. Furthermore, there is an important subclasses: `RealtimeThreadGroup`. This class provides additional means of managing tasks.

An instance of the `RealtimeThreadGroup` provides scheduling constraints for schedulables similar to how a `TheadGroup` does for conventional Java threads. The scheduler and maximum `SchedulingParameters` can be set. A schedulable can only be created in an instance of `RealtimeThreadGroup` or its subclass. Therefore the root thread group and the thread group of the initial thread must both be realtime thread groups in an `RTSJ` implementation.

The `ProcessingConstraint` class is a subclass of `RealtimeThreadGroup`. An instance of the `ProcessingConstraint` class contains values that define a temporal scope for a processing group. When a schedulable has an associated instance of the `ProcessingConstraint` class, it is said to execute within the temporal scope defined by that instance. A single instance of the `ProcessingConstraint` class can be, and typically is, associated with many schedulables. In an implementation that supports cost enforcement, the combined processor demand of all of the schedulables associated with an instance of the `ProcessingConstraint` class must not exceed the values in that instance (i.e., the defined temporal scope). The processor demand is determined by the `Scheduler`.

The scheduling classes provide the necessary support for realtime scheduling. These classes

- enable the definition of schedulables,
- manage the assignment of execution eligibility to schedulable objects,
- manage the execution of instances of the `AsyncBaseEventHandler` and `RealtimeThread` classes,
- assign release characteristics to schedulables,
- assign execution eligibility values to schedulables, and
- manage the execution of groups of schedulables that collectively exhibit additional release characteristics.

6.1 Definitions

Task — A unit of independent execution. In conventional Java, this is a thread. The `Schedulable` interface marks realtime tasks. The classes that implement `Schedulable` are subject to the scheduling behavior of realtime schedulers. Instances of these classes are referred to as *Schedulables* (SO) and provide four principle execution states: *executing*, *eligible-for-execution*, *blocked*, and *descheduled*.

1. *Executing* refers to the state where the schedulable is currently running on a processor.
2. *Blocked* refers to the state where the schedulable is not among those schedulables that could be selected to have their state changed to executing. The blocked state will have a reason associated with it, e.g., blocked-for-I/O-completion, blocked-for-release-event, or blocked-by-cost-overrun.
3. *Eligible-for-execution* refers to the state where the schedulable could be selected to have its state changed to executing.
4. *Descheduled* refers to the state where the schedulable is ineligible to be released.

Each type of schedulable defines its own *release events*, for example, the release events for a periodic schedulable are caused by the passage of time and occur at programmatically specified intervals.

Release — The changing of the state of a schedulable from blocked-for-release-event to eligible-for-execution. When the state of a schedulable is blocked-for-release-event and a release event occurs then the state of the schedulable is changed to eligible-for-execution. Otherwise, a state transition from blocked-for-release-event to eligible-for-execution is queued; this is known as a *pending release*. When the next transition of the schedulable into state blocked-for-release-event occurs, and there is a pending release, the state of the schedulable is immediately changed to eligible-for-execution.

Completion — The changing of the state of a schedulable from executing to blocked-for-release-event. Each completion corresponds to a release. A realtime thread is deemed to complete its most recent release when it terminates.

Deadline — A time before which a schedulable should complete. The i^{th} deadline is associated with the i^{th} release event and a *deadline miss* occurs when the i^{th} completion would occur after the i^{th} deadline.

Deadline Monitoring — The process by which the implementation responds to deadline misses. When a deadline miss occurs for a schedulable object, the deadline miss handler, if any, for that schedulable is released. This behaves as if there were an asynchronous event associated with the schedulable, to which the miss handler was bound, and which was fired when the deadline miss occurred.

Periodic, Sporadic, and Aperiodic — Adjectives applied to schedulables which describe the temporal relationship between consecutive release events. Let R_i denote the time at which a schedulable has had the i^{th} release event occur. Ignoring the effect of release jitter:

1. a schedulable is periodic when there exists a value $T > 0$ such that for all i, $R_{i+1} - R_i = T$, where T is called the period;
2. a schedulable that is not periodic is said to be aperiodic; and
3. an aperiodic schedulable is said to be sporadic when there is a known value $T > 0$ such that for all i, $R_{i+1} - R_i >= T$. T is then called the minimum interarrival time (MIT).

Cost — The maximum amount of CPU time that a schedulable is allowed between a release and its associated completion.

Current CPU Consumption — The amount of CPU time that the schedulable

has consumed since its last release.

Cost Overrun — The time at which a schedulable's current CPU consumption becomes greater than, or equal to, its cost.

Cost Monitoring — The process by which the implementation tracks CPU consumption and responds to cost overruns. When a cost overrun occurs for a schedulable, its cost overrun handler, if any, is released. This behaves as if there were an asynchronous event associated with the schedulable, to which the overrun handler was bound, and which is fired when a cost overrun occurs.

Cost Enforcement — The process by which the implementation ensures that the CPU consumption of a schedulable is no more than the value of the cost parameter in its associated `ReleaseParameters`. (Cost enforcement is an optional facility in an implementation of the `RTSJ`.)

Base Priority — The priority assigned to a task, either in its associated `PriorityParameters` object or by `Thread.setPriority`; the base priority of a Java thread is the priority returned by its `getPriority` method.

Enforced Priority — A priority below the idle priority, which ensures the schedulable has no execution eligibility.

Active Priority — The execution eligibility criterion for the priority-based schedulers. It is the maximum of the *base* (or *enforced priority*) and any priority a task has acquired due to the action of priority inversion avoidance algorithms (see the *Synchronization Chapter).*

Processing Group — A collection of tasks whose combined execution has further execution time constraints which the scheduler uses to govern the group's execution eligibility.

Base Scheduler — An instance of the `FirstInFirstOutScheduler` class as defined in this specification. This is the initial default scheduler.

Round-Robin Scheduler — An instance of the `RoundRobinScheduler` class as defined in this specification. It is specified to execute in tandem with the base scheduler in a predictable fashion.

Processor — A logical processing element that is capable of physically executing a single thread of control at any point in time. Hence, multicore platforms have multiple processors, platforms that support hyperthreading also have more than one processor. It is assumed that all processors are capable of executing the same instruction sets.

Affinity — A set of processors, where a valid affinity is a set on which the global scheduling of a schedulable can be supported.

Idle Task — A notional system or VM-provided task that consumes all CPU time not used by other tasks. It may be an actual process or thread, or it may be a power-saving mode that halts or slows the CPU, or it may be an artificial construction. For the purposes of this specification, it has a priority below that of all nonblocked tasks and above that of tasks blocked due to cost overrun. Details of its implementation are not specified here.

6.2 Semantics

Scheduling semantics determines when each task runs. Both *The Java Virtual Machine Specification*[6] and *The Java Language Specification*[5] are silent on the semantics for scheduling; only the semantics for synchronization is provided. Since scheduling is central to realtime programming, its detailed semantics, applicable across all available scheduler algorithms, is defined below, along with definitions of the required scheduling algorithms. Semantics that apply to particular classes, constructors, methods, and fields can be found in the class description and the constructor, method, and field detail sections.

6.2.1 Schedulers

There are four basic requirements for schedulers.

1. A scheduler may only change the execution eligibility of the schedulables which it manages and only in accordance with its scheduling algorithm.
2. Each scheduler provided for application code by an `RTSJ` implementation must have documentation describing its semantics including at least the following: the algorithm used to determine eligibility, what schedulables may be scheduled by it, the subclasses of `Scheduler` and `SchedulingParameters` used to control the scheduler, and any other classes needed by the scheduler.
3. Every implementation must provide a round-robin scheduler and a first in first out scheduler using priorities above the ten (1–10) conventional Java priorities as documented below.
4. Tasks with a conventional Java priority (1–10) must be scheduled such that when two or more threads run at the same priority, one thread cannot block another indefinitely or violate the requirements dictated by `java.lang.Thread`.
5. Tasks with a conventional Java priority must be scheduled using some sort of fair scheduler such that higher-priority Java tasks cannot starve lower-priority Java tasks indefinitely.

6.2.1.1 Affinity

For systems that support more than a single processor, one often needs to control what may run on each processor. The `Affinity` class provides a mean of expressing these sets of processors. Affinity has three uses: to inform a scheduler on what processors a task may run, to show what subsets of processors on a system a scheduler may use, and to limit what processors a set of tasks may use.

To this end, valid affinities define a distinguished subset of all possible affinities. These are implementation defined and may even be specifiable for each run of a JVM. They can be used either to reflect the scheduling arrangement of the underlying OS or they can be used by the system designer to impose defaults for groups of task. A program is only allowed to dynamically create new valid affinities with cardinality of one. This restriction reflects the concern that not all operating systems will support multiprocessor affinities.

A valid set is used to show on what subsets of processors a task may run and only members of this set may be used in the `SchedulingParameters` given to a

task. Others sets may be created, but may only be used to limit general processor availability. For example, a RealtimeThreadGroup has an affinity for this purpose.

Tasks are subject to both their own processor affinity and the one of their realtime thread group. A task's affinity must be a valid affinity and also a subset of the affinity of its realtime thread group.

Ordinarily, a task inherits its affinity from its creator unless the creator is an unbound instance of AsyncBaseEventHandler, since such an instance has no affinity. A task created by an unbound instance of AsyncBaseEventHandler inherits its affinity from the thread running the handler. An instance of Schedulable can receive a different affinity, so long as that affinity is subsumed by that of its closest enclosing RealtimeThreadGroup.

In the case of an instance of BoundSchedulable, the affinity can be assigned by specifying an affinity in the SchedulingParameters. Otherwise, it defaults to that of the thread current during creation as stated above.

The affinity of a task can only be changed via setting the task's SchedulingParameters. It may only be changed when the thread is not running. The affinity must be valid and compatible with the RealtimeThreadGroup in which the task is a member when the task is started. In other words, the intersection of the affinity of the group and the task may not be empty or an invalid affinity. When the ThreadGroup is set, but not the affinity, there is a danger that the default affinity will not be compatible with the affinity of that ThreadGroup.

In this case a thread is started with an invalid or incompatible affinity, as describe above, a ProcessorAffinityException will be thrown when the thread is started. In the case of an AsyncBaseEventHandler, this exception is thrown when the handler is added to an event under the same condition. Thus the effective affinity of a task must be a valid affinity for that task to run.

6.2.1.2 Parameter Values

A scheduler uses the values contained in the different parameter objects associated with a schedulable to control the behavior of the schedulable. The scheduler determines what values are valid for the schedulables it manages, which defaults apply and how changes to parameter values are acted upon by the scheduler. Invalid parameter values result in exceptions, as documented in the relevant classes and methods.

1. The default values for all schedulers are as follows, unless otherwise stated.
   (a) Scheduling parameters are copied from the creating schedulable when possible; when the creating schedulable does not have scheduling parameters, the default is an instance of the default parameters for the prevailing scheduler when the schedulable starts.
   (b) The default for release parameters depend on the type of schedulable:
      i. for instance of RealtimeThread, the default is an instance of BackgroundParameters with default values (see AperiodicParameters), and
      ii. for instance of AsyncBaseEventHandler the default is an instance of aperiodic parameters with default values (see AperiodicParameters).
2. Memory parameters default to null which signifies that memory allocation by the schedulable is not constrained by the scheduler.

3. The default scheduling parameters are scheduler dependent.
4. All numeric or `RelativeTime` attributes in parameter values must be greater than or equal to zero.
5. Values of period must be greater than zero.
6. Changes to scheduling, release, memory, and processing group parameters, either by methods on the schedulables bound to the parameters or by altering the parameter objects themselves, potentially modify the behavior of the scheduler with regard to those schedulables. When such changes in behavior take effect depends on the parameter in question, and the type of schedulable, as described below.
7. When changes to a parameter type—scheduling, release, memory, and processing group—take effect depends on the parameter type.
   (a) Changes to scheduling parameters take effect according to rules defined by the associated `Scheduler`.
   (b) Changes to release parameters depend on the parameter being changed, the type of release parameter object, and the type of schedulable.
      i. Changes to the deadline and the deadline miss handler take effect at each release event as follows: when the i_{th} release event occurred at a time t_i, then the i^{th} deadline is the time $t_i + D_i$, where D_i is the value of the deadline stored in the schedulable's release parameters object at the time t_i. When a deadline miss occurs then it is the deadline miss handler that was installed in the schedulable's release parameters at time t_i that is released.
      ii. Changes to cost and the cost overrun handler take effect immediately.
      iii. Changes to the period and start time values in `PeriodicParameters` objects are described in "Release of a Realtime Thread" below.
      iv. Changes to the additional values in `ReleaseParameters` objects and `SporadicParameters` are described, respectively, in "General Release Control" and "Sporadic Release Control", below.
      v. Changes to the type of release parameters object generally take effect after completion, except as documented in the following sections.
   (c) Changes to memory parameters take effect immediately.
   (d) Changes to processing group parameters take effect as described in "Processing Groups" below.
   (e) Changes to the scheduler responsible for a schedulable object take effect at completion.
   (f) Changes to cost enforcement state, i.e., enabling or disabling cost enforcement on a processing group or release parameters object associated with one or more schedulables, take effect at the next release of the associated `ProcessingConstraint` or associated `Schedulable`, respectively.

6.2.1.3 Release Control

Schedulables are released in response to the occurrence of events, such as starting a realtime thread, calling the `release` method of a realtime thread, or firing the asynchronous event associated with an asynchronous event handler. The occurrence of these events, each of which is a potential release event, is termed an *arrival*, and

the time that they occur is termed the *arrival time*. The only difference between a periodic and an aperiodic event is the regularity of the arrival times.

A scheduler behaves effectively as if it maintained a queue, called the arrival time queue, for each schedulable object. This queue maintains information related to each release event, including any parameters passed with the release mechanism, from its "arrival" time until the associated release completes, or another release event occurs, whichever is later. When an arrival is accepted into the arrival time queue, then it is a release event and the time of the release event is the arrival time. The initial size of this queue is an attribute of the schedulable's aperiodic parameters, and is set when an aperiodic parameter object is first associated with the schedulable. Over time, the queue may become full and its behavior in this situation is determined by the queue overflow policy specified in the schedulable's aperiodic parameters. The enumeration class `QueueOverflowPolicy` defines four overflow policies.

Policy	Action on Overflow
`IGNORE`	Silently ignore the arrival. The arrival is not accepted, no release event occurs, and, when the arrival was caused programmatically, such as by invoking `fire` on an asynchronous event, the caller is not informed that the arrival has been ignored.
`EXCEPT`	Throw an `ArrivalTimeQueueOverflowException`. The arrival is not accepted, and no release event occurs, but when the arrival was caused programmatically, the caller will have `ArrivalTimeQueueOverflowException` thrown.
`REPLACE`	The arrival replaces the latest release in the queue, when there is one, but no new release event occurs. When the completion associated with the last release event in the queue has not yet occurred, and the deadline has not been missed, the release event time for that release event is replaced with the arrival time of the new arrival and any associated parameters overwritten. This will alter the deadline for that release event. When the deadline has already been missed or the queue length is zero, the behavior of the `REPLACE` policy is equivalent to the `IGNORE` policy.
`SAVE`	Behave effectively as if the queue were expanded as necessary to accommodate the new arrival. This expansion is permanent. The arrival is accepted and a release event occurs.
`DISABLE`	No queuing takes place. All incoming events increment the pending fire or release count. I may only be used where there is no payload and the release parameters are not sporadic.

Changes to the queue overflow policy take effect immediately. When an arrival occurs, and the queue is full, the policy applied is the policy as defined at that time.

6.2.1.3.1 Sporadic Release Control

"Sporadic Release Control" is a special case of "Release Control," where the arrival time or execution time may be additionaly regulated. Sporadic parameters include a minimum interarrival time (MIT) which characterizes the expected frequency of releases. When an arrival is accepted, the implementation behaves as if it calculates the earliest time at which the next arrival could be accepted, by adding the current MIT to the arrival time of this accepted arrival. The scheduler guarantees that each sporadic schedulable it manages, is released at most once in any MIT.

Two mechanisms are specified for enforcing this rule: *arrival-Time regulation* and *release-time regulation*. Arrival-time regulation controls the work-load by considering the time between arrivals. When a new arrival occurs earlier than the expected next arrival time then a MIT violation has occurred, and the scheduler acts to prevent a release from occurring that would break the "one release per MIT" guarantee. Release-time regulation controls when events are released. Under this policy all arrivals that can be queued under the current `QueueOverflowPolicy` are accepted, but the scheduler behaves effectively as if released schedulables were further constrained by a scheduling policy that restricts releases to at most one release per MIT. As described in the following tables, three types of arrival-time regulation and one type of release-time regulation are supported.

Arrival-Time Regulation	
Policy	**Action on Violation**
IGNORE	Silently ignore the violating arrival. The arrival is not accepted, no release event occurs, and, when the arrival was caused programmatically (such as by invoking `fire` on an asynchronous event), the caller is not informed that the arrival has been ignored.
EXCEPT	Throw a `MITViolationException`. The arrival is not accepted, and no release event occurs, but when the arrival was caused programmatically, the caller will have `MITViolationException` thrown.
REPLACE	The arrival is not accepted and no release event occurs. When the completion associated with the last release event in the queue has not yet occurred, and the deadline has not been missed, then the release event time for that release event is replaced with the arrival time of the new arrival and any associated parameters overwritten. This will alter the deadline for that release event. When the completion associated with the last release event has occurred, or the deadline has already been missed, the behavior of the REPLACE policy is equivalent to the IGNORE policy.

Release-Time Regulation	
Policy	**Action on Violation**
SAVE	The arrival time is delayed until after the current MIT interval. This policy is only able to delay the effective release of a schedulable. The deadline of each release event is always set relative to its arrival time. This policy might not schedule the effective release of an asynchronous event handler until after its deadline has passed. In this case, the deadline miss handler is released at the deadline time even though the related asynchronous event has not yet reached its effective release. Once an arrival is queued, the SAVE policy makes no direct use of the next expected arrival time, but it maintains the value in case the MIT violation policy is changed from SAVE to one of the arrival-time regulation policies.

The *effective release time* of a release event i is the earliest time that the handler can be released in response to that release event. It is determined for each release event based on the MIT policy in force at the release event time.

1. For IGNORE, EXCEPT and REPLACE the effective release time is the release event time.
2. For SAVE the effective release time of release event i is the effective release time of release event *i-1* plus the current value of the MIT.

The scheduler will delay the release associated with the release event at the head of the arrival time queue until the current time is greater than or equal to the effective release time of that release event.

Changes to minimum interarrival time and the MIT violation policy take effect immediately, but only affect the next expected arrival time, and effective release time, for release events that occur after the change.

6.2.1.3.2 Releasing a Realtime Thread

The repeated release of a realtime thread is achieved by executing in a loop and invoking the `RealtimeThread.waitForNextRelease`[1] methods, or its interruptible equivalent `RealtimeThread.waitForNextReleaseInterruptible)` within that loop. For simplicity, unless otherwise stated, the semantics in this section apply to both forms of this method.

1. A realtime thread's release characteristics are determined by the following:
   (a) the invocation of the realtime thread's `start` method and the value of its phasing policy parameter (if applicable);
   (b) the action of the `RealtimeThread` methods `waitForNextRelease`, `schedule`, and `deschedule`;
   (c) the occurrence of deadline misses and whether or not a miss handler is installed; and

[1]The method `RealtimeThread.waitForNextPeriod` has been replaced by `RealtimeThread.waitForNextRelease` as of `RTSJ` 2.0. The same goes for its interruptible equivalent.

   (d) whether the passing of time generates periodic release events or calls to the `release` method generates aperiodic release events.

2. The *initial release event* depends on the type of release parameters given the realtime thread:
   (a) for a realtime thread with periodic parameters, the *initial release event* occurs in response to the invocation of its `start` method in accordance with the start time specified in its release parameters and its assigned phasing policy—see `PeriodicParameters` and `PhasingPolicy`;
   (b) For a realtime thread with aperiodic parameters, the *initial release event* occurs immediately in response to the invocation of its `start` method.
3. Changes to the start time in a realtime thread's `PeriodicParameters` object only have an effect on its initial release time. Consequently, when a `PeriodicParameters` object is bound to multiple realtime threads, a change in the start time may affect all, some or none, of those threads, depending on whether or not `start` has been invoked on them.
4. When subsequent release events occur also depends on the type of release parameters given to the realtime thread:
   (a) for periodic realtime threads, each period (and hence each release) falls due, except as described below (in 6d), at regular intervals such that when the i^{th} release event occurred at a time t_i, the $i+1$ release event occurs at the time $t_i + T_i$, where T_i is the value of the period stored in the realtime thread's `PeriodicParameters` object at the time t_i;
   (b) for aperiodic realtime threads, a release occurs with each call of the release method, except as described below (in 6d); and
   (c) for sporadic realtime threads, a release occurs with each call of the release method, except, as described below (in 6d), when additional regulation is required to enforce MIT as defined in *Sporadic Release Control* below.
5. Each release of an aperiodic realtime thread is an arrival.
   (a) When the thread has release parameters of type `ReleaseParameters`, then the arrival may become a release event for the thread according to the semantics given in "General Release Control" below.
   (b) When the thread has release parameters of type `SporadicParameters`, then the arrival may become a release event for the thread according to the semantics given in "Sporadic Release Control" below.
6. The implementation should behave effectively as if the following state variables were added to a realtime thread's state,
   boolean `deschedule`,
   integer `pendingReleases`,
   integer `missCount`, and
   boolean `lastReturn`;
   and manipulated by the actions as described below.
   (a) Initially
   `deschedule` = false,
   `pendingReleases` = 0,
   `missCount` = 0, and
   `lastReturn` = true.

(b) The function of the `deschedule` method depends on the current state of the realtime thread.
   i. When current state is a blocked state, either blocked-for-release-event or blocked-for-missed-release, it sets the value of `deschedule` to `true` and sets the thread's state to descheduled.
   ii. When the current state is not a blocked state, it just sets the value of `deschedule` to `true`.

(c) The function of the `reschedule` method also depends on the current state of the realtime thread.
   i. When the realtime thread is in the descheduled state, it sets the value of `deschedule` to `false`, sets the values of `pendingReleases` and `missCount` to zero, changes the thread's state to blocked-for-release-event, and tells the cost monitoring and enforcement system to reset for this thread.
   ii. When the realtime thread is *not* in the Descheduled state, it just sets the value of `deschedule` to `false`.

(d) A realtime thread that is in the descheduled state will not receive any further release events until after it has been rescheduled by a call to `reschedule`; this means that no deadline misses can occur.

(e) What happens when a release event occurs depends on the current state.
   i. When the state of the realtime thread is descheduled, do nothing.
   ii. When the state is blocked-for-release-event, i.e., it is waiting in `waitForNextRelease`, increment the value of `pendingReleases`, inform cost monitoring and enforcement that the next release event has occurred, and notify the thread to make it eligible for execution;
   iii. Otherwise, when the thread is in a release, increment the value of `pendingReleases`, and inform cost monitoring and enforcement that the next release event has occurred.

(f) On each deadline miss, one of two things happen:
   i. when the realtime thread has a deadline miss handler, the value of `deschedule` is set to `true`, the handler is atomically released with its `fireCount` increased by the value of `missCount + 1`, and zero for `missCount`;
   ii. otherwise, one is added to the `missCount` value.

(g) When the `waitForNextRelease` method is invoked by the current realtime thread there are three possible behaviors depending on the value of `missCount` and `lastReturn`.
   i. When `missCount` is zero, any pending parameter changes are applied, cost monitoring and enforcement are informed of completion, and then the thread waits while `deschedule` is `true`, or `pendingReleases` is zero. Then the `lastReturn` value is set to `true`, `pendingReleases` is decremented, and `true` is returned.
   ii. When `missCount` is greater than zero and the `lastReturn` value is `false`, completion occurs: the `missCount` value is decremented; then any pending parameter changes are applied, `pendingReleases` is decremented, cost monitoring and enforcement is informed that the

realtime thread has completed, and `false` is returned;

iii. Otherwise, when `missCount` is greater than zero and the `lastReturn` value is `true`, the `missCount` value is decremented and the `lastReturn` value is set to `false` and `false` is returned.

7. An invocation of the `RealtimeThread.waitForNextRelease` method with release parameters, where `ReleaseParameters.isRousable` returns `true`, behaves as described above with the following differences.
   (a) When the invocation commences with an instance of `AsynchronouslyInterruptedException` (AIE) is pending on the realtime thread, then the invocation immediately completes abruptly by throwing that pending instance as an `InterruptedException`. When this occurs, the most recent release has not completed. When the pending instance is the generic AIE instance, then the interrupt state of the realtime thread is cleared.
   (b) What happens when an instance of AIE becomes pending on a realtime thread is dependent on the state of the thread.
      i. When the thread is descheduled, the AIE remains pending until the realtime thread is no longer descheduled. The associated reschedule acts as a release event. Execution then continues as in 7c where the time value used as t_{int} is the time at which the schedulable was rescheduled.
      ii. When it is blocked-for-release-event, then this acts as a release event. Execution then continues as in 7c, where the time value used as t_{int} is the time at which the AIE becomes pending.
   (c) i. The realtime thread is made eligible for execution.
      ii. Upon execution, the invocation completes abruptly by throwing the pending AIE instance as an `InterruptedException`. When the pending instance is the generic AIE instance, the interrupt state of the realtime thread is cleared.
      iii. The deadline associated with this release is the time t_{int}+D_{int}, where D_{int} is the value of the deadline stored in the realtime thread's release parameters object at the time t_{int}.
      iv. The next release time for the realtime thread will be t_{int}+T_{int}, where T_{int} is the value of the period stored in the realtime thread's release parameters object at the time t_{int}.
      v. Cost monitoring and enforcement is informed of the release event.

   When the thrown AIE instance is caught, the AIE becomes pending again (as per the usual semantics for AIE) until it is explicitly cleared.
8. Changes to release parameter types are treated as a pseudo RESTART of the realtime thread and
   (a) any old pending releases are cleared,
   (b) any old arrival queue is flushed,
   (c) any outstanding call to deschedule is cleared, and
   (d) any outstanding deadline misses are cleared.
9. The effect of the change on the thread falls into one of four main cases.
   (a) When the realtime thread is not waiting for the next release event and is not descheduled,

i. there is no effect until the end of current release, and
ii. when the change occurs, it is a pseudo restart of the thread, i.e., when the new parameters are aperiodic, the release is immediate and when the parameters are periodic, the periodic start time algorithm is used.

(b) When the realtime thread is not waiting for the next release event, but there is an outstanding deschedule,
i. there is an immediate "schedule" of the thread,
ii. there is no further effect until end of current release, and
iii. when change occurs, it is a pseudo restart of the thread, i.e., when the new parameters are aperiodic, the release is immediate, and when the new parameters are periodic, the periodic start time algorithm is used.

(c) When the realtime thread state is blocked-for-release-event, i.e., it is waiting in `waitForNextRelease`, and the release parameter type is changed,
i. from Periodic to Aperiodic, at the next periodic release event occurs, the thread becomes aperiodic with an immediate release, or
ii. from Aperiodic to Periodic, there is an immediate pseudo restart of the thread using the periodic start time algorithm.

(d) When the realtime thread state is descheduled and the of release parameters is changed,
i. the change is from Periodic to Aperiodic, there is an immediate "schedule" of the thread, and when the next periodic release event occurs, the thread becomes aperiodic with an immediate release, or
ii. the change is from Aperiodic to Periodic, there is an immediate "schedule" of the thread and there is an immediate pseudo restart of the thread using the periodic start time algorithm.

6.2.1.3.3 UML Diagrams for Realtime Thread Releases

The three UML diagrams in Figures 6.1, 6.2, and 6.3, are provided to illustrate the foregoing rules for releasing realtime threads. The first two figures are for a thread without a deadline miss handler. The first is a UML sequence diagram of some examples of Realtime Thread releases. The second is a UML state chart of the release process for a realtime thread. The third is a UML state chart of the release process for a realtime thread with a deadline miss handler.

In Figure 6.1, a yellow background marks the execution of a normal release, an orange background marks the execution of a miss handler, and a red background marks the execution of a missed release. Both the miss handler and all missed releases are eligible to run as soon as the previous release is finished. A normal release, which encounters a deadline miss during its execution, is not complete until its miss handler completes.

In the other two figures, a yellow background marks releases and a pink background marks blocked states. There are three release states: normal release, miss handler, and missed release. They can only be left by a call to `waitForNextRelease` or its equivalent. The miss handler state is part of a normal release that misses its deadline during the release. There are two blocked-for-release-event states: blocked for normal

Figure 6.1: Sequence Diagram of Some Example Realtime Thread Releases

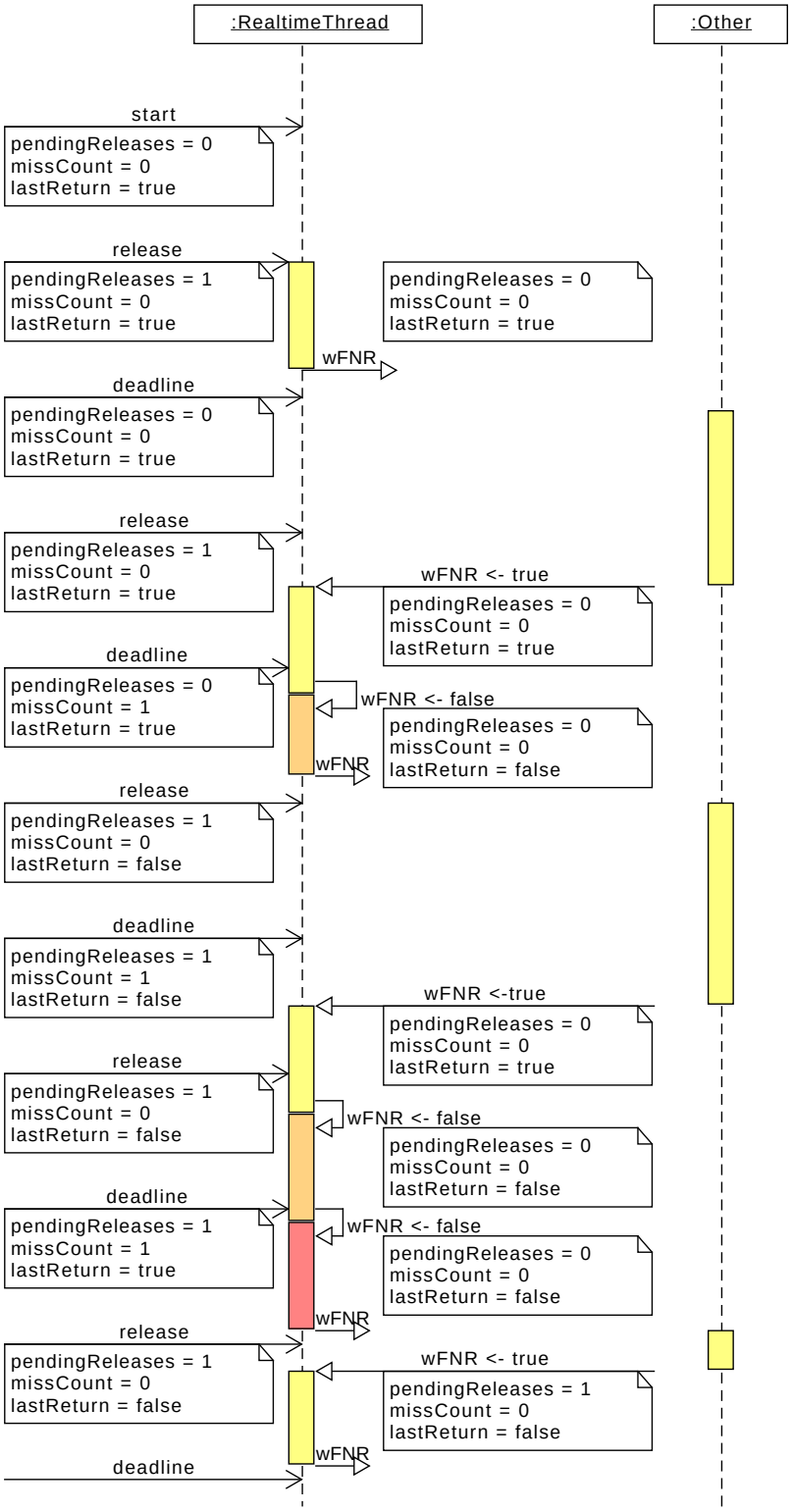
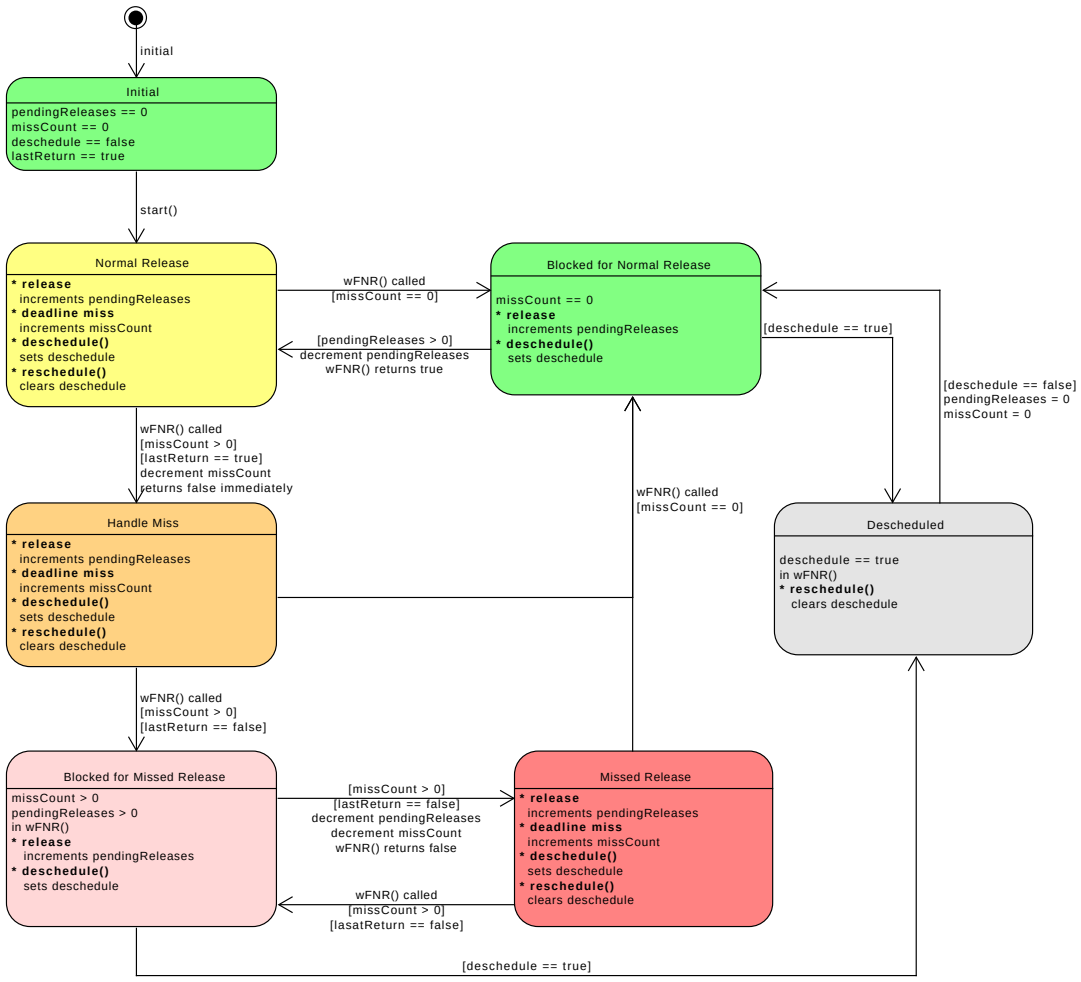
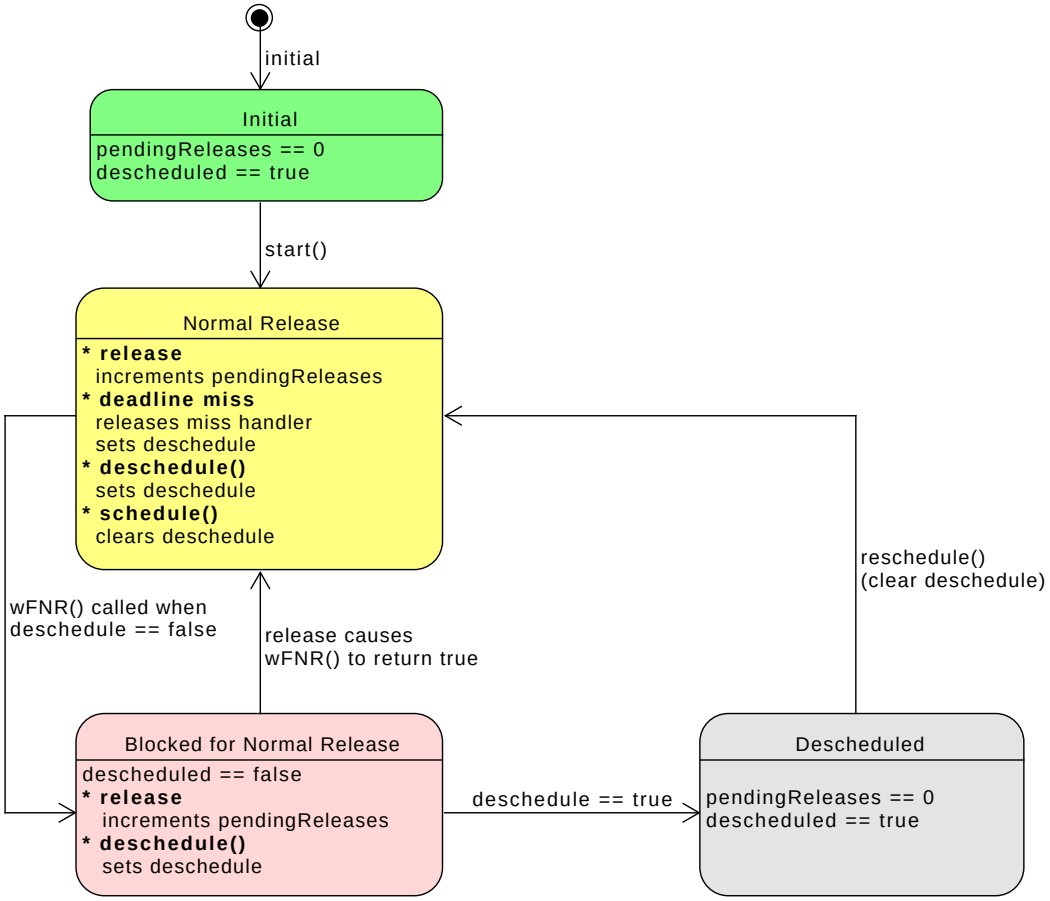


Figure 6.2: A State Chart for a Realtime Thread without a Deadline Miss Handler



release and blocked for missed release. It is only in these states that rescheduling can occur, because only completion occurs upon their entry. In addition, the blocked for missed release is a ephemeral state, since the deadline miss has already occurred before the state is entered, so state is left immediately. It is there to enable all actions that occur on completion.

Figure 6.3: A State Chart for a Realtime Thread with a Deadline Miss Handler



6.2.1.3.4 Releasing an Asynchronous Event Handlers

Asynchronous event handlers can be associated with one or more asynchronous events. When an asynchronous event is fired, all handlers associated with it are released, according to the semantics below.

1. Each firing of an associated asynchronous event is an arrival. Unless the handler has release parameters of type `SporadicParameters`, the arrival becomes a release event for the handler in strict accordance with the semantics given in "General Release Control" above. When the handler has release parameters of type `SporadicParameters`, the arrival becomes a release event for the handler in strict accordance with the semantics given in "Sporadic Release Control" above.
2. For each release event that occurs for a handler, an entry is made in the arrival-time queue and the handler's `fireCount` is incremented by one.
3. Initially, a handler is considered to be blocked-for-release-event and its `fireCount` is zero.
4. Releases of a handler are serialized by having its `handleAsyncEvent` method

invoked repeatedly while its `fireCount` is greater than zero:

   (a) before invoking handleAsyncEvent, the `fireCount` is decremented and the front entry (when still present) removed from the arrival-time queue;
   (b) each invocation of `handleAsyncEvent`, in this way, is a release;
   (c) the return from `handleAsyncEvent` is the completion of a release; and
   (d) processing of any exceptions thrown by `handleAsyncEvent` occurs prior to completion.

5. The deadline for a release is relative to the release event time and determined at the release event time according to the value of the deadline contained in the handler's release parameters. This value does not change, except as described previously for handlers using a REPLACE policy for MIT violation or arrival-time queue overflow.
6. The application code can directly modify the `fireCount`.

   (a) The `getAndDecrementPendingFireCount` method decreases the `fireCount` by one (when it is greater than zero), and returns the old value. This removes the front entry from the arrival-time queue but otherwise has no effect on the scheduling of the current schedulable, nor the handler itself. Any data parameter passed with the associated fire request is lost.
   (b) The `getAndClearPendingFireCount` method is functionally equivalent to invoking `getAndDecrementPendingFireCount` until it returns zero, and returning the original `fireCount` value. Any data parameters passed with the associated fire requests are lost.

7. The scheduler may delay the invocation of `handleAsyncEvent` to ensure that the effective release time honors any restrictions imposed by the MIT violation policy, when applicable, of that release event.
8. Cost monitoring and enforcement for an asynchronous event handler interacts with release events and completions as previously defined with the added requirement that at the completion of `handleAsyncEvent`, when the `fireCount` is now zero, the cost monitoring and enforcement system is told to reset for this handler.
9. The value of `ReleaseParameters.isRousable` controls whether a call to `Schedulable.interrupt` causes a premature release or only affects a running schedulable.

   (a) When interrupt is called on an instance of `Schedulable` and the schedulable is running, the interrupt is made pending and as soon as AI code is entered, an AIE is thrown.
   (b) Depending on the value of the isRousable property, start will prematurely complete, i.e., start user code, or simply wait for the start time to occur.
   (c) Depending on the value of the isRousable property, the next release of a firable handler, i.e., an enabled instance of `AsyncBaseEventHandler` which is attached to an instance of `AsyncBaseEvent`, will occur immediately or not, but in both cases an AIE will be pending until the next AI method.

6.2.1.4 Dispatching

The execution scheduling semantics described in this section are defined in terms of a conceptual model that contains a set of queues of schedulables that are eligible for execution. There is, conceptually, one queue for each scheduler eligibility on each processor. No implementation structures are necessarily implied by the use of this conceptual model. It is assumed that no time elapses during operations described using this model, and therefore no simultaneous operations are possible.

The `RTSJ` dispatching model specifies its dispatching rules in terms of task priority for priority schedulers, but other schedulers should act similarly with respect to their own scheduler eligibility levels.

1. A `Schedulable` can become an executing schedulable only when it is eligible for execution and one of the processors in its associated affinity is available.
2. When two schedulables have different active priorities and request the same processor, the schedulable with the higher active priority will always execute in preference to the schedulable with the lower value when both are eligible for execution.
3. Processors are allocated to schedulables based on each schedulable's active priority and their associated affinity.
4. Schedulable dispatching is the process by which one ready schedulable is selected for execution on a processor. This selection is done at certain points during the execution of a schedulable called *schedulable dispatching points*.
5. A schedulable reaches *a schedulable dispatching point* whenever it becomes blocked, when it terminates, or when a higher priority schedulable becomes ready for execution on its processor. That is, a schedulable that is executing will continue to execute until it either blocks, terminates or is preempted by a higher-priority schedulable.
6. The dispatching policy is specified in terms of ready queues and schedulable states. The ready queues are purely conceptual; there is no requirement that such lists physically exist in an implementation. A ready queue is an ordered list of ready schedulable objects. The first position in a queue is called the head of the queue, and the last position is called the tail of the queue.
7. A schedulable is ready when it is in a ready queue, or when it is running. Each processor has one ready queue for each priority value. At any instant, each ready queue of a processor contains exactly the set of schedulables of that priority that are ready for execution on that processor, but are not running on any processor; that is, those schedulables that are ready, are not running on any processor, and can be executed using that processor.
8. Each processor has one running schedulable, which is the schedulable currently being executed by that processor. Whenever a schedulable running on a processor reaches a schedulable dispatching point, a new schedulable object is selected to run on that processor. The schedulable selected is the one at the head of the highest priority nonempty ready queue for that processor; this schedulable is then removed from all ready queues to which it belongs.
9. In a multiprocessor system, a schedulable can be on the ready queues of more than one processor. At the extreme, when several processors share the same set of ready schedulables, the contents of their ready queues are identical, and so

they can be viewed as sharing one ready queue, and can be implemented that way. Thus, the dispatching model covers multiprocessors where dispatching is implemented using a single ready queue, as well as those with separate dispatching domains.

10. The dispatching mechanism must enable the preemption of the execution of schedulables and Java threads with a bounded delay at a point not governed by the preempted object. The bound on this delay may be implementation-defined, and could be the time to the next point in execution that the heap is in a consistent state or some similar restriction. The implementation should document this bound.
11. A schedulable that is preempted by a higher priority schedulable is placed in the queue for its active priority, at a position determined by the implementation. The implementation must document the algorithm used for such placement. It is recommended that a preempted schedulable be placed at the front of the appropriate queue.
12. A realtime thread that performs a `yield()` is placed at the tail of the queue (dictated by its affinity) for its active priority level.
13. A blocked schedulable that becomes eligible for execution is added to the tail of the queues (dictated by its affinity) for that priority. This behavior also applies to the initial release of a schedulable.
14. A schedulable whose active priority is raised as a result of explicitly setting its base priority (through the `RealtimeThread` `setSchedulingParameters()` method, or `Thread`'s `setPriority()` method) is added to the tail of the queues (dictated by its affinity) for its new priority level.
15. Queuing when priorities are adjusted by priority inversion avoidance algorithms is governed by semantics specified in the *Synchronization* chapter.

6.2.1.5 Cost Monitoring and Cost Enforcement

The cost of a schedulable is defined by the value returned by invoking the `getCost` method of the schedulable's release parameters object. When a schedulable is initially released, its current CPU consumption is zero, and as the schedulable executes, the current CPU consumption increases. For cost monitoring, an implementation must conform to the following requirements.

1. If, at any time, due to either execution of the schedulable or a change in the schedulable's cost, the current CPU consumption becomes greater than or equal to the current cost of the schedulable, then a cost overrun is triggered.
2. The implementation is required to document the granularity at which the current CPU consumption is updated.
3. When a cost overrun is triggered, the cost overrun handler associated with the schedulable, if any, is released. No further action is taken.
4. The current CPU consumption is reset to zero when the schedulable is next released (i.e. it moves from the blocked-for-release-event state to the eligible-for-execution state).

When cost enforcement is supported, an implementation must conform to the following requirements.

1. When a cost overrun is triggered, in addition to releasing any cost overrun handler, the following actions must be performed.
   (a) When the most recent release of the schedulable is the i^{th} release, and the $i + 1$ release event has not yet occurred, the following must hold.
      i. When the state of the schedulable is either executing or eligible-for-execution, the schedulable is placed into the state blocked-by-cost-overrun. There may be a bounded delay between the time at which a cost overrun occurs and the time at which the schedulable becomes blocked-by-cost-overrun.
      ii. Otherwise, the schedulable must have been blocked for a reason other than blocked-by-cost-overrun. In this case, the state change to blocked-by-cost-overrun is left pending; when the blocking condition for the schedulable is removed, then its state changes to blocked-by-cost-overrun. There may be a bounded delay between the time at which the blocking condition is removed and the time at which the schedulable becomes blocked-by-cost-overrun.
   (b) When the most recent release of the schedulable is the i^{th} release, and the $i + 1$ release event has occurred, the current CPU consumption is set to zero, the schedulable remains in its current state, and the cost monitoring system considers the most recent release to be the $i + 1$ release.
2. When the i^{th} release event occurs for a schedulable, the action taken depends on the state of the schedulable.
   (a) When the schedulable is blocked-by-cost-overrun then the cost monitoring system considers the most recent release to be the i^{th} release, the current CPU consumption is set to zero and the schedulable is made eligible for execution;
   (b) When the schedulable is blocked for a reason other than blocked-by-cost-overrun then
      i. when there is a pending state change to blocked-by-cost-overrun then the pending state change is removed, the cost monitoring system considers the most recent release to be the i^{th} release, the current CPU consumption is set to zero, and the schedulable remains in its current blocked state;
      ii. otherwise, no cost monitoring action occurs.
   (c) When the schedulable is not blocked, no cost monitoring action occurs.
3. When the i^{th} release of a schedulable completes, and the cost monitoring system considers the most recent release to be the i^{th} release, then the current CPU consumption is set to zero and the cost monitoring system considers the most recent release to be the $i + 1$ release. Otherwise, no cost monitoring action occurs.
4. Changes to the cost parameter take effect immediately.
   (a) When the new cost is less than or equal to the current CPU consumption, and the old cost was greater than the current CPU consumption, then a cost overrun is triggered.
   (b) When the new cost is greater than the current CPU consumption,
      i. in the case that the schedulable is blocked-by-cost-overrun, the sched-

ulable is made eligible for execution;
   ii. in the case that the schedulable is blocked for a reason other than blocked-by-cost-overrun and there is a pending state change to blocked-by-cost-overrun, the pending state change is removed;
   iii. in all other cases, no cost monitoring action occurs.
5. When a schedulable changes state to blocked-by-cost-overrun, it must behave as if its base priority has been reduced to the enforced priority. In other words, unless its active priority has been modified by a priority inversion avoidance algorithm as defined in this specification, it should not be scheduled on any CPU. Upon moving out of this state, it will resume execution as if its base priority had been restored to its configured base priority.
6. The state of the cost monitoring system for a schedulable can be *reset* by the scheduler (see 6.2.1.3.2 in the **Release of a Realtime Thread** section, below). When the most recent release of the schedulable is considered to be the m^{th} release and the most recent release event for the schedulable was the n^{th} release event (where $n > m$), a reset causes the cost monitoring system to consider the most recent release to be the n^{th} release, and to zero the current CPU consumption.

6.2.2 Priority Schedulers

This specification defines a class of scheduler that are priority preemptive. Their semantics assumes a uniprocessor or shared memory multiprocessor execution environment. Two subclasses are defined: the base scheduler and a round-robin scheduler.

The semantics for the base scheduler is priority preemptive with run to completion semantics, also known as first-in-first-out (FIFO) semantics: `FirstInFirstOutScheduler`. The base scheduler supports the execution of all schedulables. When a schedulable managed by the base scheduler is scheduled, it will run either until it blocks (as on a monitor or for some I/O operation), voluntarily relinquishes the CPU (as for sleep), or is preempted by a higher priority task.

The round-robin scheduler is a fixed-quantum, fixed-priority, priority-preemptive scheduler that interacts predictably with the base scheduler: `RoundRobinScheduler`. The time at which a quantum expires may be calculated either from the last task switch or on a heartbeat. It uses the `PriorityParameters` class for the configuration of schedulable priorities. It may not be present on all systems, but if it is present then it will obey the semantics specified here. When a schedulable managed by the round-robin scheduler is scheduled, it will run no longer than until it blocks (as on a monitor or for some I/O operation), it voluntarily relinquishes the CPU (as for sleep), or it is preempted by a higher priority task, as with the base scheduler, but also yields when its quantum has expired.

The scheduler is not responsible for ensuring that a release, such as an event handler, will complete within the quantum. A release which would run longer than its quantum will be rescheduled at the end of that quantum, when another task with the same priority is ready to run, even if it has not completed. When this is not the desired behavior, the `FirstInFirstOutScheduler` should be used instead.

Both schedulers share the same base class: `PriorityScheduler`.

6.2.2.1 Priorities

Not only the presence or absence of a time quantum, but also the semantics for scheduling eligibility differ between the base (FIFO) and round-robin schedulers. Both schedulers use a numerical priority value to determine scheduling eligibility. A higher value means a higher scheduler eligibility and a lower one means a lower scheduler eligibility. Although the values themselves have the same relative meaning between the two schedulers, the details of their semantics vary.

6.2.2.2 First-In-First-Out-Scheduler

The base scheduler is a priority scheduler with the following requirements.

1. The base scheduler must able to support at least 28 distinct values[2] (realtime priorities) that can be stored in an instance of `PriorityParameters` in addition to the values 1 through 10 required to support the priorities defined by `java.lang.Thread`.
2. The realtime priority values must be greater than 10, and they must include all integers from the base scheduler's `getMinPriority()` value to its `getMaxPriority()` value inclusive.
3. Higher priority values in an instance of `PriorityParameters` have a higher execution eligibility.
4. The 10 priorities defined for `java.lang.Thread` must effectively have lower execution eligibility than the realtime priorities.
5. When the round-robin scheduler is present, the base scheduler must support at least one priority value numerically greater than the maximum allowable round-robin priority.
6. For realtime scheduling, the base priority of each `Schedulable` under the control of the base scheduler must be from the range of realtime priorities. A `Schedulable` with a priority in the `java.lang.Thread` range will be scheduled as if it were an instance of `java.lang.Thread`.
7. Assignment of any of the realtime priority values to any `Schedulable` controlled by the base priority scheduler is legal. It is the responsibility of application logic to make rational priority assignments.
8. The base scheduler does not use the `importance` value in the `ImportanceParameters` subclass of `PriorityParameters`.
9. Calling the `java.lang.Thread.setPriority` on a thread can only be used to set the thread's priority to a conventional Java priority (1–10).
10. For schedulables managed by the base scheduler, the implementation must not change the execution eligibility for any reason other than
    (a) the implementation of a priority inversion avoidance algorithm requires it, or
    (b) as a result of a program's request to change the priority parameters associated with one or more schedulables; e.g., by changing a value in a scheduling parameter object that is used by one or more schedulables, or by using `setSchedulingParameters()` to give a schedulable a different `SchedulingParameters` value.

[2] A system may be configured to have fewer, when few are required.

11. Use of `Thread.setPriority()`, or any of the methods defined for schedulables, or any of the methods defined for parameter objects must not affect the correctness of the priority inversion avoidance algorithms controlled by `PriorityCeilingEmulation` and `PriorityInheritance`—see Chapter7.
12. When schedulable A, managed by the base scheduler, creates Java thread B, then the initial base priority of B is the minimum of the priority value returned by the `getMaxPriority` method of B's `java.lang.ThreadGroup` object and the priority of A.
13. `PriorityScheduler.getNormPriority()` shall be set to

```
1 ((PriorityScheduler.getMaxPriority() -
2   PriorityScheduler.getMinPriority()) / 3) +
3   PriorityScheduler.getMinPriority()
```

14. Hardware priorities, where supported, have values above the base scheduler's priority range (see Section 13.2.4).

6.2.2.3 The Round-Robin Scheduler

Priorities in the round-robin scheduler are as in the base scheduler, and priority values are numerically equivalent between the two. Schedulables managed by the round-robin scheduler behave as if they are scheduled from the same FIFO queue as schedulables managed by the base scheduler of the same numeric priority, except that they will consume no more than one quantum of execution time before being moved to the tail of the queue. Implementations are permitted to use a single, shared queue for this purpose.

If the round-robin scheduler is present, its priorities will have the same properties as the base scheduler, except for the following.

1. The round-robin scheduler must support at least one priority, and may support an arbitrarily large number of priorities.
2. All round-robin priorities must be greater than 10, and they must include all integers from the round-robin scheduler's `getMinPriority()` value to its `getMaxPriority()` value, inclusive.
3. The round-robin scheduler does not use the `importance` value in the `ImportanceParameters` subclass of `PriorityParameters`.
4. `RoundRobinScheduler.getNormPriority()` shall be set to

```
1 ((RoundRobinScheduler.getMaxPriority() -
2   RoundRobinScheduler.getMinPriority()) / 3) +
3   RoundRobinScheduler.getMinPriority()
```

The round-robin scheduler may provide priorities strictly lower than that of the base scheduler or a set of priorities partially or entirely overlapping with the priorities provided by the base scheduler.

6.2.2.4 Parameter Values

The parameter values used by the priority schedulers shall have the following scheduler-specific properties.

1. The default scheduling parameter values for parameter objects created by a schedulable controlled by the priority schedulers are given by the following table (see `FirstInFirstOutScheduler`).

Attribute	Default Value
Scheduling parameters affinity	inherited from creating task
Priority parameters priority	norm priority

2. For a task changing its own `SchedulingParameters`, the change shall take effect immediately.
3. For a task Changing another task's `SchedulingParameters`, when the other task is in the running state, the change shall take effect as soon as practical and, when the other task is in any other execution state, the change will take effect immediately.

6.2.3 Associating Schedulables with Schedulers

The `Scheduler` associated with a `Schedulable` at the time it is started is derived from its scheduler setting and scheduler parameters, as well as the scheduler of the task, instance of `Thread` or `Schedulable`, that started it. The start time of a `RealtimeThread` is the time at which its `RealtimeThread.start()` method is invoked, and the start time of an event handler is the time at which it is attached to an event with `AsyncBaseEvent.addHandler()`.

For the following discussion, let `si` be the instance of `Schedulable` being started, `parent` be the task from which it is started, `ns` be some arbitrary scheduler, and `sg` be the `RealtimeThreadGroup` instance associated with `si`. The `Scheduler` for `si` is determined as follows and in the order stated.

1. When `Scheduler.setScheduler(ns)` has been used to explicitly configure a scheduler for `si`, that scheduler will be the scheduler associated with `si`.
2. When `parent` is an instance of `Schedulable` and the scheduler associated with `parent` is an instance of the class returned by `sg.getScheduler()`, then the scheduler associated with `si` will be the scheduler associated with `parent`.
3. When `parent` is not an instance of `Schedulable` (i.e., it is a Java `Thread`) but is currently scheduled with a realtime `Scheduler` and that scheduler is an instance of the class returned by `sg.getScheduler()`, then `si` will use the scheduler currently associated with `parent`.
4. When the default scheduler is an instance of the class returned by `sg.getScheduler()`, then `si` will use the default scheduler.
5. When none of these conditions hold, a scheduler cannot be determined for `si` and an `IllegalStateException` will be thrown.

A task that is eligible for execution must always have a compatible `Scheduler` and `SchedulingParameters`. This means that appropriate configuration objects

must be passed in at construction time, and that all later changes must be compatible; if both the Scheduler and SchedulingParameters must be changed in such a way that neither is compatible with the current configuration, setScheduler may be called on the Schedulable with both a scheduler and compatible parameters passed at the same time.

In order to change a task's scheduler to one that is inconsistent with its SchedulingParameter or visa versa, it must be in the the descheduled state. This compatibility must be restored before the task becomes eligible for execution. For RealtimeThread, rescheduling will throw an IllegalTaskStateException when called on a Schedulable with scheduling parameters that are inconsistent with its scheduler. Likewise, since adding a handler to its first event makes it eligible to be fired and hence eligible to be executed, trying to add a handler with SchedulingParameters that do not match its scheduler to an event will also result in an IllegalTaskStateException being thrown.

6.2.4 Additional Schedulers

The RTSJ allows an implementation to support schedulers other than the FirstInFirstOut and RoundRobin schedulers. However, it does not define how these implementation-defined schedulers interact with the RTSJ schedulers. All the RTSJ requires is that, for each processor (core), it must be possible to determine the rules that govern which task will be executing on that processor at every instant in time. Furthermore, it requires (in the absence of any execution-eligibility avoidance technique) that this task be one of the most eligible tasks from each scheduler that is active on that processor. In all cases, the servicing of interrupts must be given higher execution eligibility than all schedulables.

6.2.5 Managing Groups of Schedulables

Conventional Java provides the class ThreadGroup to manage groups of threads. Only minimal functionality is provided: limiting priority, setting daemon status, and interrupting a group of threads at once. RTSJ extends this concept in two ways: limiting CPU affinity on an instance of ThreadGroup through the Affinity class and providing subclasses for managing Schedulables.

6.2.5.1 Realtime Thread Groups

The RealtimeThreadGroup subclass of ThreadGroup provides a means of constraining the possible scheduling parameters and scheduler of tasks. The setMaxPriority method on ThreadGroup only pertains to tasks scheduled in the conventional Java range (1–10), and not to tasks scheduled with a realtime scheduler. To ensure that this works and that conventional thread groups must not need to be scope aware, an implementation must enforce several restrictions:

1. only threads in a realtime thread group may use a realtime scheduler,
2. instances of RealtimeThread may only be created in a realtime thread group,
3. the root ThreadGroup instance must be an instance of RealtimeThreadGroup,

4. the `ThreadGroup` instance of the initial thread must be an instance of `RealtimeThreadGroup`,
5. an instance of `RealtimeThreadGroup` may not have a parent that is not an instance of `RealtimeThreadGroup`, and
6. all groups contained in a `RealtimeThreadGroup` allocated in a `ScopedMemory` must be instances of `RealtimeThreadGroup`.

Furthermore, the enumeration methods on a realtime thread group are not aware of scoped memory and the referential integrity restrictions discussed in Chapter 11, Alternative Memory Areas. The enumeration methods of `RealtimeThreadGroup` will not return references to any `Thread` that is also a `RealtimeThread` and to any `ThreadGroup` that is also a `RealtimeThreadGroup`. This ensures that decendants allocated in a `ScopedMemory` will not need to be referenced from an enumation object allocated in an incompatible allocation context. Since the enumeration object is allocated in the current allocation context, only conventional threads are guaranteed to be referencable. For processing `RealtimeThreadGroup` instances, a visitor should be used.

The maximum priority and scheduler restrictions on `RealtimeThreadGroup` and `ThreadGroup` apply only to the base priority of a task belonging to that group. Priority inversion avoidance algorithms (see Chapter 7, Synchronization) may cause a task to temporarily obtain a priority notionally higher than its maximum base priority as specified in its associated instance of `ThreadGroup`.

A maximum eligibility is provided for capping realtime priorities, but this can only be set once a scheduler type is set that limits the `SchedulingParameters` to a set of comparable types. Changing the maximum eligibility allowed to tasks in a `RealtimeThreadGroup` via the `RealtimeThreadGroup.setMaxEligibility(SchedulingParameters)` method takes effect immediately, and will do the following.

1. For any task `t` in the affected `RealtimeThreadGroup` that is associated with a `SchedulingParameters` not allowable under the new eligibility restriction, set the `SchedulingParameters` associated with `t` to the `SchedulingParameters` currently being set by `setMaxEligibility()`.
2. For any `RealtimeThreadGroup` child `sg` of the affected `RealtimeThreadGroup` that has a maximum eligibility not allowed under the new eligibility restriction, set the maximum eligibility of `sg` to the `SchedulingParameters` currently being set by `setMaxEligibility()`. Note that this will recursively effect the tasks and `RealtimeThreadGroup` children in `sg`.

6.3 javax.realtime

6.3.1 Interfaces

6.3.1.1 BoundSchedulable

---

public interface BoundSchedulable

Interfaces

javax.realtime.Schedulable

Description

A marker interface to provide a type safe reference to all schedulables that are bound to a single underlying thread. A `RealtimeThread` is by definition bound.

Since RTSJ 2.0

6.3.1.2 Schedulable

---

public interface Schedulable

Interfaces

`Runnable`
javax.realtime.Timable
javax.realtime.Subsumable

Description

An interface for all types of task defined in this specification. All implementations of `Schedulable` can be scheduled by any `Scheduler` defined here. A scheduler uses the information available through this interface to create a suitable context in which to execute the code encapsulated by this object.

`Schedulable` also represents one of the two subclasses of `Timable` defined in this specification, together with `AsyncTimable`. This type represents those objects that can be woken by a clock event, while `AsyncTimable` represents those that can be released. This functionality is folded into `Schedulable` because the set of types that can be woken by a clock event and the set of types that can be scheduled on a scheduler are the same, avoiding an extra layer of interface.

6.3.1.2.1 Methods

---

getMemoryParameters

Signature

```
public javax.realtime.MemoryParameters
getMemoryParameters()
```

Description

Gets a reference to the `MemoryParameters` object for this schedulable.

Returns

a reference to the current `MemoryParameters` object.

setMemoryParameters(MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setMemoryParameters(MemoryParameters memory)
```

Description

Sets the memory parameters associated with this instance of `Schedulable`.

This change becomes effective at the next allocation; on multiprocessor systems, there may be some delay due to synchronization between processors.

Parameters

`memory`—A `MemoryParameters` object which will become the memory parameters associated with `this` after the method call. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `memory` is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and `memory` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `memory`, or when `memory` cannot hold a reference to this schedulable instance.

Returns

`this`

Since RTSJ 2.0 returns itself

getReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
getReleaseParameters()
```

Description

Gets a reference to the `ReleaseParameters` object for this schedulable.

Returns

a reference to the current `ReleaseParameters` object.

setReleaseParameters(ReleaseParameters)

Signature

```
public javax.realtime.Schedulable
setReleaseParameters(ReleaseParameters<?> release)
```

Description

Sets the release parameters associated with this instance of `Schedulable`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. The different properties of the release parameters may take effect at different times. See the documentation for the scheduler for details.

Parameters

`release`—A `ReleaseParameters` object which will become the release parameters associated with this after the method call, and take effect as determined by the associated scheduler. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `release` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `release` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `release` or `release` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is running and the new release parameters are not compatible with the current scheduler.

Returns

`this`

Since RTSJ 2.0 returns itself

getScheduler

Signature

```
public javax.realtime.Scheduler
getScheduler()
```

Description

Gets a reference to the `Scheduler` object for this schedulable.

Returns

a reference to the associated `Scheduler` object.

setScheduler(Scheduler)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler)
throws StaticSecurityException,
       IllegalTaskStateException
```

Description

Sets the reference to the Scheduler object. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`. If the `Schedulable` is running, its associated `SchedulingParameters` (if any) must be compatible with `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage execution of this schedulable. `Null` is not a permissible value.

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null`, or the schedulable's existing parameter values are not compatible with `scheduler`. Also when this schedulable may not use the heap and `scheduler` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `scheduler` or the current `Schedulable` is running and its associated `SchedulingParameters` are incompatible with `scheduler`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

`IllegalTaskStateException`—when `scheduler` has scheduling or release parameters that are not compatible with the new scheduler and this schedulable is running.

Returns

`this`

Since RTSJ 2.0 returns itself

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
             MemoryParameters memoryParameters)
```

Description

Sets the scheduler and associated parameter objects. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Returns

`this`

Since RTSJ 2.0

getSchedulingParameters

Signature

```
public javax.realtime.SchedulingParameters
getSchedulingParameters()
```

Description

Gets a reference to the `SchedulingParameters` object for this schedulable.

Returns

A reference to the current `SchedulingParameters` object.

setSchedulingParameters(SchedulingParameters)

Signature

```
public javax.realtime.Schedulable
setSchedulingParameters(SchedulingParameters scheduling)
throws IllegalTaskStateException,
       IllegalAssignmentError,
       StaticIllegalArgumentException
```

Description

Sets the scheduling parameters associated with this instance of `Schedulable`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation of the scheduler for details.

Parameters

`scheduling`—A reference to the `SchedulingParameters` object. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.). When the Affinity is not defined in `scheduling`, then the affinity that will be used is the one of the creating Thread. However, this default affinity will not appear when calling `getSchedulingParameters`, unless explicitly set using this method.

Throws

`StaticIllegalArgumentException`—when `scheduling` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `scheduling` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `scheduling` or `scheduling` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is active and the new scheduling parameters are not compatible with the current scheduler or when the task is active and the affinity in `scheduling` is not a subset of the affinity of `this` object's `RealtimeThreadGroup` or when the task is active and the affinity in `scheduling` is invalid.

Returns

`this`

Since RTSJ 2.0, method returns a reference to `this`.

getRealtimeThreadGroup

Signature

```
public javax.realtime.RealtimeThreadGroup
getRealtimeThreadGroup()
```

Description

Gets a reference to the `RealtimeThreadGroup` instance of this `Schedulable`. For instance that are not also instances of `RealtimeThread`, such as instance if `AsyncBaseEventHandler`, the group returned is the group that contains the thread or threads that are used to execute said `Schedulable` instance. For each instance of `Schedulable`, there can be only one directly associated instance of `Schedulable`.

Returns

a reference to the associated `RealtimeThreadGroup` object.

Since RTSJ 2.0

getConfigurationParameters

Signature

```
public javax.realtime.ConfigurationParameters
getConfigurationParameters()
```

Description

Gets a reference to the `ConfigurationParameters` object for this schedulable.

Returns

a reference to the associated `ConfigurationParameters` object.

Since RTSJ 2.0

getMinConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)
```

Description

Determines the minimum CPU consumption for this schedulable in any single release. When this method is called on the current schedulable, the CPU consumption of the current release is not considered. When `dest` is `null`, returns the minimum consumption in a `RelativeTime` instance from the current allocation context. When `dest` is not `null`, returns the minimum consumption in `dest`

Parameters

`dest`—When not `null`, the object in which to return the result.

Returns

the minimum time consumed in any release.

Since RTSJ 2.0

getMinConsumption

Signature

```
public javax.realtime.RelativeTime
getMinConsumption()
```

Description

Equivalent to `getMinConsumption(null)`.

Returns

the minimum time consumed in any release.

Since RTSJ 2.0

getMaxConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption(RelativeTime dest)
```

Description

Determines the maximum CPU consumption for this schedulable in any single release. When this method is called on the current schedulable, the CPU consumption of the current release is not considered. When `dest` is `null`, returns the maximum consumption in a `RelativeTime` instance from the current allocation context. When `dest` is not `null`, returns the maximum consumption in `dest`

Parameters

`dest`—When not `null`, the object in which to return the result.

Returns

the maximum time consumed in any release.

Since RTSJ 2.0

getMaxConsumption

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption()
```

Description

Equivalent to `getMaxConsumption(null)`.

Returns

the maximum time consumed in any release.

Since RTSJ 2.0

setDaemon(boolean)

Signature

```
public void
setDaemon(boolean on)
```

Description

Marks this schedulable as either a daemon or a user task. A realtime virtual machine exits when the only tasks running are all daemons. This method must be called before the task is attached to any event or started. Once attached or started, it cannot be changed.

Parameters

`on`—When `true`, marks this event handler as a daemon handler.

Throws

`IllegalThreadStateException`—when this schedulable is active.

StaticSecurityException—when the current schedulable cannot modify this event handler.

Since RTSJ 2.0

isDaemon

Signature

```
public boolean
isDaemon()
```

Description

Tests if this event handler is a daemon handler.

Returns

`true` when this event handler is a daemon handler; `false` otherwise.

Since RTSJ 2.0

mayUseHeap

Signature

```
public boolean
mayUseHeap()
```

Description

Determines whether or not this `schedulable` may use the heap.

Returns

`true` only when this `Schedulable` may allocate on the heap and may enter the `Heap`.

Since RTSJ 2.0

interrupt

Signature

```
public void
interrupt()
throws IllegalTaskStateException
```

Description

In a system where `RTSJModule.CONTROL` is implemented, it makes the generic `AsynchronouslyInterruptedException` pending for `this`, and sets the interrupted state to `true`. As with `Thread.interrupt()`, blocking operations that are interruptible are interrupted. When `this.isRousable()` is `true` a release happens event if the first release has not yet happend. In any case, `AsynchronouslyInterruptedException` is thrown once a method is entered that implements `AsynchronouslyInterruptedException`.

Otherwise, it behaves as if `Thread.interrupt()` were called.

For instances of `AsyncBaseEventHandler`, it behaves as if `RealtimeThread.interrupt()` was called on the implementation thread underlying it.

Throws
`IllegalTaskStateException`—when `this` is not currently releasable, i.e., is disabled, not firable, its start method has not been called, or it has terminated.

Since RTSJ 2.0

isInterrupted

Signature

```
public boolean
isInterrupted()
```

Description

Determines whether or not any `AsynchronouslyInterruptedException` is pending.

Returns
`true` when and only when the generic `AsynchronouslyInterruptedException` is pending.

Since RTSJ 2.0

awaken

Signature

```
public void
awaken()
throws StaticIllegalStateException
```

Description

Provides a means for a `Clock` to end a sleep.

Throws
`StaticIllegalStateException`—when called from user code.

Since RTSJ 2.0

subsumes(Schedulable)

Signature

```
public boolean
subsumes(Schedulable other)
```

Description

Determine whether or not this instance of `Schedulable` is more eligible than `other`. On multicore systems, this only gives a partial ordering over all schedulables. Schedulables with disjoint processor affinity do not subsume one another.

Returns
`true` when and only when this instance of `Schedulable` is more eligible than `other`.

Since RTSJ 2.0

6.3.2 Enumerations

6.3.2.1 MinimumInterarrivalPolicy

---

public enum MinimumInterarrivalPolicy

Inheritance

java.lang.Object
  java.lang.Enum<MinimumInterarrivalPolicy>
    MinimumInterarrivalPolicy

Description

Defines the set of policies for handling interarrival time violations in `SporadicParameters`. Each policy governs every instance of `Schedulable` which has `SporadicParameters` with that minimum interarrival time policy.

Since RTSJ 2.0

6.3.2.1.1 Enumeration Constants

EXCEPT

```
public static final MinimumInterarrivalPolicy EXCEPT
```

Description

Represents the "EXCEPT" policy for minimum interarrival time. Under this policy, when an arrival time of a release occurs at a time less than the last release time plus its minimum interarrival time, the `fire()` method shall throw a preallocated instance of `MITViolationException`.

IGNORE

```
public static final MinimumInterarrivalPolicy IGNORE
```

Description

Represents the "IGNORE" policy for minimum interarrival time. Under this policy, when an arrival time of a release occurs at a time less than the last release time plus its minimum interarrival time, the new arrival time is ignored.

REPLACE

```
public static final MinimumInterarrivalPolicy REPLACE
```

Description

Represents the "REPLACE" policy for minimum interarrival time. Under this policy, when an arrival time of a release occurs at a time less than the last release time plus its minimum interarrival time, the information for this arrival replaces a previous arrival. For cases when the previous event has already been released or the event queue has a length of zero, the arrival is ignored as with the IGNORE policy.

SAVE

```
public static final MinimumInterarrivalPolicy SAVE
```

Description

Represents the "SAVE" policy for minimum interarrival time. Under this policy, when an arrival time of a release occurs at a time less than the last release time plus its minimum interarrival time, the new release is queued until the last release time plus its minimum interarrival time is reached, but its deadline is not changed.

6.3.2.1.2 Methods

---

values

Signature

```
public static javax.realtime.MinimumInterarrivalPolicy[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.MinimumInterarrivalPolicy
valueOf(String name)
```

Description

value

Signature

```
public java.lang.String
value()
```

Description

Determines the string corresponding to this value.

Returns
the corresponding string.

value(String)

Signature

```
public static javax.realtime.MinimumInterarrivalPolicy
value(String value)
```

Description

Converts a string into a policy type.

Parameters
`value`—is the string to convert.
Returns
the corresponding policy type.

6.3.2.2 QueueOverflowPolicy

---

public enum QueueOverflowPolicy

Inheritance
java.lang.Object
java.lang.Enum<QueueOverflowPolicy>
QueueOverflowPolicy

Description

Defines the set of policies for handling overflow on event queues used by `ReleaseParameters`. An event queue holds a number of event arrival times with any respective payload provided with the event. A reference to the event itself is only held when it happens to be the payload, e.g., for an `AsyncObjectEvent` associated with a `Timer`.

Since RTSJ 2.0

6.3.2.2.1 Enumeration Constants

DISABLE

```
public static final QueueOverflowPolicy DISABLE
```

Description

Represents the "DISABLE" policy which means, when an arrival occurs, no queuing takes place, thus no overflow can happen. This policy is for instances of `ActiveEvent` with no payload and instances of `RealtimeThread` with `PeriodicParameters`. In contrast to `IGNORE`, all incoming events increment the pending fire or release count, respectively. For this reason, it may not be used with an event handler that supports an event payload or any instance of `Schedulable` with `SporadicParameters`. This policy is also the default for `PeriodicParameters`. Instances of `RealtimeThread` with `null` release parameters have this policy implicitly, as they do not have an event queue either.

EXCEPT

```
public static final QueueOverflowPolicy EXCEPT
```

Description

Represents the "EXCEPT" policy which means, when an arrival occurs and its event time and payload should be queued but the queue already holds a number of event times and payloads equal to the initial queue length, the `fire()` method shall throw an `ArrivalTimeQueueOverflowException`. When fire is used within a `Timer`, the exception is ignored and the fire does nothing, i.e., it acts the same as “IGNORE”.

IGNORE

```
public static final QueueOverflowPolicy IGNORE
```

Description

Represents the "IGNORE" policy which means, when an arrival occurs and its event time and payload should be queued, but the queue already holds a number of event times and payloads equal to the initial queue length, the arrival is ignored.

REPLACE

```
public static final QueueOverflowPolicy REPLACE
```

Description

Represents the "REPLACE" policy which means, when an arrival occurs and should be queued but the queue already holds a number of event times and payloads equal to the initial queue length, the information for this arrival replaces a previous arrival. When the queue length is zero, the behavior is the same as the "IGNORE" policy.

SAVE

```
public static final QueueOverflowPolicy SAVE
```

Description

Represents the "SAVE" policy which means, when an arrival occurs and should be queued but the queue is full, the queue is lengthened and the arrival time and payload are saved. This policy does not update the"initial queue length" as it alters the actual queue length. Since the `SAVE` policy grows the arrival time queue as necessary, for the `SAVE` policy the initial queue length is only an optimization. It is also the default for `AperiodicParameters`.

6.3.2.2.2 Methods

---

values

Signature

```
public static javax.realtime.QueueOverflowPolicy[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.QueueOverflowPolicy
valueOf(String name)
```

Description

value

Signature

```
public java.lang.String
value()
```

Description

Determines the string corresponding to this value.

Returns

the corresponding string.

value(String)

Signature

```
public static javax.realtime.QueueOverflowPolicy
value(String value)
```

Description

Converts a string into a policy type.

Parameters
`value`—is the string to convert.
Returns
the corresponding policy type.

6.3.3 Classes

6.3.3.1 Affinity

---

public class Affinity

Inheritance
java.lang.Object
Affinity

Interfaces
`Cloneable`
`Serializable`

Description

This is class for specifying processor affinity. It includes a factory that generates `Affinity` objects. With it, the affinity of every task in a JVM can be controlled.

An affinity is a set of processors that can be associated with certain types of tasks. Each task can be associated with an affinity via its `SchedulingParameters`. Groups of these can be assigned an affinity through their `RealtimeThreadGroup`.

The processor membership of an affinity is immutable. The tasks associations of an affinity are mutable. The internal representation of a set of processors in an `Affinity` instance is not specified, but the representation that is used to communicate with this class is a `BitSet` where each bit corresponds to a logical processor ID. The relationship between logical and physical processors is beyond the scope of this specification, and may change.

The set of affinities created at startup (the predefined set) is visible through the `getPredefinedAffinities(Affinity[])` method. Only the Affinities made available at startup and the Affinities generated using `generate(BitSet)` but with a cardinality of one may be used as parameters for schedulables. These are referred to as
emph{valid} affinities. However, it is still possible to create Affinity instances that are not equals to the ones defined at startup and with a cardinality more than one using `generate(BitSet)`. These affinities are not considered to be valid as they can not be used as parameters for schedulables. The purpose of these invalid affinities is to be used as parameter if a RealtimeThreadGroup instance to limit the processors available to its members.

There is no public constructor for this class. All instances must be created by the factory method (`generate`).

Since RTSJ 2.0

6.3.3.1.1 Methods

---

getPredefinedAffinitiesCount

Signature

```
public static final int
getPredefinedAffinitiesCount()
```

Description

Determines the minimum array size required to store references to all the predefined processor affinities.

Returns

the minimum array size required to store references to all the predefined affinities.

getPredefinedAffinities

Signature

```
public static final javax.realtime.Affinity[]
getPredefinedAffinities()
```

Description

Equivalent to invoking `getPredefinedAffinitySets(null)`.

Returns

an array of the predefined affinities.

getPredefinedAffinities(Affinity)

Signature

```
public static final javax.realtime.Affinity[]
getPredefinedAffinities(Affinity[] dest)
```

Description

Determines what affinities are predefined by the Java runtime.

Parameters

`dest`—The destination array, or `null`.

Throws

`StaticIllegalArgumentException`—when `dest` is not large enough.

Returns

`dest` or a newly created array when `dest` is `null`, populated with references to the predefined affinities. When `dest` has excess entries, those entries are filled with `null`.

isSetAffinitySupported

Signature

```
public static final boolean
isSetAffinitySupported()
```

Description

Determines whether or not affinity control is supported.

Returns

`true` when more than one affinity set is available.

generate(BitSet)

Signature

```
public static final javax.realtime.Affinity
generate(BitSet set)
```

Description

Determines the Affinity corresponding to a `BitSet`, where each bit in `set` represents a CPU. When `BitSet` does not correspond to a predefined affinity or an affinity with a cardinality of one, the resulting `Affinity` instance is not a valid affinity and can only be used for limiting the CPUs that can be used by a `RealtimeThreadGroup`. The method `isValid` can be used to determine whether or not the result is a valid affinity.

Platforms that support specific affinities will register those `Affinity` instances with `Affinity`. They appear in the arrays returned by `getPredefinedAffinities()` and `getPredefinedAffinities(Affinity[])`.

Parameters

`set`—The `BitSet` to convert into an `Affinity`.

Throws

`StaticIllegalArgumentException`—when `set` is `null` or when `set` is empty.

Returns

the resulting `Affinity`.

getRootAffinity

Signature

```
public static final javax.realtime.Affinity
getRootAffinity()
```

Description

Gets the root Affinity: the Affinity that can be used to allow a schedulable to run on all the processing units available to the VM.

Returns

the root `Affinity`.

getAvailableProcessors

Signature

```
public static final java.util.BitSet
getAvailableProcessors()
```

Description

This method is equivalent to `getAvailableProcessors(BitSet)` with a `null` argument. In systems where the set of processors available to a process is dynamic, e.g., system management operations or fault tolerance capabilities can add or remove processors, the set of available processors shall reflect the processors that are allocated to the RTSJ runtime and are currently available to execute tasks.

Returns

a `BitSet` representing the set of processors currently valid for use in the `BitSet` argument to `generate(BitSet)`.

getAvailableProcessors(BitSet)

Signature

```
public static final java.util.BitSet
getAvailableProcessors(BitSet dest)
```

Description

In systems where the set of processors available to a process is dynamic (e.g., because of system management operations or because of fault tolerance capabilities), the set of available processors shall reflect the processsors that are allocated to the RTSJ runtime and are currently available to execute tasks.

Parameters

`dest`—When `dest` is non-null, use `dest` as the returned value. When it is `null`, create a new `BitSet`.

Returns

a `BitSet` representing the set of processors currently valid for use in the `bitset` argument to `generate(BitSet)`.

isAffinityChangeNotificationSupported

Signature

```
public static final boolean
isAffinityChangeNotificationSupported()
```

Description

Determines whether or not the system can trigger an event for notifying the application when the set of available CPUs changes.

Returns

`true` when change notification is supported. (See `setProcessorAddedEvent(AsyncEvent)` and `setProcessorRemovedEvent(AsyncEvent)`.)

getProcessorAddedEvent

Signature

```
public static javax.realtime.AsyncEvent
getProcessorAddedEvent()
```

Description

Gets the event used for CPU addition notification.

Returns

the async event that will be fired when a processor is added to the set available to the JVM. Returns `null` when change notification is not supported, or when no async event has been designated.

setProcessorAddedEvent(AsyncEvent)

Signature

```
public static void
setProcessorAddedEvent(AsyncEvent event)
throws StaticUnsupportedOperationException,
       StaticIllegalArgumentException
```

Description

Sets the AsyncEvent that will be fired when a processor is added to the set available to the JVM.

Parameters

`event`—The async event to fire in case an added processor is detected, or `null` to cause no async event to be called in case an added processor is detected.

Throws

`StaticUnsupportedOperationException`—when change notification is not supported.

`StaticIllegalArgumentException`—when `event` is not in immortal memory.

getProcessorRemovedEvent

Signature

```
public static javax.realtime.AsyncEvent
getProcessorRemovedEvent()
```

Description

Gets the event used for CPU removal notification.

Returns

the async event that will be fired when a processor is removed from the set available to the JVM. Returns `null` when change notification is not supported, or when no async event has been designated.

setProcessorRemovedEvent(AsyncEvent)

Signature

```
public static void
setProcessorRemovedEvent(AsyncEvent event)
```

Description

Sets the `AsyncEvent` that will be fired when a processor is removed from the set available to the JVM.

Parameters

`event`—Called when a processor is removed.

Throws

`StaticUnsupportedOperationException`—when change notification is not supported.

`StaticIllegalArgumentException`—when `event` is not `null` or in immortal memory.

getProcessors

Signature

```
public final java.util.BitSet
getProcessors()
```

Description

Obtains a `BitSet` representing the processor affinity set for this `Affinity`.

Returns

a newly created `BitSet` representing this `Affinity`.

getProcessors(BitSet)

Signature

```
public final java.util.BitSet
getProcessors(BitSet dest)
```

Description

Determines the set of CPUs representing the processor affinity of this `Affinity`.

Parameters

`dest`—Set `dest` to the `BitSet` value. When `dest` is `null`, create a new `BitSet` in the current allocation context.

Returns

a `BitSet` representing the processor affinity set of this `Affinity`.

isProcessorInSet(int)

Signature

```
public final boolean
isProcessorInSet(int processorId)
```

Description

Asks whether a processor is included in this affinity set.

Parameters

`processorId`—A number identifying a single CPU in a multiprocessor system.

Returns

`true` when and only when `processorNumber` is represented in this affinity set.

getProcessorCount

Signature

```
public int
getProcessorCount()
```

Description

Determines the number of CPUs in this affinity

Returns

the number of CPUs.

isValid

Signature

```
public boolean
isValid()
```

Description

Determine whether or not the affinity can be used for scheduling or just for limiting the processors available to members of `RealtimeThreadGroup`.

Returns

`true` when valid for scheduling and `false` otherwise.

subsumes(Affinity)

Signature

```
public boolean
subsumes(Affinity other)
```

Description

Determines whether or not `other` is equal to or a proper subset of this affinity.

Parameters

`other`—The other affinity with which to compare

Returns

`true` Only when the affinity in parameter is a equal to or a proper subset of this affinity.

6.3.3.2 AperiodicParameters

---

public class AperiodicParameters

Inheritance

java.lang.Object
ReleaseParameters<AperiodicParameters>
AperiodicParameters

Description

When a reference to an `AperiodicParameters` object is given as a parameter to a schedulable's constructor or passed as an argument to one of the schedulable's setter methods, the `AperiodicParameters` object becomes the release parameters object bound to that schedulable. Changes to the values in the `AperiodicParameters` object affect that schedulable. When bound to more than one schedulable, changes to the values in the `AperiodicParameters` object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

Only changes to an `AperiodicParameters` object caused by methods on that object cause the change to propagate to all schedulables using the object. For instance, calling `setCost` on an `AperiodicParameters` object will make the change, then notify the scheduler that the parameter object has changed. At that point the object is reconsidered for every schedulable that uses it. Invoking a method on the `RelativeTime` object that is the cost for this object may change the cost but it does not pass the change to the scheduler at that time. That change must not change the behavior of the schedulables that use the parameter object until a setter method on the `AperiodicParameters` object is invoked, the parameter object is used in `setReleaseParameters()`, or it is used in a constructor for a schedulable.

The implementation must use modified copy semantics for each `HighResolutionTime` parameter value. The value of each time object should be treated as if it were copied at the time it is passed to the parameter object, but the object reference must also be retained. For instance, the value returned by `getCost()` must be the same object passed in by setCost(), but any changes made to the time value of the cost must not take effect in the associated `AperiodicParameters` instance unless they are passed to the parameter object again, e.g. with a new invocation of `setCost`.

Correct initiation of the deadline miss and cost overrun handlers requires that the underlying system know the arrival time of each aperiodic task. For an instance of `RealtimeThread` the arrival time is the time at which the `start()` is invoked. For other instances of `Schedulable`, the required behavior may force the implementation to act effectively as if it maintained a queue of arrival times.

When the release parameters for a `RealtimeThread` are set to an instance of this class or one of its subclasses, the thread does not start executing code until the `RealtimeThread.release()` method is called.

The following table gives the default values for the constructors parameters.

Table 6.3: AperiodicParameters Default Values

Attribute	Value
cost	`new RelativeTime(0,0)`
deadline	`new RelativeTime(Long.MAX_VALUE, 999999)`
overrunHandler	None
missHandler	None
rousable	false
Arrival time queue size	0
Queue overflow policy	SAVE

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

6.3.3.2.1 Constructors

AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)

Signature

```
public
AperiodicParameters(RelativeTime cost,
                    RelativeTime deadline,
                    AsyncEventHandler overrunHandler,
                    AsyncEventHandler missHandler,
                    boolean rousable)
```

Description

Creates an `AperiodicParameters` object.

Since RTSJ 2.0

Parameters

`cost`—Processing time per invocation. On implementations which can measure the amount of time a schedulable object is executed, this value is the maximum amount of time a schedulable receives. On implementations which cannot

measure execution time, it is not possible to determine when any particular object exceeds cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. When `null`, the default value is a new instance of `RelativeTime(Long.MAX_VALUE, 999999)`.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost. Not required for minimum implementation. When `null`, the default value is no overrun handler.

`missHandler`—This handler is invoked when the `run()` method of the schedulable object is still executing after the deadline has passed. When `null`, the default value is no miss handler.

`rousable`—determines whether or not an instance of `Schedulable` can be prematurely released by a thread interrupt.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the time value of `deadline` is less than or equal to zero.

`IllegalAssignmentError`—when `cost`, `deadline`, `overrunHandler` or `missHandler` cannot be stored in `this`.

AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
AperiodicParameters(RelativeTime cost,
                    RelativeTime deadline,
                    AsyncEventHandler overrunHandler,
                    AsyncEventHandler missHandler)
```

Description

Equivalent to `AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(cost, deadline, overrunHandler, missHandler, false)`.

Parameters

`cost`—Processing time per invocation. On implementations that support cost enforcement, this value is the maximum amount of time a schedulable receives. On implementations which do not support cost enforcement, it is not possible to determine when any particular object exceeds cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. When `null`, the default value is a new instance of `RelativeTime(Long.MAX_VALUE, 999999)`.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost. Not required for minimum implementation. When `null`, the

default value is no overrun handler.

`missHandler`—This handler is invoked when the `run()` method of the schedulable object is still executing after the deadline has passed. When `null`, the default value is no miss handler.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the time value of `deadline` is less than or equal to zero.

`IllegalAssignmentError`—when `cost`, `deadline`, `overrunHandler` or `missHandler` cannot be stored in `this`.

AperiodicParameters(RelativeTime, AsyncEventHandler, boolean)

Signature

```
public
AperiodicParameters(RelativeTime deadline,
                    AsyncEventHandler missHandler,
                    boolean rousable)
```

Description

Equivalent to `AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(null, deadline, null, missHandler, rousable)`.

Since RTSJ 2.0

AperiodicParameters(RelativeTime)

Signature

```
public
AperiodicParameters(RelativeTime deadline)
```

Description

Equivalent to `AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(null, deadline, null, null, false)`.

Since RTSJ 2.0

AperiodicParameters

Signature

```
public
AperiodicParameters()
```

Description

Equivalent to `AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(null, null, null, null, false)`.

Since RTSJ 1.0.1

6.3.3.3 BackgroundParameters

---

public class BackgroundParameters

Inheritance

java.lang.Object
ReleaseParameters<BackgroundParameters>
BackgroundParameters

Description

Parameters for realtime threads that are only released once. A thread using this release parameters may not use `RealtimeThread.waitForNextRelease()` or have its `RealtimeThread.release()` methods called. Calling these methods results in an `IllegalThreadStateException`. Event handlers may not use this type of `ReleaseParameters`.

Since RTSJ 2.0

6.3.3.3.1 Constructors

BackgroundParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
BackgroundParameters(RelativeTime cost,
                     RelativeTime deadline,
                     AsyncEventHandler overrunHandler,
                     AsyncEventHandler missHandler)
```

Description

A constructor for both cost and deadline monitoring.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

Parameters

`cost`—The maximum cost for executing the run method

`deadline`—The deadline for the completion of the run method

`overrunHandler`—The handler to call on cost overrun.

`missHandler`—The handler to call on deadline miss.

Throws

`StaticIllegalArgumentException`—when the time value of cost is less than zero, or the time value of deadline is less than or equal to zero, or the chronograph associated with the `cost` or `deadline` parameters is not an instance of `Clock`.

`IllegalAssignmentError`—when cost, deadline, overrunHandler, or missHandler cannot be stored in this.

BackgroundParameters(RelativeTime, AsyncEventHandler)

Signature

```
public
BackgroundParameters(RelativeTime deadline,
                     AsyncEventHandler missHandler)
```

Description

A constructor for deadline monitoring. Equivalent to BackgroundParameters(null, deadline, null, missHandler)

BackgroundParameters

Signature

```
public
BackgroundParameters()
```

Description

A constructor for not having any restrictions on, or monitoring of, scheduling. Equivalent to BackgroundParameters(null, null, null, null, false)

6.3.3.4 FirstInFirstOutParameters

---

public class FirstInFirstOutParameters

Inheritance

java.lang.Object
  SchedulingParameters
    PriorityParameters
      FirstInFirstOutParameters

Description

Same as `PriorityParameters` except that it is only valid with the `FirstInFirstOutScheduler`.

Since RTSJ 2.0

6.3.3.4.1 Constructors

FirstInFirstOutParameters(int, Affinity)

Signature

```
public
FirstInFirstOutParameters(int priority,
                          Affinity affinity)
```

Description

Create scheduling parameters restricted to the FIFO scheduler.

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

`affinity`—The affinity assigned to schedulables that use this parameter instance.

FirstInFirstOutParameters(int)

Signature

```
public
FirstInFirstOutParameters(int priority)
```

Description

Create scheduling parameters restricted to the FIFO scheduler.

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

6.3.3.4.2 Methods

---

isCompatible(Scheduler)

Signature

```
public boolean
isCompatible(Scheduler scheduler)
```

Description

Parameters

`scheduler`—The scheduler to check against

Returns

`true` when and only when `this` can be used with `scheduler` as the scheduler.

Since RTSJ 2.0

subsumes(SchedulingParameters)

Signature

```
public boolean
subsumes(SchedulingParameters other)
```

Description

Parameters

`other`—The other parameters object to be compared with.

Returns

true when and only when this parameters is more eligible than the other parameters.

6.3.3.5 FirstInFirstOutScheduler

---

public class FirstInFirstOutScheduler

Inheritance

java.lang.Object
  Scheduler
    PriorityScheduler
      FirstInFirstOutScheduler

Description

A version of `PriorityScheduler` where once a thread is scheduled at a given priority, it runs until it is blocked or is preempted by a higher priority thread. When preempted, it remains the next thread ready for its priority. This is the default scheduler for realtime tasks. It represents the required (by the RTSJ) priority-based scheduler. The default instance is the base scheduler which does fixed priority, preemptive scheduling.

This scheduler, like all schedulers, governs the default values for scheduling-related parameters in its client schedulables. The defaults are as follows:

Table 6.5: FirstInFirstOut Default PriorityParameter Values

Attribute	Default Value
Priority	norm priority

The system contains one instance of the `FirstInFirstOutScheduler` which is the system's base scheduler and is returned by `FirstInFirstOutScheduler.instance()`. The instance returned by the `instance()` method is the *base scheduler* and is returned by `Scheduler.getDefaultScheduler()` unless the default scheduler is reset with `Scheduler.setDefaultScheduler(Scheduler)`.

Since RTSJ 2.0

6.3.3.5.1 Methods

instance

Signature

```
public static javax.realtime.FirstInFirstOutScheduler
instance()
```

Description

Obtains a reference to the distinguished instance of `PriorityScheduler` which is the system's base scheduler.

Returns

a reference to the distinguished instance `PriorityScheduler`.

getMaxPriority

Signature

```
public int
getMaxPriority()
```

Description

Obtains the maximum priority available for a schedulable managed by this scheduler.

Returns

the value of the maximum priority.

getMinPriority

Signature

```
public int
getMinPriority()
```

Description

Obtains the minimum priority available for a schedulable managed by this scheduler.

Returns

the minimum priority used by this scheduler.

getNormPriority

Signature

```
public int
getNormPriority()
```

Description

Obtains the normal priority available for a schedulable managed by this scheduler.

Returns
the value of the normal priority.

getPolicyName

Signature

```
public java.lang.String
getPolicyName()
```

Description

Obtains the policy name of `this`.

Returns
the policy name (Fixed Priority First In First Out) as a string.

reschedule(Thread, SchedulingParameters)

Signature

```
public void
reschedule(Thread thread,
           SchedulingParameters eligibility)
```

Description

Parameters
`thread`—The thread to promote to realtime scheduling.
`eligibility`—A `SchedulingParameters` instance such as `PriorityParameters` for a `PriorityScheduler`.
Throws
`StaticIllegalArgumentException`—when `eligibility` is not valid for the scheduler.
`StaticIllegalStateException`—when `eligibility` specifies parameters that are out of range for the scheduler or the threads state or the intersection of affinity in `scheduling` and the affinity of realtime thread group associated with `thread` is empty.
`StaticUnsupportedOperationException`—when `thread` a normal Java thread and the scheduler does not support promoting normal java threads.

Since RTSJ 2.0

6.3.3.6 PeriodicParameters

public class PeriodicParameters

Inheritance

java.lang.Object
  ReleaseParameters<PeriodicParameters>
    PeriodicParameters

Description

This release parameter indicates that the schedulable is released on a regular basis. For an `AsyncEventHandler`, this means the handler is either released by a periodic timer or the associated event occurs periodically. For a `RealtimeThread`, this means the `RealtimeThread.waitForNextRelease` method will unblock the associated realtime thread at the start of each period.

When a reference to a `PeriodicParameters` object is given as a parameter to a schedulable's constructor or passed as an argument to one of the schedulable's setter methods, the `PeriodicParameters` object becomes the release parameters object bound to that schedulable. Changes to the values in the `PeriodicParameters` object affect that schedulable object. When bound to more than one schedulable then changes to the values in the `PeriodicParameters` object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

Only a change to a `PeriodicParameters` object caused by methods on that object cause the change to be propagate to all instances of `Schedulable` using that parameter object. For instance, calling `setCost` on a `PeriodicParameters` object will make the change, then notify the scheduler that the parameter object has changed. At that point the object is reconsidered for every SO that uses it. Invoking a method on a `RelativeTime` object that is the cost for this object changes the cost value but does not pass the change to the scheduler at that time. That change must not change the behavior of the SOs that use the parameter object until a setter method on the `PeriodicParameters` object is invoked, the parameter object is used in `setReleaseParameters()`, or it is used in a constructor for an SO.

Periodic parameters use `HighResolutionTime` values for period and start time. Since these times are expressed as a `HighResolutionTime` values, these values use accurate timers with nanosecond granularity. The actual resolution available and even the quantity the timers measure depend on the clock associated with each time value.

The implementation must use modified copy semantics for each `HighResolutionTime` parameter value. The value of each time object should be treated as if it were copied at the time it is passed to the parameter object, but the object reference must also be retained. For instance, the value returned by `getCost()` must be the same object passed in by setCost(), but any changes made to the time value of the cost must not take effect in the associated `PeriodicParameters` instance unless they are passed to the parameter object again, e.g. with a new

invocation of `setCost`.

The following table gives the default parameter values for the constructors.

Table 6.7: PeriodicParameter Default Values

Attribute	Default Value
start	new RelativeTime(0,0)
period	No default. A value must be supplied
cost	new RelativeTime(0,0)
deadline	new RelativeTime(period)
overrunHandler	None
missHandler	None
EventQueueOverflowPolicy	QueueOverflowPolicy.DISABLE

Periodic release parameters are strictly informational when they are applied to async event handlers. They must be used for any feasibility analysis, but release of the async event handler is not entirely controlled by the scheduler.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

6.3.3.6.1 Constructors

PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)

Signature

```
public
PeriodicParameters(HighResolutionTime<?> start,
                   RelativeTime period,
                   RelativeTime cost,
                   RelativeTime deadline,
                   AsyncEventHandler overrunHandler,
                   AsyncEventHandler missHandler,
                   boolean rousable)
```

Description

Creates a `PeriodicParameters` object with attributes set to the specified values.

Since RTSJ 2.0

Parameters

`start`—Time at which the first release begins (i.e. the realtime thread becomes eligible for execution.) When a `RelativeTime`, this time is relative to the first time the thread becomes activated (that is, when `start()` is called). When an `AbsoluteTime`, then the first release is the maximum of the start parameter and the time of the call to the associated RealtimeThread.start() method (modified according to any phasing policy). When null, the default value is a new instance of `RelativeTime(0,0)`.

`period`—The period is the interval between successive releases. There is no default value. When `period` is null an exception is thrown.

`cost`—Processing time per release. On implementations which can measure the amount of time a schedulable is executed, this value is the maximum amount of time a schedulable receives per release. When null, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. When null, the default value is new instance of `RelativeTime(period)`.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost in the given release. Implementations may ignore this parameter. When null, the default value is no overrun handler.

`missHandler`—This handler is invoked when the `run()` method of the schedulable is still executing after the deadline has passed. When null, the default value is no deadline miss handler.

`rousable`—When `true`, an interrupt will cause an early release, otherwise not.

Throws

`StaticIllegalArgumentException`—when the `period` is `null` or its time value is not greater than zero, or when the time value of `cost` is less than zero, or when the time value of `deadline` is not greater than zero, or when the clock associated with the `cost` is not the realtime clock, or when the clocks associated with the `deadline` and `period` parameters are not the same.

`IllegalAssignmentError`—when `start` `period`, `cost`, `deadline`, `overrunHandler` or `missHandler` cannot be stored in `this`.

PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
PeriodicParameters(HighResolutionTime<?> start,
                   RelativeTime period,
                   RelativeTime cost,
                   RelativeTime deadline,
                   AsyncEventHandler overrunHandler,
                   AsyncEventHandler missHandler)
```

Description

Equivalent to `PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(start, period, cost, deadline, overrunHandler, missHandler, false)`;

PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler, boolean)

Signature

```
public
PeriodicParameters(HighResolutionTime<?> start,
                   RelativeTime period,
                   RelativeTime deadline,
                   AsyncEventHandler missHandler,
                   boolean rousable)
```

Description

Equivalent to `PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(start, period, deadline, null, null, missHandler, rousable)`;

Since RTSJ 2.0

PeriodicParameters(HighResolutionTime, RelativeTime)

Signature

```
public
PeriodicParameters(HighResolutionTime<?> start,
                   RelativeTime period)
```

Description

Equivalent to `PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with the argument list `(start, period, null, null, null, null, false)`;

Since RTSJ 1.0.1

PeriodicParameters(RelativeTime)

Signature

```
public
PeriodicParameters(RelativeTime period)
```

Description

Creates a `PeriodicParameters` object with the specified period and all other attributes set to their default values. This constructor has the same effect

as invoking `PeriodicParameters(null, period, null, null, null, null, false)`

Since RTSJ 1.0.1

6.3.3.6.2 Methods

---

getPeriod

Signature

```
public javax.realtime.RelativeTime
getPeriod()
```

Description

Determines the current value of period.

Returns

the object last used to set the period containing the current value of period.

getPeriod(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getPeriod(RelativeTime value)
```

Description

Determines the current value of period.

Returns

`value` or, when `null`, the last object used to set the period, set to the current value of period.

Since RTSJ 2.0

getStart

Signature

```
public javax.realtime.HighResolutionTime<?>
getStart()
```

Description

Determines the time used to start an instance of `Schedulable`, which is not necessarily the time at which it actually started.

Returns

the object last used to set the start containing the current value of start.

setPeriod(RelativeTime)

Signature

```
public javax.realtime.PeriodicParameters
setPeriod(RelativeTime period)
```

Description

Sets the period.

Parameters

`period`—The value to which `period` is set.

Throws

`StaticIllegalArgumentException`—when the given period is `null` or its time value is not greater than zero. Also when `period` is incompatible with the scheduler for any associated schedulable or when an associated `AsyncBaseEventHandler` is associated with a `Timer` whose period does not match `period`.

`IllegalAssignmentError`—when `period` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

setStart(HighResolutionTime)

Signature

```
public javax.realtime.PeriodicParameters
setStart(HighResolutionTime<?> start)
```

Description

Sets the start time.

Changes to the start time in a realtime thread's PeriodicParameters object only have an effect on its initial release time.

Note that an instance of `PeriodicParameters` may be shared by several schedulables. A change to the start time may take effect on a subset of these schedulables. That leaves the start time returned by `getStart` unreliable as a way to determine the start time of a schedulable.

Parameters

`start`—The new start time. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

Throws

`StaticIllegalArgumentException`—when the given start time is incompatible with the scheduler for any of the schedulable objects which are presently using this parameter object.

`IllegalAssignmentError`—when `start` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

6.3.3.7 PriorityParameters

public class PriorityParameters

Inheritance

java.lang.Object
SchedulingParameters
PriorityParameters

Description

Instances of this class should be assigned to schedulables that are managed by schedulers which use a single integer to determine execution order. The base scheduler required by this specification and represented by the class `PriorityScheduler` is such a scheduler.

6.3.3.7.1 Constructors

PriorityParameters(int, Affinity)

Signature

```
public
PriorityParameters(int priority,
                   Affinity affinity)
```

Description

Creates an instance of `PriorityParameters` with the given features.

Since RTSJ 2.0

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

`affinity`—The affinity assigned to schedulables that use this parameter instance.

PriorityParameters(int)

Signature

```
public
PriorityParameters(int priority)
```

Description

Creates an instance of `PriorityParameters` with the default affinity.

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

6.3.3.7.2 Methods

getPriority

Signature

```
public int
getPriority()
```

Description

Gets the priority value.

Returns

the priority.

isCompatible(Scheduler)

Signature

```
public boolean
isCompatible(Scheduler scheduler)
```

Description

Parameters

`scheduler`—The scheduler to check against

Returns

`true` when and only when `this` can be used with `scheduler` as the scheduler.

Since RTSJ 2.0

subsumes(SchedulingParameters)

Signature

```
public boolean
subsumes(SchedulingParameters other)
```

Description

Parameters

`other`—The other parameters object to be compared with.

Returns

true when and only when this parameters is more eligible than the other parameters.

toString

Signature

```
public java.lang.String
toString()
```

Description

Converts the priority value to a string.

Returns

a string representing the value of priority.

6.3.3.8 PriorityScheduler

---

public abstract class PriorityScheduler

Inheritance

java.lang.Object
  Scheduler
    PriorityScheduler

Description

Class which represents the required (by the RTSJ) priority-based schedulers. The default instance is the base scheduler which uses a fixed priority, first-in-first-out, preemptive scheduling algorithm.

This scheduler, like all schedulers, governs the default values for scheduling-related parameters in its client schedulables. The defaults are as follows:

Table 6.9: PriorityScheduler Default PriorityParameter Values

Attribute	Default Value
Priority	norm priority

Note that the system contains by default one instance of `PriorityScheduler`, which is the system's base scheduler and is returned by `FirstInFirstOutScheduler.instance()`, so a subclass of PriorityScheduler. It may, however, contain other instances of subclasses of `PriorityScheduler` created through this class' protected constructor. The instance returned by the `FirstInFirstOutScheduler.instance()` method, the *base scheduler*, is also returned by `Scheduler.getDefaultScheduler()` unless the default scheduler is changed with `Scheduler.setDefaultScheduler(Scheduler)`.

Since RTSJ 2.0 PriorityScheduler is abstract.

6.3.3.8.1 Constructors

PriorityScheduler

Signature

```
protected
PriorityScheduler()
```

Description

Constructs an instance of `PriorityScheduler`. Applications will likely not need any instance other than the default instance.

6.3.3.8.2 Methods

getPolicyName

Signature

```
public java.lang.String
getPolicyName()
```

Description

Gets the policy name of `this`.

Returns

the policy name (Fixed Priority) as a string.

getMaxPriority

Signature

```
public abstract int
getMaxPriority()
```

Description

Gets the maximum priority available for a schedulable managed by this scheduler.

Returns

the value of the maximum priority.

getMinPriority

Signature

```
public abstract int
getMinPriority()
```

Description

Gets the minimum priority available for a schedulable managed by this scheduler.

Returns
the minimum priority used by this scheduler.

getNormPriority

Signature

```
public abstract int
getNormPriority()
```

Description

Gets the normal priority available for a schedulable managed by this scheduler.

Returns
the value of the normal priority.

createDefaultSchedulingParameters

Signature

```
protected javax.realtime.SchedulingParameters
createDefaultSchedulingParameters()
```

Description

Throws
`IllegalTaskStateException`—when the current task is using a scheduler that does not support `null` scheduling parameters.

Returns
parameters that are suitable for this scheduler in the current context.

Since RTSJ 2.0

6.3.3.9 RealtimeThreadGroup

---

public class RealtimeThreadGroup

Inheritance
java.lang.Object
  java.lang.ThreadGroup
    RealtimeThreadGroup

Description

An enhanced `ThreadGroup` in which a `RealtimeThread` instance may be started, as well as a convention `Thread`. Limits for what realtime scheduler and scheduling parameters can be enforced on all tasks in this group. A normal `ThreadGroup` may not contain an instance of `Schedulable` or instances of `RealtimeThreadGroup`. Every thread is in some instance of `ThreadGroup` and every instance of `RealtimeThread` is in some instance of `RealtimeThreadGroup`. This means that the `main` thread of a realtime Java implementation must be in an instance of this class, not a normal `ThreadGroup`.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level. **Since** RTSJ 2.0

6.3.3.9.1 Constructors

RealtimeThreadGroup(RealtimeThreadGroup, String, Class)

Signature

```
public
RealtimeThreadGroup(RealtimeThreadGroup parent,
                    String name,
                    java.lang.Class<?  extends Scheduler> scheduler)
```

Description

Creates a new realtime thread group with its scheduler type inherited from `parent`.

Parameters

`parent`—The parent group of the new group

`name`—The name of the new group

`scheduler`—a scheduler class limiting the schedulers allowed for scheduling group members. When `null` inherits from parent. Instances of `java.lang.ThreadGroup` do not have a scheduler and may not contain instances of `RealtimeSchedulerGroup`.

Throws

`StaticIllegalStateException`—when the parent `ThreadGroup` instance is not an instance of `RealtimeThreadGroup`.

`IllegalAssignmentError`—when the parent `ThreadGroup` instance is not assignable to this.

RealtimeThreadGroup(RealtimeThreadGroup, String)

Signature

```
public
RealtimeThreadGroup(RealtimeThreadGroup parent,
                    String name)
```

Description

Creates a new realtime thread group with its scheduler type inherited from `parent`.

Parameters

`parent`—The parent group of the new group

`name`—The name of the new group

Throws

`StaticIllegalStateException`—when the parent `ThreadGroup` instance is not an instance of `RealtimeThreadGroup`.

`IllegalAssignmentError`—when the parent `ThreadGroup` instance is not assignable to this.

RealtimeThreadGroup(String)

Signature

```
public
RealtimeThreadGroup(String name)
throws StaticIllegalStateException,
       IllegalAssignmentError
```

Description

Creates a new group with the current `ThreadGroup` instance as its parent and that parent's scheduler type for its scheduler type. That parent must be an instance of `RealtimeThreadGroup`. The primordial realtime thread group has `Scheduler.class` as its scheduler type.

Parameters

`name`—The name of the new group

Throws

`StaticIllegalStateException`—when the parent `ThreadGroup` instance is not an instance of `RealtimeThreadGroup`.

`IllegalAssignmentError`—when the parent `ThreadGroup` instance is not assignable to this.

6.3.3.9.2 Methods

---

getScheduler

Signature

```
public java.lang.Class<?  extends javax.realtime.Scheduler>
getScheduler()
```

Description

Finds the type of scheduler tasks in this group may use. The scheduler of each thread must be an instance of the type returned. The default is `class<Scheduler>`, but it may be set to any subtype.

Returns

the scheduler type

getMaxEligibility

Signature

```
public javax.realtime.SchedulingParameters
getMaxEligibility()
```

Description

Finds the upper bound on scheduling eligibility that tasks in this group may have. For example, when it is an instance of `PriorityParameters`, it gives the maximum base priority any task in this group.

Returns

the scheduling parameter instance denoting the upper bound on the scheduling eligibility of threads in this group, The maximal possible eligibility is represented by an instance of `SchedulingParamters`, not one of its subclasses, with an affinity that contains all processors available to the process. This may not be `null`.

setMaxEligibility(SchedulingParameters)

Signature

```
public javax.realtime.RealtimeThreadGroup
setMaxEligibility(SchedulingParameters parameters)
throws StaticIllegalStateException
```

Description

Sets the upper bound on scheduling eligibility that tasks in this group may have. For example, when it is an instance of `PriorityParameters`, it sets the maximum base priority any task in this group may have. When a task in the group has a higher eligibility than specified in `parameters`, the task's eligibility is silently set to the max specified in `parameters`.

When the new eligibility is higher than that of any parent's eligibility, then eligibility is set to the minimum of those priorities. When a child of this `RealtimeThreadGroup` has a higher max eligibility than specified in `parameters`, its max eligibility is silently set to the max specified in `parameters` as if `setMaxEligibility` were invoked on it recursively.

When a task in this `RealtimeThreadGroup` or a child of this `RealtimeThreadGroup` has previously had its maximum eligibility reduced by a call to this method, setting a higher maximum eligibility via this method will not automatically reraise its eligibility. Please note that this method is not thread safe, as it uses methods from ThreadGroup that are not thread safe.

Parameters

`parameters`—The SchedulingParameter instance denoting the new upper bound on the scheduling eligibility of threads in this group.

Throws

`StaticIllegalArgumentException`—when `parameters` are not consistent with the scheduler type. The scheduler specified must be specific enough that only mutually compatible `SchedulingParameters` could be set. For example, `Scheduler` is not sufficient to restrict the scheduling parameters to compatible types, but `PriorityScheduler` does since all `PriorityScheduler` instances require `PriorityParameters`.

`StaticIllegalStateException`—when `parameters` is a higher eligibility than the max eligibility enforced by a `SchedulingParameters` above `this` in the hierarchy.

Returns

`this`

visitThreads(Consumer, boolean)

Signature

```
public void
visitThreads(java.util.function.Consumer<java.lang.Thread> visitor,
             boolean recurse)
throws ForEachTerminationException
```

Description

Visit all `java.lang.Thread` instances contained by `this` group and optionally all `ThreadGroup` instances contained within recursively.

Parameters

`visitor`—A consumer of each schedulable instance.

`recurse`—A boolean to indicated that the visit should be recursive.

Throws

`ForEachTerminationException`—

visitThreads(Consumer)

Signature

```
public void
visitThreads(java.util.function.Consumer<java.lang.Thread> visitor)
throws ForEachTerminationException
```

Description

Visit all `java.lang.Thread` instances contained by `this` group. It is equivalent to calling `visitThreads(Consumer, boolean)` with `recurse` set to `false`.

Parameters

`visitor`—A consumer of each thread instance

Throws

`ForEachTerminationException`—when the visitor is prematurely ended.

visitThreadGroups(Consumer)

Signature

```
public void
visitThreadGroups(java.util.function.Consumer<java.lang.ThreadGroup> visitor)
throws ForEachTerminationException
```

Description

Performs some operation on all the groups in the current group. The traversal of these children continues as long as `visitor` does not throw a `ForEachTerminationException`. Thus the traversal can be prematurely ended by `visitor` throwing this exception, e.g., when a particular element is found. It is equivalent to a call to `visitThreadGroups(Consumer, boolean)` with `recurse` set to `false`.

Parameters

`visitor`—The function to be called on each child thread group.

Throws

`ForEachTerminationException`—when the traversal ends prematurely.

visitThreadGroups(Consumer, boolean)

Signature

```
public void
visitThreadGroups(java.util.function.Consumer<java.lang.ThreadGroup> visitor,
                  boolean recursive)
```

Description

Performs some operation on all th groups in the current group. The traversal of these children continues as long as `visitor` does not throw a `ForEachTerminationException`. Thus the traversal can be prematurely ended by `visitor` throwing this exception, e.g., when a particular element is found.

Parameters

`visitor`—The function to be called on each child thread group.

`recursive`—A boolean to determine whether or not all subgroups are included, where `true` means yes and `false` means no.

Throws

`ForEachTerminationException`—when the traversal ends prematurely.

6.3.3.10 ReleaseParameters

public abstract class ReleaseParameters<T extends ReleaseParameters<T>>

Inheritance

java.lang.Object
ReleaseParameters<T extends ReleaseParameters<T>>

Interfaces

`Cloneable`
`Serializable`

Description

The top-level class for release characteristics used by `Schedulable`. When a reference to a `ReleaseParameters` object is given as a parameter to a constructor of a schedulable, the `ReleaseParameters` object becomes bound to the object being created. Changes to the values in the `ReleaseParameters` object affect the constructed object. When given to more than one constructor, then changes to the values in the `ReleaseParameters` object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

Only changes to an `ReleaseParameters` object caused by methods on that object cause the change to propagate to all schedulables using the object. For instance, invoking `setDeadline` on a `ReleaseParameters` instance will make the change, and then notify the scheduler that the object has been changed. At that point the object is reconsidered for every SO that uses it. Invoking a method on the `RelativeTime` object that is the deadline for this object may change the time value but it does not pass the new time value to the scheduler at that time. Even though the changed time value is referenced by `ReleaseParameters` objects, it will not change the behavior of the SOs that use the parameter object until a setter method on the `ReleaseParameters` object is invoked, the parameter object is used in `setReleaseParameters()`, or the object is used in a constructor for a schedulable.

Release parameters use `HighResolutionTime` values for cost, and deadline. Since the times are expressed as `HighResolutionTime` values, these values use accurate timers with nanosecond granularity. The actual precision available and even the quantity the timers measure depend on the clock associated with each time value.

The implementation must use modified copy semantics for each `HighResolutionTime` parameter value. The value of each time object should be treated as when it were copied at the time it is passed to the parameter object, but the object reference must also be retained. For instance, the value returned by `getCost()` must be the same object passed in by setCost(), but any changes made to the time value of the cost must not take effect in the associated `ReleaseParameters` instance unless they are passed to the parameter object again, e.g. with a new invocation of `setCost`.

The following table gives the default parameter values for the constructors.

Table 6.11: ReleaseParameter Default Values

Attribute	Default Value
cost	new RelativeTime(0,0)
deadline	no default
overrunHandler	None
missHandler	None
rousable	false
initial event queue length	0

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

6.3.3.10.1 Fields

DISABLE_MONITORING

```
public static final RelativeTime DISABLE_MONITORING
```

Description

A special value for cost for turning off cost monitoring. This is just a notification to the VM that the application does not require cost monitoring for a give instance of `Schedulable`. What the VM does with it is system dependent; though, when a cost is so set, the application cannot rely on any cost tracking that involves said instance.

6.3.3.10.2 Constructors

ReleaseParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)

Signature

```
protected
ReleaseParameters(RelativeTime cost,
                  RelativeTime deadline,
                  AsyncEventHandler overrunHandler,
                  AsyncEventHandler missHandler,
                  boolean rousable)
```

Description

Creates a new instance of `ReleaseParameters` with the given parameter values.

Parameters

`cost`—Processing time units per release. On implementations which can measure the amount of time an instance of `schedulable` is executed, when null, the default value is a new instance of `RelativeTime(0, 0)` meaning that no cost enforcement will take place. Setting it to `DISABLE_MONITORING` disables cost monitoring as well.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. There is no default for deadline in this class. The default must be determined by the subclasses.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost. In the minimum implementation overrunHandler is ignored. When null, no application event handler is executed on cost overrun.

`missHandler`—This handler is invoked when the run() method of the schedulable is still executing after the deadline has passed. When null, no application event handler is executed on the miss deadline condition.

`rousable`—When `true`, an interrupt will cause this schedulable fire immediately.

Throws

`StaticIllegalArgumentException`—when the time value of cost is less than zero, or the time value of deadline is less than or equal to zero, or the chronograph associated with the `cost` or `deadline` parameters is not an instance of `Clock`.

`IllegalAssignmentError`—when cost, deadline, overrunHandler, or missHandler cannot be stored in this. Since RTSJ 2.0

ReleaseParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
protected
ReleaseParameters(RelativeTime cost,
                  RelativeTime deadline,
                  AsyncEventHandler overrunHandler,
                  AsyncEventHandler missHandler)
```

Description

Creates a new instance of `ReleaseParameters` with the given parameter values.

Parameters

`cost`—Processing time units per release. On implementations which can measure the amount of time an instance of `schedulable` is executed, when null, the default value is a new instance of `RelativeTime(0, 0)` meaning that no cost enforcement will take place. Setting it to `DISABLE_MONITORING` disables cost monitoring as well.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. There is no default for deadline in this class. The default must be determined by the subclasses.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost. In the minimum implementation overrunHandler is ignored. When null, no application event handler is executed on cost overrun.

`missHandler`—This handler is invoked when the run() method of the schedulable is still executing after the deadline has passed. When null, no application event handler is executed on the miss deadline condition.

Throws

`StaticIllegalArgumentException`—when the time value of cost is less than zero, or the time value of deadline is less than or equal to zero, or the chronograph associated with the `cost` or `deadline` parameters is not an instance of `Clock`.

`IllegalAssignmentError`—when cost, deadline, overrunHandler, or missHandler cannot be stored in this.

ReleaseParameters

Signature

```
protected
ReleaseParameters()
```

Description

Equivalent to `ReleaseParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)` with the argument list `(null, null, null, null)`.

6.3.3.10.3 Methods

clone

Signature

```
public java.lang.Object
clone()
```

Description

Obtains a clone of `this`. This method should behave effectively as when it constructed a new object with clones of the high-resolution time values of `this`.

- The new object is in the current allocation context.
- `clone` does not copy any associations from `this` and it does not implicitly bind the new object to a SO.
- The new object has clones of all high-resolution time values (deep copy).
- References to event handlers are copied (shallow copy.)

Since RTSJ 1.0.1

getCost

Signature

```
public javax.realtime.RelativeTime
getCost()
```

Description

Determines the current value of cost. A value of `RelativeTime(0,0` meaning that no cost enforcement will take place; whereas a value of `DISABLE_MONITORING` means cost monitoring is disabled.

Returns

the object last used to set the cost containing the current value of cost.

getCost(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getCost(RelativeTime value)
```

Description

Determines the current value of cost, where `Relative(0,0)` means no cost enforcement in being done and `DISABLE_MONITORING` means cost monitoring is disabled as well.

Parameters

`value`—The parameter in which to return the cost.

Returns

`value` or, when `null`, the last object used to set the cost, set to the current value of cost.

Since RTSJ 2.0

getCostOverrunHandler

Signature

```
public javax.realtime.AsyncEventHandler
getCostOverrunHandler()
```

Description

Gets a reference to the cost overrun handler.

Returns

a reference to the associated cost overrun handler.

getDeadline

Signature

```
public javax.realtime.RelativeTime
getDeadline()
```

Description

Determines the current value of deadline.

Returns

the object last used to set the deadline containing the current value of deadline.

getDeadline(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getDeadline(RelativeTime value)
```

Description

Determines the current value of deadline.

Parameters

`value`—The parameter in which to return the deadline.

Returns

`value` or, when `null`, the last object used to set the deadline, set to the current value of deadline.

Since RTSJ 2.0

getDeadlineMissHandler

Signature

```
public javax.realtime.AsyncEventHandler
getDeadlineMissHandler()
```

Description

Gets a reference to the deadline miss handler.

Returns

a reference to the deadline miss handler.

setCost(RelativeTime)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setCost(RelativeTime cost)
```

Description

Sets the cost value.

When this parameter object is associated with any schedulable object (by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setReleaseParameters(ReleaseParameters)`) the cost of those schedulables takes effect immmediately.

Parameters

`cost`—Processing time units per release. On implementations which can measure the amount of time a schedulable is executed, this value is the maximum amount of time a schedulable receives per release. On implementations which cannot measure execution time, it is not possible to determine when any particular object exceeds cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the clock associated with the `cost` parameters is not the realtime clock.

`IllegalAssignmentError`—when `cost` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

setCostOverrunHandler(AsyncEventHandler)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setCostOverrunHandler(AsyncEventHandler handler)
throws IllegalAssignmentError
```

Description

Sets the cost overrun handler.

When this parameter object is associated with any schedulable object (by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setReleaseParameters(ReleaseParameters)`) the cost overrun handler of those schedulables is effective immediately.

Parameters

`handler`—This handler is invoked when an invocation of the schedulable attempts to exceed `cost` time units in a release. A `null` value of `handler` signifies that no cost overrun handler should be used.

Throws

`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

setDeadline(RelativeTime)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setDeadline(RelativeTime deadline)
```

Description

Sets the deadline value.

When this parameter object is associated with any schedulable object (by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setReleaseParameters(ReleaseParameters)`) the deadline of those schedulables take effect at completion.

Parameters

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. The default value of the deadline must be controlled by the classes that extend `ReleaseParameters`.

Throws

`StaticIllegalArgumentException`—when `deadline` is `null`, the time value of `deadline` is less than or equal to zero, or when the new value of this deadline is incompatible with the scheduler for any associated schedulable.

`IllegalAssignmentError`—when `deadline` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

setDeadlineMissHandler(AsyncEventHandler)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setDeadlineMissHandler(AsyncEventHandler handler)
```

Description

Sets the deadline miss handler.

When this parameter object is associated with any schedulable object (by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setReleaseParameters(ReleaseParameters)`) the deadline miss handler of those schedulables take effect at completion.

Parameters

`handler`—This handler is invoked when any release of the schedulable fails to complete before the deadline passes. A `null` value of `handler` signifies that no deadline miss handler should be used.

Throws

`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

isRousable

Signature

```
public boolean
isRousable()
```

Description

Determines whether or not a thread interrupt will cause instances of `Schedulable` associated with an instance of this class to be prematurely released, i.e., released before the very first release event happens. It has no effect for periodic realtime threads, since the first event of a timing is when start is called. The default value, i.e., before any call to `setRousable(boolean)`, is `false`.

Note that the rousable state has no effect on instances of `RealtimeThread` which have an instance of `BackgroundParameters` for `ReleaseParameters` or on ordinary event handlers, i.e., those which do not extend `ActiveEvent`. In the former case, there are no releases to interrupt and, in the case, the handler does not have a `ActiveEventDispatcher` to release it.

Returns

`true` when rousable and `false` when not.

Since RTSJ 2.0

setRousable(boolean)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setRousable(boolean value)
```

Description

Dictates whether or not a thread interrupt will cause instances of `Schedulable` associated with an instance of this class to be prematurely released, i.e., released before the very first release event happens.

Parameters

`value`—When rousable, `true` and `false` when not.

Returns

`this`

Since RTSJ 2.0

enforcingCost

Signature

```
public boolean
enforcingCost()
```

Description

Determines whether or not cost is being enforced for releases.

Returns

`true` when enforcing code.

Since RTSJ 2.0

enforceCost(boolean)

Signature

```
public void
enforceCost(boolean value)
throws StaticUnsupportedOperationException
```

Description

Sets cost enforcement.

Parameters

`value`—`true` to enforce code, `false` to turn off enforcement.

Throws

`StaticUnsupportedOperationException`—when cost enforcement is not supported on this platform.

Since RTSJ 2.0

getEventQueueOverflowPolicy

Signature

```
public javax.realtime.QueueOverflowPolicy
getEventQueueOverflowPolicy()
```

Description

Gets the behavior of the arrival time queue in the event of an overflow.

Returns

the behavior of the arrival time queue.

Since RTSJ 2.0

setEventQueueOverflowPolicy(QueueOverflowPolicy)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setEventQueueOverflowPolicy(QueueOverflowPolicy policy)
```

Description

Sets the policy for the arrival time queue for when the insertion of a new element would make the queue size greater than the initial size given in `this`.

Parameters

`policy`—A queue overflow policy to use for handlers associated with `this`.

Returns

`this`

Since RTSJ 2.0

getInitialQueueLength

Signature

```
public int
getInitialQueueLength()
```

Description

Gets the initial number of elements the event queue can hold. This returns the initial queue length currently associated with this parameter object. When the overflow policy is `SAVE` the initial queue length may not be related to the current queue lengths of schedulables associated with this parameter object.

Returns

the initial length of the queue.

Since RTSJ 2.0 replaces the subclasse method `AperiodicParameters.getInitialArrivalTimeQueueLength()`.

setInitialQueueLength(int)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setInitialQueueLength(int initial)
```

Description

Sets the initial number of elements the arrival time queue can hold without lengthening the queue. The initial length of an arrival queue is set when the schedulable using the queue is constructed, after that time changes in the initial queue length are ignored. The queue may have a length of zero, i.e., any event, along with its arrival time, received during a previous release is lost.

Parameters

`initial`—The initial length of the queue.

Throws

`StaticIllegalArgumentException`—when `initial` is less than zero.

Returns

`this`

Since RTSJ 2.0 replaces the subclass method `AperiodicParameters.setInitialArrivalTimeQueueLength(int)`.

6.3.3.11 RoundRobinParameters

---

public class RoundRobinParameters

Inheritance

java.lang.Object
  SchedulingParameters
    PriorityParameters

RoundRobinParameters

Description

Same as `PriorityParameters` except that it is only valid with the `RoundRobinScheduler`.

Since RTSJ 2.0

6.3.3.11.1 Constructors

RoundRobinParameters(int, Affinity)

Signature

```
public
RoundRobinParameters(int priority,
                     Affinity affinity)
```

Description

Create scheduling parameters restricted to the round robin scheduler.

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

`affinity`—The affinity assigned to schedulables that use this parameter instance.

RoundRobinParameters(int)

Signature

```
public
RoundRobinParameters(int priority)
```

Description

Create scheduling parameters restricted to the round robin scheduler.

Parameters

`priority`—The priority assigned to schedulables that use this parameter instance.

6.3.3.11.2 Methods

---

isCompatible(Scheduler)

Signature

```
public boolean
isCompatible(Scheduler scheduler)
```

Description

Parameters
`scheduler`—The scheduler to check against
Returns
`true` when and only when `this` can be used with `scheduler` as the scheduler.

Since RTSJ 2.0

subsumes(SchedulingParameters)

Signature

```
public boolean
subsumes(SchedulingParameters other)
```

Description

Parameters
`other`—The other parameters object to be compared with.
Returns
true when and only when this parameters is more eligible than the other parameters.

6.3.3.12 RoundRobinScheduler

---

public class RoundRobinScheduler

Inheritance
java.lang.Object
Scheduler
PriorityScheduler
RoundRobinScheduler

Description

Class which represents a priority-based round-robin scheduler.
The default instance of this scheduler (returned by `instance()`) represents the RTSJ-specified round-robin scheduler.

Since RTSJ 2.0

6.3.3.12.1 Methods

---

instance

Signature

```
public static javax.realtime.RoundRobinScheduler
instance()
```

Description

Gets a reference to the distinguished instance of `RoundRobinScheduler` which is the RTSJ-specified round-robin scheduler.

Throws

`StaticUnsupportedOperationException`—if this platform has no default round-robin scheduler.

Returns

a reference to the distinguished instance of `RoundRobinScheduler`

setQuantum(RelativeTime)

Signature

```
public javax.realtime.RoundRobinScheduler
setQuantum(RelativeTime quantum)
throws StaticUnsupportedOperationException,
       StaticIllegalArgumentException
```

Description

Sets the quantum of this instance of `RoundRobinScheduler`. This takes effect at the end of the current quantum.

Parameters

`quantum`—The new quantum to use. Copy semantics are used for this argument, and future changes to `quantum` will not affect this scheduler unless it is again passed to `setQuantum()`.

Throws

`StaticUnsupportedOperationException`—if this scheduler's quantum is not configurable at runtime.

`StaticIllegalArgumentException`—if the provided quantum is null, less than zero, or not appropriate for this platform.

Returns

`this`

getQuantum

Signature

```
public javax.realtime.RelativeTime
getQuantum()
```

Description

Gets the quantum of this instance of `RoundRobinScheduler`.

Returns

a newly-allocated `RelativeTime` containing the currently-configured quantum of this scheduler.

getQuantum(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getQuantum(RelativeTime dest)
```

Description

Gets the quantum of this instance of `RoundRobinScheduler`.

Parameters

`dest`—A time object in which to hold the quantum. When `dest` is `null`, a new `RelativeTime` instance is allocated to hold the returned value.

Returns

the currently-configured quantum of this scheduler.

getMaxPriority

Signature

```
public int
getMaxPriority()
```

Description

Gets the maximum priority available for a schedulable managed by this scheduler.

Returns

the value of the maximum priority.

getMinPriority

Signature

```
public int
getMinPriority()
```

Description

Gets the minimum priority available for a schedulable managed by this scheduler.

Returns

the minimum priority used by this scheduler.

getNormPriority

Signature

```
public int
getNormPriority()
```

Description

Gets the normal priority available for a schedulable managed by this scheduler.

Returns

the value of the normal priority.

getPolicyName

Signature

```
public java.lang.String
getPolicyName()
```

Description

Gets the policy name of `this`.

Returns

the policy name (Fixed Priority Round Robin) as a string.

reschedule(Thread, SchedulingParameters)

Signature

```
public void
reschedule(Thread thread,
           SchedulingParameters eligibility)
```

Description

Parameters

`thread`—The thread to promote to realtime scheduling.

`eligibility`—A `SchedulingParameters` instance such as `PriorityParameters` for a `PriorityScheduler`.

Throws

`StaticIllegalArgumentException`—when `eligibility` is not valid for the scheduler.

`StaticIllegalStateException`—when `eligibility` specifies parameters that are out of range for the scheduler or the threads state or the intersection of affinity in `scheduling` and the affinity of realtime thread group associated with `thread` is empty.

`StaticUnsupportedOperationException`—when `thread` a normal Java thread and the scheduler does not support promoting normal java threads.

Since RTSJ 2.0

6.3.3.13 Scheduler

---

public abstract class Scheduler

Inheritance
java.lang.Object
Scheduler

Description

An instance of `Scheduler` manages the execution of schedulables.

Subclasses of `Scheduler` are used for alternative scheduling policies and should define an `instance()` class method to return the default instance of the subclass. The name of the subclass should be descriptive of the policy, allowing applications to deduce the policy available for the scheduler obtained via `Scheduler.getDefaultScheduler`, e.g., `EDFScheduler`.

6.3.3.13.1 Constructors

Scheduler

Signature

```
protected
Scheduler()
```

Description

Creates an instance of `Scheduler`.

6.3.3.13.2 Methods

---

getDefaultScheduler

Signature

```
public static javax.realtime.Scheduler
getDefaultScheduler()
```

Description

Gets a reference to the default scheduler.

Returns
a reference to the default scheduler.

setDefaultScheduler(Scheduler)

Signature

```
public static void
setDefaultScheduler(Scheduler scheduler)
```

Description

Sets the default scheduler. This is the scheduler given to instances of schedulables when they are constructed by a Java thread. The default scheduler is set to the required `PriorityScheduler` at startup.

Parameters

`scheduler`—The `Scheduler` that becomes the default scheduler assigned to new schedulables created by Java threads. When `null` nothing happens.

Throws

`StaticSecurityException`—when the caller is not permitted to set the default scheduler.

inSchedulableExecutionContext

Signature

```
public static boolean
inSchedulableExecutionContext()
```

Description

Determines whether the current calling context is a `Schedulable`: `RealtimeThread` or `AsyncBaseEventHandler`.

Returns

`true` when yes and `false` otherwise.

Since RTSJ 2.0

currentSchedulable

Signature

```
public static javax.realtime.Schedulable
currentSchedulable()
```

Description

Gets the current execution context when called from a `Schedulable` execution context.

Throws

`ClassCastException`—when the caller is not a `Schedulable`

Returns

the current `Schedulable`.

Since RTSJ 2.0

getPolicyName

Signature

```
public abstract java.lang.String
getPolicyName()
```

Description

Gets a string representing the policy of `this`. The string value need not be interned, but it must be created in a memory area that does not cause an illegal assignment error when stored in the current allocation context and does not cause a `MemoryAccessError` when accessed.

Returns

a `String` object which is the name of the scheduling policy used by `this`.

reschedule(Thread, SchedulingParameters)

Signature

```
public abstract void
reschedule(Thread thread,
           SchedulingParameters eligibility)
```

Description

Promotes a `java.lang.Thread` to realtime priority under this scheduler. The affected thread will be scheduled as if it was a `RealtimeThread` with the given eligibility. This does not make the affected thread a `RealtimeThread`, however, and it will not have access to facilities reserved for instances of `RealtimeThread`. Instances of `RealtimeThread` will be treated as if their scheduling parameters were set to `eligibility`.

Parameters

`thread`—The thread to promote to realtime scheduling.

`eligibility`—A `SchedulingParameters` instance such as `PriorityParameters` for a `PriorityScheduler`.

Throws

`StaticIllegalArgumentException`—when `eligibility` is not valid for the scheduler.

`StaticIllegalStateException`—when `eligibility` specifies parameters that are out of range for the scheduler or the threads state or the intersection of affinity in `scheduling` and the affinity of realtime thread group associated with `thread` is empty.

`StaticUnsupportedOperationException`—when `thread` a normal Java thread and the scheduler does not support promoting normal java threads.

Since RTSJ 2.0

createDefaultSchedulingParameters

Signature

```
protected javax.realtime.SchedulingParameters
createDefaultSchedulingParameters()
```

Description

Create a default `SchedulingParameters` instance for this schedulers. A scheduler must define this in order to support setting `Schedulable.setSchedulingParameters` with `null` as its parameter. Otherwise, null is not allowed.

Throws

`IllegalTaskStateException`—when the current task is using a scheduler that does not support `null` scheduling parameters.

Returns

parameters that are suitable for this scheduler in the current context.

Since RTSJ 2.0

6.3.3.14 SchedulingParameters

---

public class SchedulingParameters

Inheritance

java.lang.Object
  SchedulingParameters

Interfaces

`Cloneable`
`Serializable`
javax.realtime.Subsumable

Description

Subclasses of `SchedulingParameters` (`PriorityParameters`, `ImportanceParameters`, and any others parameters defined for particular schedulers) provide the parameters to be used by the `Scheduler`. Changes to the values in a parameters object affects the scheduling behavior of all the `Schedulable` objects to which it is bound.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

6.3.3.14.1 Constructors

SchedulingParameters(Affinity)

Signature

```
protected
SchedulingParameters(Affinity affinity)
```

Description

Creates a new instance of `SchedulingParameters`.

Since RTSJ 2.0

Parameters

`affinity`—Sets the affinity for these parameters.

SchedulingParameters

Signature

```
protected
SchedulingParameters()
```

Description

Creates a new instance of `SchedulingParameters` with the default Affinity.

Since RTSJ 1.0.1

6.3.3.14.2 Methods

---

clone

Signature

```
public java.lang.Object
clone()
```

Description

Creates a clone of `this`.

- The new object is in the current allocation context.
- `clone` does not copy any associations from `this` and it does not implicitly bind the new object to a schedulable.

Since RTSJ 1.0.1

isCompatible(Scheduler)

Signature

```
public boolean
isCompatible(Scheduler scheduler)
```

Description

Determines whether `this` scheduling parameters can be used by tasks scheduled by `scheduler`.

Parameters
`scheduler`—The scheduler to check against
Returns
`true` when and only when `this` can be used with `scheduler` as the scheduler.

Since RTSJ 2.0

subsumes(SchedulingParameters)

Signature

```
public boolean
subsumes(SchedulingParameters other)
```

Description

Determines whether this parameters is more eligible than another.

Parameters
`other`—The other parameters object to be compared with.
Returns
true when and only when this parameters is more eligible than the other parameters.

getAffinity

Signature

```
public javax.realtime.Affinity
getAffinity()
```

Description

Determines the affinity set instance associated of these parameters.

Returns
The associated affinity.

Since RTSJ 2.0

6.3.3.15 SporadicParameters

---

public class SporadicParameters

Inheritance
java.lang.Object
ReleaseParameters<AperiodicParameters>
AperiodicParameters
SporadicParameters

Description

A notice to the scheduler that the associated schedulable will be released aperiodically but with a minimum time between releases.

When a reference to a `SporadicParameters` object is given as a parameter to a schedulable's constructor or passed as an argument to one of the schedulable's setter methods, the `SporadicParameters` object becomes the release parameters object bound to that schedulable. Changes to the values in the `SporadicParameters` object affect that schedulable object. When bound to more than one schedulable then changes to the values in the `SporadicParameters` object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

The implementation must use modified copy semantics for each `HighResolutionTime` parameter value. The value of each time object should be treated as when it were copied at the time it is passed to the parameter object, but the object reference must also be retained. Only changes to a `SporadicParameters` object caused by methods on that object cause the change to propagate to all schedulables using the parameter object. For instance, calling `setCost` on a `SporadicParameters` object will make the change, then notify the scheduler that the parameter object has changed. At that point the object is reconsidered for every SO that uses it. Invoking a method on the `RelativeTime` object that is the cost for this object may change the cost but it does not pass the change to the scheduler at that time. That change must not change the behavior of the SOs that use the parameter object until a setter method on the `SporadicParameters` object is invoked, the parameter object is used in `setReleaseParameters()`, or the object is used in a constructor for an SO.

The following table gives the default parameter values for the constructors.

Table 6.13: SporadicParameters Default Values

Attribute	Value
minInterarrival time	No default. A value must be supplied
cost	new RelativeTime(0,0)
deadline	new RelativeTime(mit)
overrunHandler	None
missHandler	None
rousable	false
MIT violation policy	SAVE
Arrival queue overflow policy	SAVE
Initial arrival queue length	0

This class enables the application to specify one of four arrival behaviors defined by `MinimumInterarrivalPolicy`. Each behavior indicates what to do when an arrival occurs that is closer in time to the previous arrival than the value

given in this class as minimum interarrival time. They also specify what to do when, for any reason, the queue overflows, and what the initial size of the queue should be.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

6.3.3.15.1 Constructors

SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)

Signature

```
public
SporadicParameters(RelativeTime minInterarrival,
                   RelativeTime cost,
                   RelativeTime deadline,
                   AsyncEventHandler overrunHandler,
                   AsyncEventHandler missHandler,
                   boolean rousable)
```

Description

Creates a `SporadicParameters` object.

Since RTSJ 2.0

Parameters

`minInterarrival`—The release times of the schedulable will occur no closer than this interval. This time object is treated as if it were copied. Changes to `minInterarrival` will not affect the `SporadicParameters` object. There is no default value. When `minInterarrival` is `null` an illegal argument exception is thrown.

`cost`—Processing time per release. On implementations which can measure the amount of time a schedulable is executed, this value is the maximum amount of time a schedulable receives per release. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The latest permissible completion time measured from the release time of the associated invocation of the schedulable. When `null`, the default value is a new instance of `minInterarrival`: `new RelativeTime(minInterarrival)`.

`overrunHandler`—This handler is invoked when an invocation of the schedulable exceeds cost. Not required for minimum implementation. When `null` no overrun handler will be used.

`missHandler`—This handler is invoked when the `run()` method of the schedulable is still executing after the deadline has passed. When `null`, no deadline miss handler will be used.

`rousable`—Determines whether or not an instance of `Schedulable` can be prematurely released by a thread interrupt.

Throws

`StaticIllegalArgumentException`—when `minInterarrival` is `null` or its time value is not greater than zero, or the time value of `cost` is less than zero, or the time value of `deadline` is not greater than zero, or when the chronograph associated with `deadline` and `minInterarrival` parameters are not identical or not an instance of `Clock`.

`IllegalAssignmentError`—when `minInterarrival`, `cost`, `deadline`, `overrunHandler` or `missHandler` cannot be stored in `this`.

SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
SporadicParameters(RelativeTime minInterarrival,
                   RelativeTime cost,
                   RelativeTime deadline,
                   AsyncEventHandler overrunHandler,
                   AsyncEventHandler missHandler)
```

Description

Equivalent to `SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with an argument list of `(minInterarrival, cost, deadline, overrunHandler, missHandler, false)`.

SporadicParameters(RelativeTime, RelativeTime, AsyncEventHandler, boolean)

Signature

```
public
SporadicParameters(RelativeTime minInterarrival,
                   RelativeTime deadline,
                   AsyncEventHandler missHandler,
                   boolean rousable)
```

Description

Equivalent to `SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with an argument list of `(minInterarrival, null, deadline, null, missHandler, rousable)`.

Since RTSJ 2.0

SporadicParameters(RelativeTime)

Signature

```
public
SporadicParameters(RelativeTime minInterarrival)
```

Description

Equivalent to `SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)` with an argument list of `(minInterarrival, null, null, null, null, false)`.

Since RTSJ 1.0.1

6.3.3.15.2 Methods

---

getMinimumInterarrival

Signature

```
public javax.realtime.RelativeTime
getMinimumInterarrival()
```

Description

Determines the current value of minimal interarrival.

Returns

the object last used to set the minimal interarrival containing the current value of minimal interarrival.

getMinimumInterarrival(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMinimumInterarrival(RelativeTime value)
```

Description

Determines the current value of minimum interarrival.

Returns

`value` or, when `null`, the last object used to set the minimal interarrival, set to the current value of minimal interarrival.

Since RTSJ 2.0

setMinimumInterarrival(RelativeTime)

Signature

```
public javax.realtime.SporadicParameters
setMinimumInterarrival(RelativeTime minimum)
```

Description

Sets the minimum interarrival time.

Parameters

`minimum`—The release times of the schedulable will occur no closer than this interval.

Throws

`StaticIllegalArgumentException`—when `minimum` is `null` or its time value is not greater than zero.

`IllegalAssignmentError`—when `minimum` cannot be stored in `this`.

Returns

`this`

Since RTSJ 2.0 returns itself

setMinimumInterarrivalPolicy(MinimumInterarrivalPolicy)

Signature

```
public javax.realtime.SporadicParameters
setMinimumInterarrivalPolicy(MinimumInterarrivalPolicy policy)
```

Description

Sets the policy for handling the arrival time queue when the new arrival time is closer to the previous arrival time than the minimum interarrival time given in `this`.

Parameters

`policy`—The current policy for MIT violations.

Since RTSJ 2.0

getMinimumInterarrivalPolicy

Signature

```
public javax.realtime.MinimumInterarrivalPolicy
getMinimumInterarrivalPolicy()
```

Description

Gets the arrival time queue policy for handling minimal interarrival time underflow.

Returns

the minimum interarrival time violation behavior as a string.

Since RTSJ 2.0

setEventQueueOverflowPolicy(QueueOverflowPolicy)

Signature

```
public javax.realtime.SporadicParameters
setEventQueueOverflowPolicy(QueueOverflowPolicy policy)
throws StaticIllegalArgumentException
```

Description

Sets the policy for the arrival time queue for when the insertion of a new element would make the queue size greater than the initial size given in `this`.

Parameters

`policy`—The new overflow policy to use.

Throws

`StaticIllegalArgumentException`—when `policy` is `QueueOverflowPolicy.DISABLE`.

Returns

`this`

6.4 Rationale

As specified, the required semantics of this section establish a scheduling policy that is very similar to the scheduling policies found on the vast majority of realtime operating systems and kernels in commercial use today. The semantics for the base scheduler accommodate existing practice, which is a stated goal of the effort.

There is an important division between priority schedulers that force periodic context switching between tasks at the same priority, and those that do not cause these context switches. By not specifying time slicing[1] behavior this specification calls for the latter type of priority scheduler as the base scheduler: `FirstInFirstOutScheduler`. The specification supplies a second scheduler, `RoundRobinScheduler`, for cases where time slicing behavior is desired. In POSIX terms, `SCHED_FIFO` meets the `RTSJ` requirements for the base scheduler, and `SCHED_RR` meets the requirements for the round-robin scheduler.

Although a system may not implement the first release (start) of a schedulable as unblocking that schedulable, under the base scheduler those semantics apply; i.e., the schedulable is added to the tail of the queue for its active priority.

Some research shows that, given a set of reasonable common assumptions, 32 distinct priority levels are a reasonable choice for close-to-optimal scheduling efficiency when using the rate-monotonic priority assignment algorithm on a single processor system (256 priority levels provide better efficiency). This specification requires at least 28 distinct priority levels as a compromise noting that implementations of this specification will exist on systems with logic executing outside of the Java Virtual Machine and may need priorities above, below, or both for system activities.

The default behavior for implementations that support cost monitoring and enforcement is that a schedulable receives no more than `cost` units of CPU time during each release. The programmer must explicitly change the cost attribute to

override the scheduler. The RTSJ allows schedulables to self suspend during a release, in addition to that which might be necessary to acquire a lock. These self suspensions must be time bounded.

Any self suspension which is not time bounded may undermine the cost enforcement model specified in this document, as it may result in a schedulable suspending beyond its next release event. This can result in more time being allocated than any associated schedulability analysis might assume. See Dos Santos and Wellings for a full discussion on the problem [4].

Cost enforcement may be deferred while the overrun schedulable holds locks that are out of application control, such as locks used to protect garbage collection. Applications should include the resulting jitter in any analysis that depends on cost enforcement.

6.4.1 RealtimeThreadGroup

The RealtimeThreadGroup was added in RTSJ 2.0 to support the notion of a subsystem constrained by the greater system configuration. It also extends the existing ThreadGroup limits for realtime scheduling. In addition, provides a way to enable Java threads to be elevated to realtime scheduling priorities in a controlled fashion.

A combination of security manager policy and the RealtimeThreadGroup hierarchy may be used to constrain the maximum priority directly configurable by an entire subsystem. To achieve this, a RealtimeThreadGroup with an appropriate maximum priority must be created, the security manager must be configured to disallow threads in that RealtimeThreadGroup from accessing their parent RealtimeThreadGroup, and all threads for the subsystem must be created in that RealtimeThreadGroup. This tactic may even be used recursively.

As previously mentioned, a motivation for adding RealtimeThreadGroup as a subclass of ThreadGroup is to clarify the relationship between Java threads and realtime schedulers. In order to obtain realtime priorities, a Java thread must belong to a RealtimeThreadGroup. Its access to realtime scheduling is then restricted (with the exception of priority inversion avoidance protocols, which ignore such restrictions) by the configuration of its RealtimeThreadGroup. This enables Java threads to obtain realtime priorities in a controlled and predictable fashion. Likewise, realtime threads (but not necessarily other schedulables) may obtain nonrealtime conventional Java priorities by calling Thread.setPriority() on their RealtimeThread object. To start a realtime thread with a nonrealtime priority, this call must be made prior to the time at which the realtime thread is started.

6.4.2 Multiprocessor Support

The support that the RTSJ provides for multiprocessor systems is primarily constrained by the support it can expect from the underlying operating system. Multiprocessor systems have two main variants: Single Instruction, Multiple Data (SIMD) systems and Multiple Instruction, Multiple Data (MIMD) systems. Putting the first

class aside, since it does not fit in well with the overall Java programming model[3], there is still a good deal of variation to consider. Though most commercially available systems are symmetric multiprocessors (SMP) systems, nonuniform memory access (NUMA) systems need consideration as well.

The notion of processor *affinity* is common across operating systems and has become the accepted way to specify the constraints on which processor a thread can execute. In some sense, processor affinities can be viewed as additional release or scheduling parameters. The range of processors on which global scheduling is possible is dictated by the operating system. For SMP architectures, global scheduling across all processors in the system is typically supported. However, an application and an operator can constrain threads and processes to execute only within a subset of the processors. As the number of processors increases, the scalability of global scheduling is called into question. Hence, for NUMA architectures, some partitioning of the processors is likely to be performed by the OS. On these systems, global scheduling across all processors will not be possible.

Many OSs give system operators command-level dynamic control over the set of processors allocated to a processes. Consequently, the realtime JVM has no control over whether processors are dynamically added or removed from its OS process. Predictability is a prime concern of the `RTSJ`. Clearly, dynamic changes to the allocated processors will have a dramatic, and possibly catastrophic, effect on the ability of the program to meet timing requirements.

Being able to support a wide variety of multiprocessor systems has a direct impact on the support for multiprocessing.

1. Since affinity is a widely used concept for controlling multiprocessor systems, the specification adopts this notion.
2. In order to organize the API, affinity is modeled with its own class: `Affinity`.
3. An instance of `Affinity` is added to the `SchedulingParameters` class to avoid support for affinities to be distributed throughout the specification with a proliferation of new constructor methods.
4. The `RealtimeThreadGroup` has been added to provides affinity support for conventional Java threads without modifying the thread object's visible API and provide a partitioning mechanism for affinities.
5. Since the set of affinities possible is system dependent, the affinity class provides an array of *predefined* affinities. They can be used either to reflect the scheduling arrangement of the underlying OS. A program is only allowed to dynamically create new affinities with cardinality of one.
6. To support external dynamic control over the set of processors allocated to a `RTSJ` program, the affinity class provides a means of notifying when the processor set changes.

6.4.3 Impact of Clock Granularity

All time-triggered computation can suffer from release jitter. This is defined to be the variation in the actual time the computation becomes available for execution from

[3]The lambda extension provides an intriguing paradigm for extending Java to supporting SIMD coprocessors.

its scheduled release time. The amount of release jitter depends on two factors. The first is the granularity of the clock/timer used to trigger the release. For example, a periodic event handler that is due to be released at absolute time T will actually be release at time $T + \delta$. δ is the difference between T and the first time the timer clock advances to $T0$, where $T0 >= T$. The upper bound of δ is the value returned from calling the getResolution method of the associated clock. It is for this reason that the implementation of release times for periodic activities must use absolute rather than relative time values, in order to avoid the drift accumulating.

The second contribution to release jitter is also related to the clock/timer. It is the duration of interval between $T0$ being signaled by the clock/timer and the time this event is noticed by the underlying operating system or platform (perhaps because interrupts have been disabled). A compliant implementation of SCJ should document the maximum value of δ for the realtime clock.

6.4.4 Deadline Miss Detection

Although `RTSJ` supports deadline miss detection, it is important to understand the intrinsic limitations of the facility. The `RTSJ` facility is supported using a time-triggered event. All time-triggered computation can suffer from release jitter. Hence, any given deadline miss handler might not be released until sometime after the deadline has expired. The handlers actual execution will depend on its priority relative to other schedulables.

A related limitation is that a deadline can be missed but not detected. This can occur when the deadline has been set at a smaller granularity than the detecting timer. Consider an absolute deadline of D. Suppose that the next absolute time that the timer can recognize is $D + \delta$. When the associate thread finishes after D but before $D + \delta$, it will have missed its deadline, but this miss will have been undetected.

A third limitation is due to the inherent race condition that is present when checking for deadline misses. A deadline miss is defined to occur when a schedulable has not completed the computation associated with its release before its deadline. This completion event is signaled in the application code by the return of the `handleAsyncEvent` method or a call to `waitForNextRelease` etc. When this occurs, the infrastructure reschedules/cancels the timing event that signals the miss of a deadline. This is clearly a race condition. The timer event could fire between the last statement the completion event and the rescheduling/canceling of the timer event. Hence a deadline miss could be signaled when arguably the application had performed all of its computation.

Chapter 7

Synchronization

One of the strengths of Java is its language support for multithreading. This requires synchronization. In a realtime system, there are additional requirements on this synchronization. Therefore this specification not only tightens the semantics of the synchronization declarations, but it also provides addition classes that specifically manage synchronization.

This specification strengthens the semantics of Java `synchronized` code by mandating monitor execution eligibility control, commonly referred to as priority inversion control. The `MonitorControl` class is defined as the superclass of all such execution eligibility control algorithms. Its subclasses `PriorityInheritance` and `PriorityCeilingEmulation` avoid unbounded priority inversions, which would be unacceptable in realtime systems.

The classes described below provide two main services.

1. They enable the setting of a priority inversion control policy either as the default or for specific objects.
2. They also provide wait-free communication between schedulables (especially instances of `Schedulable`, whose `mayUseHeap` is `false`) and regular Java threads.

These classes establish a framework for priority inversion management that applies to priority-oriented schedulers in general, and a specific set of requirements for the base priority scheduler. The wait-free queue classes provide safe, concurrent access to data shared between schedulables without heap access and schedulables subject to garbage collection delays.

7.1 Definitions

Scheduling Eligibility Inversion — When a more important task is blocked by a less important task. This is usually caused by synchronization, where a more important task must wait for a less important task to release a required resource, which can in turn be blocked by a task of intermediate importance. The classical example is priority inversion in a system with a priority-based scheduler.

Governed by — An object `A` that has been assigned (either by default or via an explicit method call) to the `MonitorControlPolicy` α is said to be *governed*

by α.

Active Priority — The priority of a task used for scheduling at any given time. It is the maximum of the tasks's current base priority and any priority boosting due to priority inversion avoidance mechanisms. The base priority can be temporarily reduced by cost enforcement.

7.2 Semantics

Synchronization semantics has two main aspects: monitor control and scheduling. The first determines which inversion avoidance is to use. The second determines how it is done. Since only priority-based schedulers are defined in the `RTSJ`, the semantics is only completely defined for priority-based schedulers.

7.2.1 Monitor Control

The specification provides for two monitor control policies with the following semantics.

1. The initial default monitor control policy shall be `PriorityInheritance`. The default policy can be altered by using the `setMonitorControl()` method.
2. Notwithstanding the preceding rule, an `RTSJ` implementation may allow the program to establish a different initial default monitor control policy at JVM startup. The program can query the initial default monitor control policy via the method `RealtimeSystem.getInitialMonitorControl`.
3. The `PriorityCeilingEmulation` monitor control policy is also required.
4. An implementation that provides any additional `MonitorControl` subclasses must document their effects, particularly with respect to priority inversion control.
5. An object's monitor control policy affects *each* task that attempts to lock the object; i.e., regular Java threads as well as schedulables.
6. When a task enters synchronized code, the target object's monitor control policy must be supported by the thread schedulable's scheduler; otherwise an `IllegalTaskStateException` is thrown. An implementation that defines a new `MonitorControl` subclass must document which schedulers, if any, do not support this policy.
7. Since priorities in the interrupt priority range must be implemented by masking hardware interrupts, a thread which enters a monitor with an interrupt priority as its ceiling will cause the corresponding hardware interrupts to be masked until the monitor is exited.

7.2.2 Priority Schedulers

The two schedulers provided by the `RTSJ` must both handle synchronization in the same way. All tasks governed by these schedulers are subject to the following semantics when they synchronize on objects governed by monitor control policies defined in this section.

1. Each task has a *base priority* and an *active priority*. A task that holds a lock on a PCE-governed object also has a *ceiling priority*.
2. The *base priority* for a task is limited by the maximum priority of its realtime thread groups' maximum scheduling parameters.
3. The *active priority* for a task is independent of its realtime thread groups.
4. The *base priority* for a task `t` is initially the priority that `t` has when it is created. The base priority is updated (immediately) as an effect of invoking any of the following methods:

   (a) `pparam.setPriority(prio)`, where `t` is a schedulable with `pparams` as its `SchedulingParameters` and `pparams` is an instance of `PriorityParameters` or one of its subclasses, where the new base priority is `prio`;
   (b) `t.setSchedulingParameters(pparams)`, where `t` is a schedulable and `pparams` is an instance of `PriorityParameters`, where the new base priority is `pparams.getPriority()`;
   (c) `t.setPriority(prio)`, where `t` is a schedulable object the new base priority is `prio`, and when it is a Java thread the new base priority is the lesser of `prio` and the maximum priority for `t`'s thread group; and
   (d) `sg.setMaxEligibility(pparams)`, where `sg` is in `t`'s `RealtimeThreadGroup` hierarchy and the priority of `pparams` is less than the current base priority of `t`, where the new base priority is the priority specified in `pparams` as a result of setting the task's scheduling parameters to `pparams`.

5. When the task `t` does not hold any locks, its active priority is the same as its base priority. In such a situation, modification of the priority of `t` through an invocation of any of the above priority-setting methods for `t` causes `t` to be placed at the tail of its relevant queue (ready, blocked on a particular object, etc.) at its new priority when the new priority is higher than the old priority, and at the beginning otherwise.
6. When task `t` holds one or more locks, then `t` has a set of *priority sources*. The *active priority* for `t` at any point in time is the maximum of the priorities associated with all of these sources. The priority sources resulting from the monitor control policies defined in this section, and their associated priorities for a schedulable `t`, are as follows:

   (a) *Source* — `t` itself
   Associated Priority — The base priority for `t`
   Note — This may have been changed (either synchronously or asynchronously) while `t` has been holding its lock(s).
   (b) *Source* — Each object locked by `t` and governed by a `PriorityCeilingEmulation` policy
   Associated Priority — The maximum value `ceil`, where `ceil` is the ceiling of a `PriorityCeilingEmulation` policy governing an object locked by `t`.
   Note — This value is also referred to as the *ceiling priority* for `t`.
   (c)

	Source	Each task attempting to synchronize on an object locked by `t` and governed by a `PriorityInheritance` policy
	Associated Priority	The maximum active priority over all such threads and schedulables
	Note	This rule accounts for recursive priority inheritance.
(d)	*Source*	Each task attempting to synchronize on an object locked by `t` and governed by a `PriorityCeilingEmulation` policy.
	Associated Priority	The maximum active priority over all such threads and schedulables
	Note	This rule, which in effect allows a `PriorityCeilingEmulation` lock to behave like a `PriorityInheritance` lock, helps avoid unbounded priority inversions that could otherwise occur in the presence of nested synchronizations involving a mix of `PriorityCeilingEmulation` and `PriorityInheritance` policies.

7. The addition of a priority source for `t` either leaves `t`'s active priority unchanged, or increases it. When `t`'s active priority is unchanged, `t`'s status in its relevant queue(s), e.g., blocked waiting for some object, is not affected. When `t`'s active priority is increased, `t` is placed at the tail of the relevant queue(s) at its new active priority level.
8. The removal of a priority source for `t` either leaves `t`'s active priority unchanged, or decreases it. When `t`'s active priority is unchanged, then `t`'s status in its relevant queue, e.g., blocked waiting for some object, is not affected. When `t`'s active priority is decreased and `t` is either ready or running, then `t` must be placed at the head of the ready queue at its new active priority level, When `t`'s active priority is decreased and `t` is blocked, then `t` is queued at the end of the queue for the new priority when it becomes unblocked.

The above rules have four main consequences.

1. A thread or schedulable `t`'s priority sources from 6b are added and removed synchronously; i.e., they are established based on `t`'s entering or leaving synchronized code. However, priority sources from 6a, 6c, and 6d may be added and removed asynchronously, as an effect of actions by other threads or schedulables.
2. A task holding only one lock, when it releases this lock, has its active priority set to its base priority.
3. A task's active priority is never less than its base priority.
4. When a task blocks at a call of `obj.wait()`, it releases the lock on `obj` and hence relinquishes the priority source(s) based on `obj`'s monitor control policy. The task will be queued at a new active priority that reflects the loss of these priority sources.

When modifying the active priority of a task, the active priority may exceed the priority range of the task's scheduler. For example, a thread scheduled on the

standard Java scheduler may be assigned a priority greater than 10, or a thread scheduled on the round robin scheduler may be assigned a priority greater than the round robin maximum priority but within the default scheduler priority range. In both cases, the task will be rescheduled on the default scheduler until its active priority is once again within the range schedulable on its associated scheduler. A task scheduled on the round robin scheduler, however, need not be moved to the default scheduler while its active priority remains within the allowable range for the round robin scheduler. Any scheduler not defined in this standard must specify the behavior of tasks associated with it with respect to these priority-based monitor control policies.

Since base priorities may be shared (i.e., the same `PriorityParameters` object may be associated with multiple schedulables), a given base priority may be the active priority for some but not all of its associated schedulables. It is a consequence of other rules that, when a thread or schedulable `t` attempts to synchronize on an object `obj` governed by a `PriorityCeilingEmulation` policy with ceiling `ceil`, then `t`'s active priority may exceed `ceil` but `t`'s base priority must not. In contrast, once `t` has successfully synchronized on `obj`, then `t`'s base priority may also exceed `obj`'s monitor control policy's ceiling. Note that either or both of `t`'s base priority and `obj`'s monitor control policy may have been dynamically modified.

7.2.3 Additional Schedulers

Schedulers based on criteria other than priority, for example, deadline in a deadline first scheduler, must consider how synchronization is handled to avoid scheduling eligibility inversion. Such a scheduler must conform to the following semantics for tasks managed by that scheduler when they synchronize on objects with the monitor control policies defined above.

1. An implementation that defines a new `Scheduler` subclass must document which (if any) monitor control policies the new scheduler does not support.
2. An implementation must document how, if at all, the semantics of synchronization differ from the rules defined for the default `PriorityInheritance` instance and for the `PriorityCeilingEmulation` policy. It must supply documentation for the behavior of the new scheduler with priority inheritance and priority ceiling emulation protocol equivalent to the semantics for the default priority scheduler found in the previous section.
3. An implementation must also document the appropriate monitor control policy for use when objects are shared between tasks under the control of different schedulers.
4. The new `Scheduler` subclass must conform to the semantics for parameter values, release control, dispatching, and cost monitoring described in Section 6.2.1.

7.3 javax.realtime

7.3.1 Classes

7.3.1.1 MonitorControl

---

public abstract class MonitorControl

Inheritance
java.lang.Object
MonitorControl

Description

Abstract superclass for all monitor control policies.

7.3.1.1.1 Constructors

MonitorControl

Signature

```
protected
MonitorControl()
```

Description

Invoked from subclass constructors.

7.3.1.1.2 Methods

---

getMonitorControl(Object)

Signature

```
public static javax.realtime.MonitorControl
getMonitorControl(Object monitor)
```

Description

Gets the monitor control policy of the given instance of `Object`.

Parameters
`monitor`—The object being queried.
Throws
`StaticIllegalArgumentException`—when `monitor` is `null`.
Returns
the monitor control policy of the `monitor` parameter.

getMonitorControl

Signature

```
public static javax.realtime.MonitorControl
getMonitorControl()
```

Description

Gets the current default monitor control policy.

Returns

the default monitor control policy object.

setMonitorControl(MonitorControl)

Signature

```
public static javax.realtime.MonitorControl
setMonitorControl(MonitorControl policy)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       StaticIllegalStateException
```

Description

Sets the *default monitor control policy*. This policy does not affect the monitor control policy of any already created object, it will, however, govern any object whose creation happens after the method completes, until either

1. a new "per-object" policy is set for that object, thereby altering the monitor control policy for a single object without changing the default policy, or
2. a new default policy is set.

Like the per-object method (see `setMonitorControl(Object, MonitorControl)`, the setting of the default monitor control policy occurs immediately, but may not be visible on all processors of a multicore system simultaneously.

Parameters

`policy`—The new monitor control policy. When `null`, the default `MonitorControl` policy is not changed.

Throws

`StaticSecurityException`—when the caller is not permitted to alter the default monitor control policy.

`StaticIllegalArgumentException`—when `policy` is not in immortal memory.

`StaticUnsupportedOperationException`—when `policy` is not a supported monitor control policy.

Returns

the default `MonitorControl` policy in effect on completion.

Since RTSJ 1.0.1 The return type is changed from void to `MonitorControl`.

setMonitorControl(Object, MonitorControl)

Signature

```
public static javax.realtime.MonitorControl
setMonitorControl(Object obj,
                  MonitorControl policy)
```

Description

Immediately sets `policy` as the monitor control policy for `obj`.

Monitor control policy changes on a monitor that is actively contended may lead to queued or enqueuing tasks following either the old or new policy in an unpredictable fashion. Tasks enqueued after the monitor is released after a policy change will follow the new policy.

A thread or schedulable that is queued for the lock associated with `obj`, or is in `obj`'s wait set, is not rechecked (e.g., for a `CeilingViolationException`) under `policy`, either as part of the execution of `setMonitorControl` or when it is awakened to (re)acquire the lock.

The thread or schedulable invoking `setMonitorControl` must already hold the lock on `obj`.

Parameters

`obj`—The object that will be governed by the new policy.

`policy`—The new policy for the object. When `null` nothing will happen.

Throws

`StaticIllegalArgumentException`—when `obj` is `null` or `policy` is not in immortal memory.

`StaticUnsupportedOperationException`—when `policy` is not a supported monitor control policy.

`IllegalMonitorStateException`—when the caller does not hold a lock on `obj`.

Returns

the current `MonitorControl` policy for `obj`, which will be replaced.

Since RTSJ 1.0.1 The return type has been changed from void to `MonitorControl`.

7.3.1.2 PriorityCeilingEmulation

---

public class PriorityCeilingEmulation

Inheritance

java.lang.Object
  MonitorControl
    PriorityCeilingEmulation

Description

Monitor control class specifying the use of the priority ceiling emulation protocol (also known as the "highest lockers" protocol). Each `PriorityCeilingEmulation`

instance is immutable; it has an associated *ceiling,* initialized at construction and queryable but not updatable thereafter.

When a thread or schedulable synchronizes on a target object governed by a `PriorityCeilingEmulation` policy, then the target object becomes a priority source for the thread or schedulable object. When the object is unlocked, it ceases serving as a priority source for the thread or schedulable. The practical effect of this rule is that the thread or schedulable's active priority is boosted to the policy's ceiling when the object is locked, and is reset when the object is unlocked. The value that it is reset to may or may not be the same as the active priority it held when the object was locked; this depends on other factors (e.g. whether the thread or schedulable's base priority was changed in the interim).

The implementation must perform the following checks when a thread or schedulable `t` attempts to synchronize on a target object governed by a `PriorityCeilingEmulation` policy with ceiling `ceil`:

- `t`'s base priority does not exceed `ceil`
- `t`'s ceiling priority (when `t` is holding any other `PriorityCeilingEmulation` locks) does not exceed `ceil`.

Thus for any object `targetObj` that will be governed by priority ceiling emulation, the programmer needs to provide (via `MonitorControl.setMonitorControl(Object, MonitorControl)`) a `PriorityCeilingEmulation` policy whose ceiling is at least as high as the maximum of the following values:

- the highest base priority of any thread or schedulable that could synchronize on `targetObj`
- the maximum ceiling priority value that any task may have when it attempts to synchronize on `targetObj`.

More formally,

- when a thread or schedulable `t`, whose base priority is `p1`, attempts to synchronize on an object governed by a `PriorityCeilingEmulation` policy with ceiling `p2`, where `p1 > p2`, then a `CeilingViolationException` is thrown in `t`; likewise, a `CeilingViolationException` is thrown in `t` when `t` is holding a `PriorityCeilingEmulation` lock and has a ceiling priority exceeding `p2`.

The values of `p1` and `p2` are passed to the constructor for the exception and may be queried by an exception handler.

A consequence of the above rule is that a thread or schedulable may nest synchronizations on `PriorityCeilingEmulation`-governed objects as long as the ceiling for the inner lock is not less than the ceiling for the outer lock.

The possibility of nested synchronizations on objects governed by a mix of `PriorityInheritance` and `PriorityCeilingEmulation` policies requires one other piece of behavior in order to avoid unbounded priority inversions. When a thread or schedulable holds a `PriorityInheritance` lock, then any `PriorityCeilingEmulation` lock that it either holds or attempts to acquire will exhibit priority inheritance characteristics. This rule is captured above in the definition of priority sources (4.d).

When a thread or schedulable `t` attempts to synchronize on a `Priority-`

CeilingEmulation-governed object with ceiling ceil, then ceil must be within the priority range allowed by t's scheduler; otherwise, an IllegalTaskStateException is thrown. Note that this does not prevent a regular Java thread from synchronizing on an object governed by a PriorityCeilingEmulation policy with a ceiling higher than 10.

The priority ceiling for an object obj can be modified by invoking MonitorControl.setMonitorControl(obj, newPCE) where newPCE's ceiling has the desired value.

See also MonitorControl PriorityInheritance, and CeilingViolationException.

7.3.1.2.1 Methods

instance(int)

Signature

```
public static javax.realtime.PriorityCeilingEmulation
instance(int ceiling)
```

Description

Creates a PriorityCeilingEmulation object with the specified ceiling. This object is in ImmortalMemory. All invocations with the same ceiling value return a reference to the same object.

Parameters

ceiling—Priority ceiling value.

Throws

StaticIllegalArgumentException—when ceiling is out of the range of permitted priority values (e.g., less than PriorityScheduler.instance().getMinPriority() or greater than PriorityScheduler.instance().getMaxPriority() for the base scheduler).

Since RTSJ 1.0.1

getCeiling

Signature

```
public int
getCeiling()
```

Description

Gets the priority ceiling for this PriorityCeilingEmulation object.

Returns

the priority ceiling.

Since RTSJ 1.0.1

getMaxCeiling

Signature

```
public static javax.realtime.PriorityCeilingEmulation
getMaxCeiling()
```

Description

Gets a `PriorityCeilingEmulation` object whose ceiling is `PriorityScheduler.instance().getMaxPriority()`. This method returns a reference to a `PriorityCeilingEmulation` object allocated in immortal memory. All invocations of this method return a reference to the same object.

Returns

a `PriorityCeilingEmulation` object whose ceiling is `PriorityScheduler.instance().getMaxPriority()`.

Since RTSJ 1.0.1

7.3.1.3 PriorityInheritance

---

public class PriorityInheritance

Inheritance

java.lang.Object
  MonitorControl
    PriorityInheritance

Description

Singleton class specifying use of the priority inheritance protocol. When a thread or schedulable `t1` attempts to enter code that is synchronized on an object `obj` governed by this protocol, and `obj` is currently locked by a lower-priority thread or schedulable `t2`, then

1. When `t1`'s active priority does not exceed the maximum priority allowed by `t2`'s scheduler, then `t1` becomes a priority source for `t2`; `t1` ceases to serve as a priority source for `t2` when either `t2` releases the lock on `obj`, or `t1` ceases attempting to synchronize on `obj` (e.g., when `t1` incurs an ATC).
2. Otherwise (i.e., `t1`'s active priority exceeds the maximum priority allowed by `t2`'s scheduler), an `IllegalTaskStateException` is thrown in `t1`.

Note on the second rule, throwing the exception in `t1`, rather than in `t2`, ensures that the exception is synchronous.

See also `MonitorControl` and `PriorityCeilingEmulation`

7.3.1.3.1 Methods

---

instance

Signature

```
public static javax.realtime.PriorityInheritance
instance()
```

Description

Obtains a reference to the singleton `PriorityInheritance`.

This is the default `MonitorControl` policy in effect at system startup.

The `PriorityInheritance` instance shall be allocated in `ImmortalMemory`.

7.3.1.4 WaitFreeReadQueue

---

public class WaitFreeReadQueue<T>

Inheritance

java.lang.Object
WaitFreeReadQueue<T>

Description

A queue that can be non-blocking for consumers. The `WaitFreeReadQueue` class is intended for single-reader multiple-writer communication, although it may also be used (with care) for multiple readers. A *reader* is generally an instance of `Schedulable` which may not use the heap, and the *writers* are generally regular Java threads or heap-using instances of `Schedulable`. Communication is through a bounded buffer of Objects that is managed first-in-first-out. The principal methods for this class are write and read.

- The `write` method appends a new element onto the queue. It is synchronized, and blocks when the queue is full. It may be called by more than one writer, in which case, the different callers will write to different elements of the queue.
- The `read` method removes the oldest element from the queue. It is not synchronized and does not block; it will return `null` when the queue is empty. Multiple reader threads or schedulables are permitted, but when two or more intend to read from the same `WaitFreeWriteQueue` they will need to arrange explicit synchronization.

For convenience, and to avoid requiring a reader to poll until the queue is non-empty, this class also supports instances that can be accessed by a reader that blocks on queue empty. To obtain this behavior, the reader needs to invoke the `waitForData()` method on a queue that has been constructed with a `notify` parameter set to `true`.

`WaitFreeReadQueue` is one of the classes enabling instances of `Schedulable` that may not use the heap and conventional Java threads to synchronize on an object without the risk of that Schedulable instance incurring Garbage Collector latency due to priority inversion avoidance management.

Incompatibility with V1.0: Three exceptions previously thrown by the constructor have been deleted. These are

- `java.lang.IllegalAccessException`,
- `java.lang.ClassNotFoundException`, and
- `java.lang.InstantiationException`.

These exceptions were in error. Their deletion may cause compile-time errors in code using the previous constructor. The repair is to remove the exceptions from the catch clause around the constructor invocation.

7.3.1.4.1 Constructors

WaitFreeReadQueue(Runnable, Runnable, int, MemoryArea, boolean)

Signature

```
public
WaitFreeReadQueue(Runnable writer,
                  Runnable reader,
                  int maximum,
                  MemoryArea memory,
                  boolean notify)
throws StaticIllegalArgumentException,
       MemoryScopeException,
       InaccessibleAreaException
```

Description

Constructs a queue containing up to `maximum` elements in `memory`. The queue has an unsynchronized and nonblocking `read()` method and a synchronized and blocking `write()` method.

The `writer` and `reader` parameters, when non-null, are checked to insure that they are compatible with the `MemoryArea` specified by `memory` (when non-null.) When `memory` is `null` and both Runnables are non-null, the constructor will select the nearest common scoped parent memory area, or when there is no such scope it will use immortal memory. When all three parameters are `null`, the queue will be allocated in immortal memory.

`reader` and `writer` are not necessarily the only instances of `Schedule` that will access the queue; moreover, there is no check that they actually access the queue at all.

Note that the wait free queue's internal queue is allocated in `memory`, but the memory area of the wait free queue instance itself is determined by the current allocation context.

Parameters

`writer`—An instance of `Runnable` or `null`.

`reader`—An instance of `Runnable` or `null`.

`maximum`—The maximum number of elements in the queue.

`memory`—The `MemoryArea` in which internal elements are allocated.

`notify`—A flag that establishes whether a reader is notified when the queue becomes non-empty.

Throws

`StaticIllegalArgumentException`—when an argument holds an invalid value. The `writer` argument must be `null`, a reference to a `Thread`, or a reference to a schedulable (a `RealtimeThread`, or an `AsyncEventHandler`.) The `reader` argument must be `null`, a reference to a `Thread`, or a reference to a schedulable. The `maximum` argument must be greater than zero.

`InaccessibleAreaException`—when `memory` is a scoped memory that is not on the caller's scope stack.

`MemoryScopeException`—when either `reader` or `writer` is non-null and the `memory` argument is not compatible with `reader` and `writer` with respect to the assignment and access rules for memory areas.

WaitFreeReadQueue(Runnable, Runnable, int, MemoryArea)

Signature

```
public
WaitFreeReadQueue(Runnable writer,
                  Runnable reader,
                  int maximum,
                  MemoryArea memory)
throws StaticIllegalArgumentException,
       MemoryScopeException,
       InaccessibleAreaException
```

Description

Constructs a queue containing up to `maximum` elements in `memory`. The queue has an unsynchronized and nonblocking `read()` method and a synchronized and blocking `write()` method.

Equivalent to `WaitFreeReadQueue(writer, reader, maximum, memory, false)`

WaitFreeReadQueue(int, MemoryArea, boolean)

Signature

```
public
WaitFreeReadQueue(int maximum,
                  MemoryArea memory,
                  boolean notify)
throws StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Constructs a queue containing up to `maximum` elements in `memory`. The queue has an unsynchronized and nonblocking `read()` method and a synchronized and blocking `write()` method.

Equivalent to `WaitFreeReadQueue(null, null, maximum, memory, notify)`

Since RTSJ 1.0.1

WaitFreeReadQueue(int, boolean)

Signature

```
public
WaitFreeReadQueue(int maximum,
                  boolean notify)
throws StaticIllegalArgumentException
```

Description

Constructs a queue containing up to `maximum` elements in immortal memory. The queue has an unsynchronized and nonblocking `read()` method and a synchronized and blocking `write()` method.

Equivalent to `WaitFreeReadQueue(null, null, maximum, null, notify)`

Since RTSJ 1.0.1

7.3.1.4.2 Methods

---

clear

Signature

```
public void
clear()
```

Description

Sets `this` to empty.

Note, this method needs to be used with care. Invoking `clear` concurrently with `read` or `write` can lead to unexpected results.

isEmpty

Signature

```
public boolean
isEmpty()
```

Description

Queries the queue to determine if `this` is empty.

Note: This method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns
`true` when `this` is empty; `false` when `this` is not empty.

isFull

Signature

```
public boolean
isFull()
```

Description

Queries the system to determine if `this` is full.

Note: This method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns
`true` when `this` is full; `false` when `this` is not full.

read

Signature

```
public T
read()
```

Description

Reads the least recently inserted element from the queue and returns it as the result, unless the queue is empty. When the queue is empty, `null` is returned.

Returns
the instance of `T` read, or else `null` when `this` is empty.

size

Signature

```
public int
size()
```

Description

Queries the queue to determine the number of elements in `this`.

Note: This method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns
the number of positions in `this` occupied by elements that have been written but not yet read.

waitForData

Signature

```
public void
waitForData()
throws StaticUnsupportedOperationException,
       InterruptedException
```

Description

When `this` is empty block until a writer inserts an element.

Note: When there is a single reader and no asynchronous invocation of `clear`, then it is safe to invoke `read` after `waitForData` and know that `read` will find the queue non-empty.

Implementation note, to avoid reader and writer synchronizing on the same object, the reader should not be notified directly by a writer. (This is the issue that the non-wait queue classes are intended to solve).

Throws

`StaticUnsupportedOperationException`—when `this` has not been constructed with `notify` set to `true`.

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

Since RTSJ 1.0.1 `InterruptedException` was added to the throws clause.

write(T)

Signature

```
public synchronized void
write(T value)
throws MemoryScopeException,
       InterruptedException
```

Description

A synchronized and blocking write. This call blocks on queue full and will wait until there is space in the queue.

Parameters

`value`—The `java.lang.Object` that is placed in the queue.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

`MemoryScopeException`—when a memory access error or illegal assignment error would occur while storing `object` in the queue.

`StaticIllegalArgumentException`—when `value` is `null`.

Since RTSJ 1.0.1 The return type is changed to void since it *always* returned‘ `true`, and `InterruptedException` was added to the throws clause.

7.3.1.5 WaitFreeWriteQueue

public class WaitFreeWriteQueue<T>

Inheritance

java.lang.Object
WaitFreeWriteQueue<T>

Description

A queue that can be non-blocking for producers. The `WaitFreeWriteQueue` class is intended for single-writer multiple-reader communication, although it may also be used (with care) for multiple writers. A *writer* is generally an instance `Schedulable` which may not use the heap, and the *readers* are generally conventional Java threads or instances of `Schedulable` which use the heap. Communication is through a bounded buffer of `Objects` that is managed first-in-first-out. The principal methods for this class are write and read.

- The `write` method appends a new element onto the queue. It is not synchronized, and does not block when the queue is full (it returns `false` instead). Multiple writer threads or schedulables are permitted, but when two or more threads intend to write to the same `WaitFreeWriteQueue` they will need to arrange explicit synchronization.
- The `read` method removes the oldest element from the queue. It is synchronized, and will block when the queue is empty. It may be called by more than one reader, in which case the different callers will read different elements from the queue.

`WaitFreeWriteQueue` is one of the classes enabling schedulables which may not use the heap and regular Java threads to synchronize on an object without the risk of the schedulable incurring Garbage Collector latency due to priority inversion avoidance management.

Incompatibility with V1.0: Three exceptions previously thrown by the constructor have been deleted from the `throws` clause. These are

- `java.lang.IllegalAccessException`,
- `java.lang.ClassNotFoundException`, and
- `java.lang.InstantiationException`.

Including these exceptions on the `throws` clause was an error. Their deletion may cause compile-time errors in code using the previous constructor. The repair is to remove the exceptions from the `catch` clause around the constructor invocation.

7.3.1.5.1 Constructors

WaitFreeWriteQueue(Runnable, Runnable, int, MemoryArea)

Signature

```
public
WaitFreeWriteQueue(Runnable writer,
                   Runnable reader,
                   int maximum,
                   MemoryArea memory)
throws StaticIllegalArgumentException,
       MemoryScopeException,
       InaccessibleAreaException
```

Description

Constructs a queue in `memory` with an unsynchronized and nonblocking `write()` method and a synchronized and blocking `read()` method.

The `writer` and `reader` parameters, when non-null, are checked to insure that they are compatible with the `MemoryArea` specified by `memory` (when non-null.) When `memory` is `null` and both Runnables are non-null, the constructor will select the nearest common scoped parent memory area, or when there is no such scope it will use immortal memory. When all three parameters are `null`, the queue will be allocated in immortal memory.

`reader` and `writer` are not necessarily the only threads or schedulables that will access the queues; moreover, there is no check that they actually access the queue at all.

Note, the wait free queue's internal queue is allocated in `memory`, but the memory area of the wait free queue instance itself is determined by the current allocation context.

Parameters

`writer`—An instance of `Schedulable` or `null`.

`reader`—An instance of `Schedulable` or `null`.

`maximum`—The maximum number of elements in the queue.

`memory`—The `MemoryArea` in which `this` and internal elements are allocated.

Throws

`StaticIllegalArgumentException`—when an argument holds an invalid value. The `writer` argument must be `null`, a reference to a `Thread`, or a reference to a schedulable (a `RealtimeThread`, or an `AsyncEventHandler`.) The `reader` argument must be `null`, a reference to a `Thread`, or a reference to a schedulable. The `maximum` argument must be greater than zero.

`MemoryScopeException`—when either `reader` or `writer` is non-null and the `memory` argument is not compatible with `reader` and `writer` with respect to the assignment and access rules for memory areas.

`InaccessibleAreaException`—when `memory` is a scoped memory that is not on the caller's scope stack.

WaitFreeWriteQueue(int, MemoryArea)

Signature

```
public
WaitFreeWriteQueue(int maximum,
                   MemoryArea memory)
throws StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Constructs a queue containing up to `maximum` elements in `memory`. The queue has an unsynchronized and nonblocking `write()` method and a synchronized and blocking `read()` method.

Equivalent to `WaitFreeWriteQueue(null,null,maximum, memory)`

Since RTSJ 1.0.1

WaitFreeWriteQueue(int)

Signature

```
public
WaitFreeWriteQueue(int maximum)
throws StaticIllegalArgumentException
```

Description

Constructs a queue containing up to `maximum` elements in immortal memory. The queue has an unsynchronized and nonblocking `write()` method and a synchronized and blocking `read()` method.

Equivalent to `WaitFreeWriteQueue(null,null,mximum, null)`

Since RTSJ 1.0.1

7.3.1.5.2 Methods

---

clear

Signature

```
public void
clear()
```

Description

Sets `this` to empty.

isEmpty

Signature

```
public boolean
isEmpty()
```

Description

Queries the system to determine if `this` is empty.

Note, this method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns

`true`, when `this` is empty; `false`, when `this` is not empty.

isFull

Signature

```
public boolean
isFull()
```

Description

Queries the system to determine if `this` is full.

Note, this method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns

`true`, when `this` is full; `false`, when `this` is not full.

read

Signature

```
public synchronized T
read()
throws InterruptedException
```

Description

A synchronized and possibly blocking operation on the queue.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

Returns

the `T` least recently written to the queue. When `this` is empty, the calling schedulable blocks until an element is inserted; when it is resumed, `read` removes and returns the element.

Since RTSJ 1.0.1 Throws `InterruptedException`

size

Signature

```
public int
size()
```

Description

Queries the queue to determine the number of elements in `this`.

Note, this method needs to be used with care since the state of the queue may change while the method is in progress or after it has returned.

Returns

the number of positions in `this` occupied by elements that have been written but not yet read.

force(T)

Signature

```
public boolean
force(T value)
throws MemoryScopeException,
       StaticIllegalArgumentException
```

Description

Unconditionally inserts `value` into `this`, either in a vacant position or else overwriting the most recently inserted element. The `boolean` result reflects whether, at the time that `force()` returns, the position at which `value` was inserted was vacant (`false`) or occupied (`true`).

Parameters

`value`—An instance of `T` to insert.

Throws

`MemoryScopeException`—when a memory access error or illegal assignment error would occur while storing `value` in the queue.

`StaticIllegalArgumentException`—when `value` is `null`.

Returns

`true` when `value` has overwritten an element that was occupied when the function returns; `false` otherwise (it has been inserted into a position that was vacant when the function returns)

write(T)

Signature

```
public boolean
write(T value)
throws MemoryScopeException,
       StaticIllegalArgumentException
```

Description

Inserts `value` into `this` when `this` is non-full and otherwise has no effect on `this`; the `boolean` result reflects whether `value` has been inserted. When the queue was empty and one or more threads or schedulables were waiting to read, then one will be awakened after the write. The choice of which to awaken depends on the involved scheduler(s).

Parameters

`value`—An instance of `T` to insert.

Throws

`MemoryScopeException`—when a memory access error or illegal assignment error would occur while storing `value` in the queue.

`StaticIllegalArgumentException`—when `value` is `null`.

Returns

`true` when the queue was non-full; `false` otherwise.

7.4 Rationale

Java's rules for `synchronized` code provide a means for mutual exclusion but do not prevent unbounded priority inversions and thus are insufficient for realtime applications. This specification strengthens the semantics for `synchronized` code by mandating priority inversion control, in particular by furnishing classes for priority inheritance and priority ceiling emulation. Priority inheritance is more widely implemented in realtime operating systems and thus is the initial default mechanism in this specification.

Priority ceiling emulation is also a useful protocol. It is necessary for blocking out interrupts in interrupt service routines and simplifies scheduling analysis for single core systems. Since it can easily be implemented in user space, it is required as well.

The interaction of priority-based monitor policies such as priority inheritance and priority ceiling emulation with alternative schedulers that may not themselves be priority-based is complicated and contains many corner cases that are dependent on the scheduling protocol being implemented. Therefore, this specification does not define these interactions, but requires that the alternative scheduler implementation document the specifics of its interaction with the base priority-based schedulers defined here.

Since the same object may be accessed from synchronized code by both a schedulable which may not use the heap and an arbitrary thread or schedulable which may, unwanted dependencies may result. To avoid this problem, this specification provides three wait-free queue classes as an alternative means for safe, concurrent data accesses without priority inversion.

Chapter 8

Asynchrony

One of the most important aspects of this specification is its support for reacting to asynchronous events. This specifications provides a mechanism to bind the execution of program logic to the occurrence of internal and external events. This is provided by asynchronous event handling. Using this, an application can define some computation that is executed every time an event is "fired," either from a clock or from some signal.

Asynchronous event handling is represented by the classes `AsyncBaseEvent` (AE) and `AsyncBaseEventHandler` (AEH), along with their subclasses. An AE is an object used to direct event occurrences to asynchronous event handlers. An event occurrence may be initiated by application logic, by mechanisms internal to the `RTSJ` implementation (see the handlers in `PeriodicParameters`), or by some external input such as a clock, a signal, or an interrupt.

An asynchronous event occurrence is initiated in program logic by the invocation of the `fire` method of an AE. The `fire` method dispatches all handlers associated with its event. This means that dispatching occurs in the execution context of the caller.

An asynchronous event that is initiated from an external source has additional requirements and hence additional API features. These features are captured by the `ActiveEvent` interface. Since external events do not have a full execution context of their own, this category of events must provide an alternate execution context. In order to give the programmer control over this execution context, the specification defines the abstract class `ActiveEventDispatcher` to provide execution context for dispatching.

By convention, subclasses provide a `trigger` method for initiating dispatching. Triggering simply informs this execution context to start dispatching. The `trigger` method is not defined in `ActiveEventDispatcher`, since some classes need a `trigger` method with an argument and others do not. The types of `ActiveEvent` supported are described in subsequent chapters.

Any variety of AEH may be associated with any variety of AE. The event actually delivered depends on the combination of the two. The table 8.1 illustrates this.

Memory assignment rules apply to the payload passed to `AsyncObjectEvent-Handler`.

An AEH is a schedulable embodying code that is released for execution in

Table 8.1: Event to Handler Matrix

Types	AsyncEvent	AsyncLongEvent	AsyncObjectEvent
AsyncEventHandler	Nothing	Nothing	Nothing
AsyncLongEventHandler	Event Id	Payload	Event Id
AsyncObjectEventHandler	Event Object	Event Object	Payload

response to the occurrence of an associated event. Each AEH behaves as if it is executed by a `RealtimeThread` except that it is not permitted to use the `waitForNextRelease()` method. There is not necessarily a separate realtime thread for each AEH, but the server realtime thread (returned by `currentRealtimeThread()`) remains constant during each execution of the `handleAsyncEvent()` method. The implication of this is that calls to `Thread.currentThread()`, `RealtimeThread.currentRealtimeThread()`, and access to thread-local storage may have unpredictable results from release to release.

The default manner in which the implementation selects a realtime thread to release a given AEH at a given release is defined by `BlockableReleaseRunner`, but the user can override this default by defining a new subclass of its abstract superclass, `ReleaseRunner`. The interface `BoundSchedulable` is used to mark subclasses of `AsyncBaseEventHandler`, such as `BoundAsyncEventHandler`, which have a dedicated realtime server thread. Such a server thread is associated with one and only one bound AEH for the lifetime of that AEH.

8.1 Definitions

Asynchronous Event (AE) — An instance of one of the subclasses of the `javax.realtime.AsyncBaseEvent` class.

Asynchronous Event Handler (AEH) — An instance of one of the subclasses of the `AsyncBaseEventHandler` class.

Bound Asynchronous Event Handler (Bound AEH) — An instance of a subclasses of the `AsyncBaseEventHandler` class that also implements `BoundSchedulable`.

Bounded Execution Time — As a particular task or schedulable may not be scheduled on a CPU for an arbitrarily long period of time, bounds on the responsiveness of a given task or schedulable are defined in terms of execution time during which that task is scheduled on a CPU and executing. Time during which a task is blocked, either voluntarily, pending acquisition of a resource, or due to a higher-priority task executing on the CPUs available to it, is not considered execution time.

Firable Asynchronous Event Handler — An instance of `AsyncBaseEventHandler` is *firable* whenever there is an agent that can release it. This includes cases when the `AsyncBaseEventHandler` is

1. a miss handler or overrun handler of a `RealtimeThread` instance that has been started but not yet terminated;
2. a handler associated with an `AsyncBaseEvent` that can be fired; or
3. a miss handler or overrun handler for an instance of `AsyncBaseEvent-`

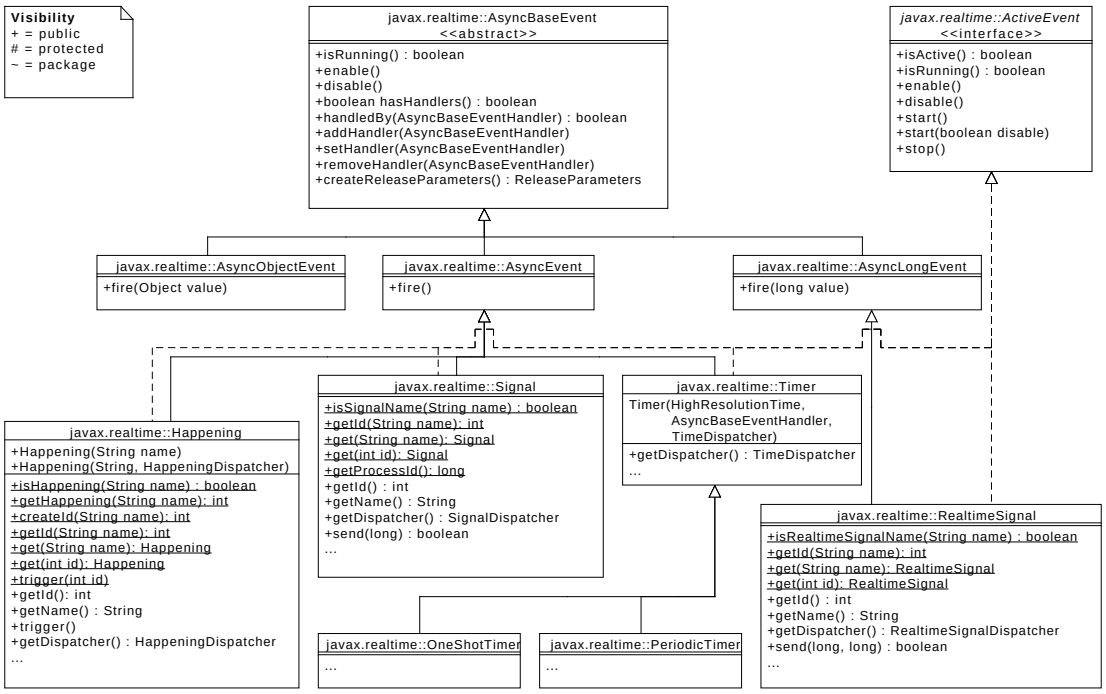
`Handler` that is firable.

Lexical Scope — The textual region within programming block, such as a constructor, method, or statement, excluding the code within any class declarations, and the code within any class instance creation expressions for anonymous classes, contained therein. The lexical scope of a construct does not include the bodies of any methods or constructors that this code invokes.

8.2 Semantics

Basic event types are passive: they are not directly associated with a thread of control. They are intended to be fired programmatically. Handling external events, such as clocks (see Chapter 10) and happenings (see Chapter 13), requires an execution context. The `ActiveEvent` interface is provided to mark these and provide additional execution semantics. Figure 8.1 illustrates the event hierarchy.

Figure 8.1: The Event Class Hierarchy



8.2.1 Asynchronous Events and their Handlers

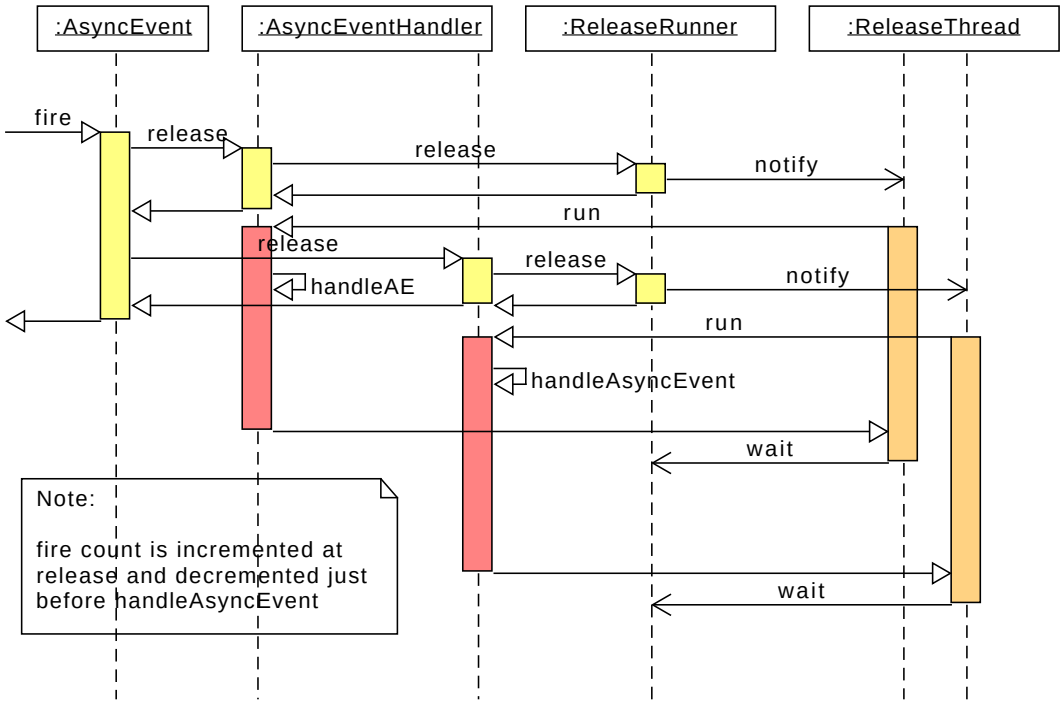
This following points give the basic semantics for asynchronous events and their handlers. Semantics that apply to particular classes, constructors, methods, and fields are provided in the class description and the constructor, method, and field specifications.

1. When an asynchronous event occurs, either by program logic or by the triggering of a happening, and the event is enabled, its attached handlers, i.e., all AEHs

that have been added to the AE by the execution of `addHandler()`, are released for execution.
   (a) Every occurrence of an event increments the `fireCount` in each attached handler.
   (b) Handlers may elect to execute logic for each occurrence of the event or not.
2. When `interrupt` is called on an AEH whose rousable state is `true`, i.e., its release parameters `isRousable` method returns `true`, that AEH will be released independently of all other AEH attached to any common AE.
3. The release of attached handlers occurs in execution eligibility order, i.e, priority order, from highest to lowest, with the default `PriorityScheduler`, and at the active priority of the schedulable that invoked the `fire` method. The release of handlers resulting from a happening or a timer must begin within a bounded time (ignoring time consumed by unrelated activities in the system). This worst-case response interval must be documented for some reference architecture.
4. The release of attached handlers is an atomic operation with respect to adding and removing handlers.
5. The logical release of an attached handler may occur before the previous release has completed.
6. Releasing an AEH is accomplished through the handler's instance of `ReleaseRunner` as depicted in Figure 8.2.
7. Each handler has an application configurable, handler type dependent queue for holding events that have been released before a previous release has completed.
8. The overflow policy of a handler's queue is also application configurable.
9. A deadline may be associated with each logical release of an attached handler. The deadline is relative to the occurrence of the associated event.
10. AEs and AEHs may be created and used by any program logic within the constraints of the memory assignment rules.
11. More than one AEH may be added to an AE. However, adding an AEH to an AE has no effect if the AEH is already attached to the AE.
12. The same AEH may be added to more than one AE.
13. By default all AEHs are daemons: the daemon status is set by their constructors. An AEH can be set to have a non daemon status after it has been created and before it has been attached to an AE.
14. The object returned by `currentRealtimeThread()` while an AEH is running shall behave with respect to memory access and assignment rules as if it were allocated in the same memory area as the AEH.
15. System-related termination activity (such as execution of finalizers for scoped objects in scopes that become unreferenced) triggered when an AEH becomes unfirable is not subject to cost enforcement or deadline miss detection.
16. AEs and AEHs behave effectively as if changes to an AEH's fireability are contained in synchronized blocks, and the AEH holds that lock while it is in the process of becoming unfirable.

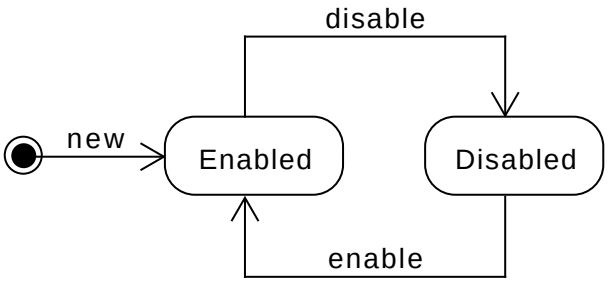
`AsyncBaseEvent` provides two basic states: enabled and disabled. In the enabled state, fire causes all associated handlers to be dispatched, whereas fire does nothing

Figure 8.2: Releasing an `AysncEventHandler`



when the event is disabled. Figure 8.3 illustrates this state space.

Figure 8.3: States of a Simple AsyncBaseEvent



8.2.2 Active Events and Dispatching

Active events refine the semantics of `AsyncBaseEventHandler` with the addition of execution semantics to support second level interrupt handling. The fire method of an event runs in the Java execution context of the caller. For events that represent external signals, whether a certain time is reached or something has occurred, there may not be a Java execution context for it, or at least that context is limited out

of necessity, and often needs to have a very short duration of execution. Thus dispatching an unlimited number of handlers in that context is not acceptable. This dispatching requires an additional execution context for releasing handlers.

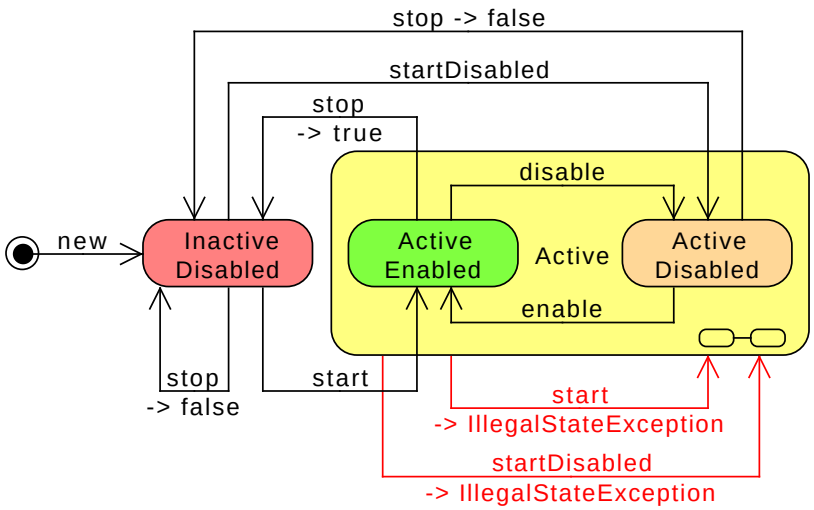
In order to be able to distinguish between events that are caused to be fired by an outside mechanism from those that are fired from another thread, the former extend the `ActiveEvent` interface. Each class implementing `ActiveEvent` must provide its own `trigger` method for initiating the handler release by releasing another execution context. Since the `trigger` methods may vary in the number of their arguments depending on the type of event, they are not provided by the `ActiveEvent` class. Each `trigger` method must act as if it calls the `fire` method on its event and then terminates. Hence, `trigger` has the same functional behavior as `fire`, but runs in a separate execution context.

This extra execution context is exposed to the user as an `ActiveEventDispatcher`. There is an active event dispatcher for each kind of active event. The programmer does not need to write a dispatcher, but just creates the one of the corresponding type. The programmer determines the priority and the affinity of a dispatcher, as well as the mapping between dispatchers and events.

Each event has a single dispatcher, but a dispatcher may serve many events. As with `fire`, the dispatcher releases handlers in reverse priority order, i.e., from highest to lowest. This enables the programmer to control the number of these execution contexts and still optimize how handlers are released.

The state space of an `ActiveEvent` is an extension of the state space for an `AsyncBaseEvent` depicted in Figure 8.3. `ActiveEvent` adds the notion of active and inactive on top of enabled and disabled, as depicted in Figure 8.4. Note that the enabled-disabled distinction only splits the active state. The inactive state is by definition disabled.

Figure 8.4: States of an ActiveEvent



8.2.3 Termination

An `RTSJ` program terminates when and only when

1. all nondaemon threads, either regular Java threads or realtime threads, are terminated;
2. the `fireCounts` of all nondaemon instances of `AsyncBaseEventHandler` are zero and all of their releases are completed; and
3. there are no nondaemon instances of `AsyncBaseEventHandler` attached to a firable instance of `ActiveEvent`.

Bound and unbound AEH are treated alike. As with conventional Java, daemon tasks, including service threads such as a dispatcher's thread or the threads used to run unbound AEH, do not hinder termination.

8.3 javax.realtime

8.3.1 Interfaces

8.3.1.1 ActiveEvent

---

public interface ActiveEvent<T extends Releasable<T, D>, D extends ActiveEventDispatcher<D, T>>

Interfaces
javax.realtime.Releasable

Description

This is the interface for defining the active event system. Classes implementing `ActiveEvent` are used to connect events that take place outside the Java virtual machine to RTSJ activities.

When an event takes place outside the Java virtual machine, some event-specific code within the Java virtual machine executes. That code notifies the `ActiveEvent` infrastructure of this event by calling a `trigger` method in the event.

An instance of this class holds a reference to its dispatcher. When `ActiveEvent.isActive` is `true`, the dispatcher must also hold a reference to the instance. For this reason, whenever an active event instance is active, it is also a execution context, so that this reference can be safely held during this time. Only the active event instance must be assignable to its dispatcher instance under the memory assignment rules, but not visa versa.

Since RTSJ 2.0

8.3.1.1.1 Methods

---

isActive

Signature

```
public boolean
isActive()
```

Description

Determines the activation state of this event, i.e., it has been started but not yet stopped again.

Returns
`true` when active, `false` otherwise.

isRunning

Signature

```
public boolean
isRunning()
```

Description

Determines the running state of this event, i.e., it is both active and enabled.

Returns

`true` when active and enabled, `false` otherwise.

start

Signature

```
public void
start()
throws StaticIllegalStateException
```

Description

Starts this active event by registering it with its dispatcher.

Throws

`StaticIllegalStateException`—when this event has already been started or its dispatcher has been destroyed.

start(boolean)

Signature

```
public void
start(boolean disabled)
throws StaticIllegalStateException
```

Description

Starts this active event by registering it with its dispatcher.

Parameters

`disabled`—True for starting in a disabled state.

Throws

`StaticIllegalStateException`—when this event has already been started or its dispatcher has been destroyed.

stop

Signature

```
public boolean
stop()
throws StaticIllegalStateException
```

Description

Stops this active event by deregistering it from its dispatcher.

Throws

`StaticIllegalStateException`—when this event is not running.

Returns

the previous enabled state.

enable

Signature

```
public void
enable()
```

Description

Changes the state of the event so that associated handlers are released on fire. Each subclass provides a fire method as a means of dispatching its handlers when requested. This method enables that request mechanism.

disable

Signature

```
public void
disable()
```

Description

Changes the state of the event so that associated handlers are skipped on fire. Each subclass provides a fire method as a means of dispatching its handlers when requested. This method disables that request mechanism.

getDispatcher

Signature

```
public D extends javax.realtime.ActiveEventDispatcher<D, T>
getDispatcher()
```

Description

Obtain the current dispatcher for this event.

Returns

the dispatcher associated with this event.

setDispatcher(D)

Signature

```
public D extends javax.realtime.ActiveEventDispatcher<D, T>
setDispatcher(D dispatcher)
```

Description

Change the current dispatcher for this event. When `dispatcher` is `null`, the default dispatcher is restored.

Returns

the dispatcher associated with this event.

8.3.1.2 Releasable

---

public interface Releasable<T extends Releasable<T, D>, D extends ActiveEventDispatcher<D, T>>

Description

A base interface for everything that can be dispatched and hence has a asynchronous release cycle. This unifies the concept behind active events and `RealtimeThread.waitForNextRelease`. Thus a realtime thread can handle events which do not have a payload too.

Since RTSJ 2.0

8.3.1.2.1 Methods

---

getDispatcher

Signature

```
public D extends javax.realtime.ActiveEventDispatcher<D, T>
getDispatcher()
```

Description

Obtains the dispatcher for `this`.

Returns

that dispatcher.

8.3.1.3 Subsumable

---

public interface Subsumable<T>

Description

A partial ordering relationship. One object subsumes another if and only if the set represented by other is a subset of `this` object}. Objects which represent disjoint set or sets whose intersection is less than either of the objects sets are mutually not subsumable.

Since RTSJ 2.0

8.3.1.3.1 Methods

---

subsumes(T)

Signature

```
public boolean
subsumes(T other)
```

Description

Indicates that some set represented by `other` is subsumed by the set represented by `this` object.

Parameters

`other`—The object to be compared with.

Returns

true when and only when the set represented by `other` is subsumed by the set represented by `this` object.

8.3.2 Classes

8.3.2.1 ActiveEventDispatcher

---

public abstract class ActiveEventDispatcher<D extends ActiveEventDispatcher<D, T>, T extends Releasable<T, D>>

Inheritance

java.lang.Object
ActiveEventDispatcher<D extends ActiveEventDispatcher<D, T>, T extends Releasable<T, D>>

Description

Provides a means of dispatching a set of `Releasable` instances. It acts as if it contains a daemon `RealtimeThread` to perform this task. The priority of this thread can be specified when a dispatcher object is created. The default dispatcher runs at the highest realtime priority on the base scheduler. Dispatchers do not maintain a queue of pending event.

Application code cannot extend this class.

Since RTSJ 2.0

8.3.2.1.1 Constructors

ActiveEventDispatcher(SchedulingParameters, RealtimeThreadGroup)

Signature

```
protected
ActiveEventDispatcher(SchedulingParameters schedule,
                      RealtimeThreadGroup group)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher.

Parameters

`schedule`—Provides scheduling information to the new object. When affinity is specified, this affinity has to be valid and to be a subset of the affinity of the realtime thread group specified in the `group` parameter. When the affinity is not specified in `schedule` or when `schedule` is null, the affinity will be assumed to be the affinity of the creating task.

`group`—The `RealtimeThreadGroup` of the thread of this dispatcher. When `null`, the closest instance of `RealtimeThreadGroup` in the hierarchy of thread groups containg the calling task is used.

Throws

`StaticIllegalArgumentException`—when scheduling parameters are not compatible with the default scheduler, i.e., when they are not null and not an instance of PriorityParameters.

ActiveEventDispatcher(SchedulingParameters)

Signature

```
protected
ActiveEventDispatcher(SchedulingParameters schedule)
throws StaticIllegalArgumentException
```

Description

Creates a new dispatcher in the same thread group as the calling task.

Parameters

`schedule`—Provides scheduling information to the new object. When `schedule` does not contain any information about the affinity, then the affinity of the current thread will be used. When its affinity is specified, this affinity must be valid and be a subset of the `RealtimeThreadGroup` of the current thread.

Throws

`StaticIllegalArgumentException`—when scheduling parameters are not compatible with the default scheduler, i.e., when they are not null and not an instance of PriorityParameters.

8.3.2.1.2 Methods

---

getScheduler

Signature

```
public javax.realtime.Scheduler
getScheduler()
```

Description

Gets a reference to the `Scheduler` object for this schedulable.

Returns

a reference to the associated `Scheduler` object.

setScheduler(Scheduler)

Signature

```
public javax.realtime.ActiveEventDispatcher<D, T>
setScheduler(Scheduler scheduler)
throws StaticSecurityException,
       IllegalTaskStateException
```

Description

Sets the reference to the Scheduler object. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`. If the `Schedulable` is running, its associated `SchedulingParameters` (if any) must be compatible with `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage execution of this schedulable. `Null` is not a permissible value.

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null`, or the schedulable's existing parameter values are not compatible with `scheduler`. Also when this schedulable may not use the heap and `scheduler` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `scheduler` or the current `Schedulable` is running and its associated `SchedulingParameters` are incompatible with `scheduler`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

`IllegalTaskStateException`—when `scheduler` has scheduling or release parameters that are not compatible with the new scheduler and this schedulable is running.

Returns

`this`

setScheduler(Scheduler, SchedulingParameters)

Signature

```
public javax.realtime.ActiveEventDispatcher<D, T>
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling)
```

Description

Sets the scheduler and associated parameter objects. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Returns

`this`

getSchedulingParameters

Signature

```
public javax.realtime.SchedulingParameters
getSchedulingParameters()
```

Description

Determines how the thread associated with this dispatcher is scheduled.

Returns

the scheduling parameters of the dispatcher thread.

setSchedulingParameters(SchedulingParameters)

Signature

```
public javax.realtime.ActiveEventDispatcher<D, T>
setSchedulingParameters(SchedulingParameters scheduling)
throws IllegalTaskStateException,
       IllegalAssignmentError,
       StaticIllegalArgumentException
```

Description

Sets the scheduling parameters associated with this instance of `Schedulable`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

Parameters

`scheduling`—A reference to the `SchedulingParameters` object. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduling` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `scheduling` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `scheduling` or `scheduling` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is active and the new scheduling parameters are not compatible with the current scheduler or the intersection of affinity in `scheduling` and the affinity of `this` object's realtime thread group is empty, or when the affinity of `scheduling` is not contained in the affinity of the current `this` object's realtime thread group or when the affinity in `scheduling` is invalid.

Returns

`this`

getRealtimeThreadGroup

Signature

```
public javax.realtime.RealtimeThreadGroup
getRealtimeThreadGroup()
```

Description

Determines in which group the thread associated with this dispatcher is.

Returns

the realtime thread group of the dispatcher thread.

getThread

Signature

```
protected javax.realtime.RealtimeThread
getThread()
```

Description

Optain the thread behind the dispatcher.

Returns

the realtime thread behind the dispatcher.

register(T)

Signature

```
public abstract void
register(T event)
throws RegistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Registers an active event with this dispatcher. This method is for supporting the starting of active events. It should not be called from application code.

Parameters

`event`—The event to register

Throws

`RegistrationException`—when `event` is already registered.

`StaticIllegalStateException`—when this object has been destroyed or its scheduling parameters are not compatible with the current scheduler.

`ProcessorAffinityException`—when affinity is not a valid affinity or is not a subset of the affinity of its realtime thread group.

`StaticIllegalArgumentException`—when `event` is not stopped. or when `event` is `null`.

deregister(T)

Signature

```
public abstract void
deregister(T event)
throws DeregistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Deregisters an active event from this dispatcher. This method is for supporting the stopping of active events. It should not be called from application code.

Parameters

`event`—The event to deregister

Throws

`DeregistrationException`—when `event` is already deregistered.

`StaticIllegalStateException`—when this object has been destroyed.

`StaticIllegalArgumentException`—when `event` is not stopped or when `event` is `null`.

destroy

Signature

```
public abstract void
destroy()
throws StaticIllegalStateException
```

Description

Makes the dispatcher unusable.

Throws

`StaticIllegalStateException`—when called on a dispatcher that has one or more registered objects.

8.3.2.2 AsyncBaseEvent

---

public abstract class AsyncBaseEvent

Inheritance

java.lang.Object
  AsyncBaseEvent

Description

This is the base class for all asynchronous events, where asynchronous is in regards to running code, not external time. This class unifies the original `AsyncEvent` with `AsyncLongEvent` and `AsyncObjectEvent`.

Note that when this class is collected, all its handlers are automatically removed as if `setHandler` was called with a `null` parameter.

Since RTSJ 2.0

8.3.2.2.1 Methods

---

isRunning

Signature

```
public boolean
isRunning()
```

Description

Determines the firing state (releasing or skipping) of this event, i.e., whether it is enabled or disabled.

Returns

`true` when releasing, `false` when skipping.

Since RTSJ 2.0 Inherited by AyncEvent

handledBy(AsyncBaseEventHandler)

Signature

```
public boolean
handledBy(AsyncBaseEventHandler handler)
```

Description

Determines whether or not the handler given as the parameter is associated with `this`.

Parameters

`handler`—The handler to be tested to determine if it is associated with `this`.

Returns

true when the parameter is associated with `this`. False when `handler` is `null` or the parameters is not associated with `this`.

Since RTSJ 2.0 Inherited by AyncEvent

enable

Signature

```
public void
enable()
```

Description

Changes the state of the event so that associated handlers are released on fire. Each subclass provides a fire method as means of dispatching its handlers when requested. This method enables that request mechanism.

Since RTSJ 2.0 Inherited by AyncEvent

disable

Signature

```
public void
disable()
```

Description

Changes the state of the event so that associated handlers are skipped on fire. Each subclass provides a fire method as means of dispatching its handlers when requested. This method disables that request mechanism.

Since RTSJ 2.0 Inherited by AyncEvent

addHandler(AsyncBaseEventHandler)

Signature

```
public void
addHandler(AsyncBaseEventHandler handler)
```

Description

Adds a handler to the set of handlers associated with this event. An instance of `AsyncBaseEvent` may have more than one associated handler. However, adding a handler to an event has no effect when the handler is already attached to the event.

The execution of this method is atomic with respect to the execution of the `fire()` method.

Note that there is an implicit reference to the handler stored in `this`. The assignment must be valid under any applicable memory assignment rules.

Parameters

`handler`—The new handler to add to the list of handlers already associated with this. When `handler` is already associated with the event, the call has no effect.

Throws

`StaticIllegalArgumentException`—when `handler` is `null` or the handler has `PeriodicParameters`. Only the subclass `PeriodicTimer` is allowed to have handlers with `PeriodicParameters`.

`IllegalAssignmentError`—when this `AsyncBaseEvent` cannot hold a reference to `handler`.

`StaticIllegalStateException`—when the configured `Scheduler` and `SchedulingParameters` for `handler` are not compatible with one another.

`ScopedCycleException`—when `handler` has an explicit initial scoped memory area that has already been entered from a memory area other than the area where `handler` was allocated.

Since RTSJ 2.0 Inherited by AyncEvent

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(AsyncBaseEventHandler handler)
```

Description

Associates a new handler with this event and removes all existing handlers. The execution of this method is atomic with respect to the execution of the `fire()` method.

Parameters

`handler`—The instance of `AsyncBaseEventHandler` to be associated with `this`. When `handler` is `null` then no handler will be associated with `this`, i.e., it behaves effectively as if `setHandler(null)` invokes `removeHandler(AsyncBaseEventHandler)` for each associated handler.

Throws

`StaticIllegalArgumentException`—when `handler` has `PeriodicParameters`. Only the subclass `PeriodicTimer` is allowed to have handlers with `PeriodicParameters`.

`IllegalAssignmentError`—when this `AsyncBaseEvent` cannot hold a reference to `handler`.

Since RTSJ 2.0 Inherited by AyncEvent

removeHandler(AsyncBaseEventHandler)

Signature

```
public void
removeHandler(AsyncBaseEventHandler handler)
```

Description

Removes a handler from the set associated with this event. The execution of this method is atomic with respect to the execution of the `fire()` method.

A removed handler continues to execute until its fireCount becomes zero and it completes.

When `handler` has a scoped non-default initial memory area and execution of this method causes `handler` to become unfirable, this method shall not return until all related finalization has completed.

Parameters

`handler`—The handler to be disassociated from `this`. When `null` nothing happens.

When the `handler` is not already associated with `this` then nothing happens.

Since RTSJ 2.0 Inherited by AyncEvent

hasHandlers

Signature

```
public boolean
hasHandlers()
```

Description

Determines whether or not this event has any handlers.

Returns

`true` when and only when at least one handler is associated with this event.

Since RTSJ 2.0 Inherited by AyncEvent

createReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
createReleaseParameters()
```

Description

Creates a `ReleaseParameters` object appropriate to the release characteristics of this event. The default is the most pessimistic: `AperiodicParameters`. This is typically called by code that is setting up a handler for this event that will fill in the parts of the release parameters for which it has values, e.g., cost. The returned `ReleaseParameters` object is not bound to the event. Any changes in the event's release parameters are not reflected in previously returned objects.

When an event returns `PeriodicParameters`, there is no requirement for an implementation to check that the handler is released periodically.

Returns

a new `ReleaseParameters` object.

8.3.2.3 AsyncBaseEventHandler

---

public abstract class AsyncBaseEventHandler

Inheritance

java.lang.Object
AsyncBaseEventHandler

Interfaces

javax.realtime.Schedulable

Description

This is the base class for all asynchronous event handlers, where asynchronous is in regards to running code, not external time. This class unifies the original `AsyncEventHandler` with `AsyncLongEventHandler` and `AsyncObjectEventHandler`. Each of these subclasses has its own `handleAsyncEvent` method, whose only difference is whether and what argument it has.

Since RTSJ 2.0

8.3.2.3.1 Methods

---

getCurrentReleaseTime

Signature

```
public static javax.realtime.AbsoluteTime
getCurrentReleaseTime()
```

Description

Gets the last release time of this timer.

Throws

`StaticIllegalStateException`—when this timer has not been released since it was last started.

Returns

a reference to a newly-created `AbsoluteTime` object representing this timer's last release time. When the timer has not been released since it was last started, throws an exception.

Since RTSJ 2.0

getCurrentReleaseTime(AbsoluteTime)

Signature

```
public static javax.realtime.AbsoluteTime
getCurrentReleaseTime(AbsoluteTime dest)
```

Description

Gets the last release time of this timer in the object provided.

Parameters

`dest`—An object used to return the results

Returns

When `dest` is `null`, returns a reference to a newly-created `AbsoluteTime` object representing this timer's last release time. When `dest` is not null, sets `dest` to this timer's last release time. When the timer has not been released, returns `null`.

Since RTSJ 2.0

getCurrentConsumption(RelativeTime)

Signature

```
public static javax.realtime.RelativeTime
getCurrentConsumption(RelativeTime dest)
```

```
throws StaticIllegalStateException
```

Description

Determines the CPU consumption for this release. When `dest` is `null`, returns the CPU consumption in an otherwise unused `RelativeTime` instance in the current execution context. Otherwise, when `dest` is not `null`, returns the CPU consumption in `dest`

Parameters

`dest`—When not `null`, the object in which to return the result.

Throws

`StaticIllegalStateException`—when the caller is not a `Schedulable`.

Returns

the time consumed in the current release.

Since RTSJ 2.0 Inherited by AyncEventHandler

getCurrentConsumption

Signature

```
public static javax.realtime.RelativeTime
getCurrentConsumption()
```

Description

Equivalent to `getCurrentConsumption(null)`.

Returns

the time consumed in the current release.

Since RTSJ 2.0 Inherited by AyncEventHandler

getPendingFireCount

Signature

```
protected abstract int
getPendingFireCount()
```

Description

This is an accessor method for `fireCount`. The `fireCount` field nominally holds the number of times associated instances of `AsyncEvent` have occurred that have not had the method `handleAsyncEvent()` invoked. It is incremented and decremented by the implementation of the RTSJ. The application logic may manipulate the value in this field for application-specific reasons.

Returns

the value held by `fireCount`.

getAndClearPendingFireCount

Signature

```
protected abstract int
getAndClearPendingFireCount()
```

Description

This is an accessor method for `fireCount`. This method atomically sets the value of `fireCount` to zero and returns the value from before it was set to zero. This may be used by handlers for which the logic can accommodate multiple releases in a single execution.

The general form for using this is

```
public void handleAsyncEvent()
{
  int numberOfReleases = getAndClearPendingFireCount();
  <handle the events>
}
```

The effect of a call to `getAndClearPendingFireCount` on the scheduling of this AEH depends on the semantics of the scheduler controlling this AEH.

Returns

the value held by `fireCount` prior to setting the value to zero.

getAndDecrementPendingFireCount

Signature

```
protected abstract int
getAndDecrementPendingFireCount()
```

Description

This is an accessor method for `fireCount`. This method atomically decrements, by one, the value of `fireCount` (when it is greater than zero) and returns the value from before the decrement. This method can be used in the `handleAsyncEvent()` method to handle multiple releases:

```
public void handleAsyncEvent()
{
  <setup>
  do
    {
      <handle the event>
    }
  while(getAndDecrementPendingFireCount() > 0);
}
```

This construction is necessary only in cases where a handler wishes to avoid the setup costs, since the framework guarantees that `handleAsyncEvent()` will be invoked whenever the `fireCount` is greater than zero. The effect of a call to `getAndDecrementPendingFireCount` on the scheduling of this AEH depends on the semantics of the scheduler controlling this AEH.

Returns
the value held by `fireCount` prior to decrementing it by one.

getMemoryArea

Signature

```
public javax.realtime.MemoryArea
getMemoryArea()
```

Description

This is an accessor method for the initial instance of `MemoryArea` associated with `this`.

Returns
the instance of `MemoryArea` which was passed as the `area` parameter when `this` was created (or the default value when `area` was allowed to default.

getMemoryParameters

Signature

```
public javax.realtime.MemoryParameters
getMemoryParameters()
```

Description

Returns
a reference to the current `MemoryParameters` object.

getReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
getReleaseParameters()
```

Description

Returns
a reference to the current `ReleaseParameters` object.

getScheduler

Signature

```
public javax.realtime.Scheduler
getScheduler()
```

Description

Returns

a reference to the associated `Scheduler` object.

getSchedulingParameters

Signature

```
public javax.realtime.SchedulingParameters
getSchedulingParameters()
```

Description

Returns

A reference to the current `SchedulingParameters` object.

getRealtimeThreadGroup

Signature

```
public javax.realtime.RealtimeThreadGroup
getRealtimeThreadGroup()
```

Description

Returns

a reference to the associated `RealtimeThreadGroup` object.

Since RTSJ 2.0

getConfigurationParameters

Signature

```
public javax.realtime.ConfigurationParameters
getConfigurationParameters()
```

Description

Gets a reference to the `ConfigurationParameters` object for this schedulable.

Returns

the `ConfigurationParameters` instance of its `ReleaseRunner` instance, i.e., `getReleaseRunner().getConfigurationParameters()`

setMemoryParameters(MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setMemoryParameters(MemoryParameters memory)
```

Description

Parameters

`memory`—A `MemoryParameters` object which will become the memory parameters associated with `this` after the method call. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `memory` is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and `memory` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `memory`, or when `memory` cannot hold a reference to this schedulable instance.

Returns

`this`

Since RTSJ 2.0 returns itself

setReleaseParameters(ReleaseParameters)

Signature

```
public javax.realtime.Schedulable
setReleaseParameters(ReleaseParameters<?> release)
```

Description

Parameters

`release`—A `ReleaseParameters` object which will become the release parameters associated with this after the method call, and take effect as determined by the associated scheduler. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `release` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `release` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `release` or `release` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is running and the new release parameters are not compatible with the current scheduler.

Returns
`this`

Since RTSJ 2.0 returns itself

setScheduler(Scheduler)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler)
```

Description

Sets the reference to the Scheduler object. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`. If the `Schedulable` is running, its associated `SchedulingParameters` (if any) must be compatible with `scheduler`.

For an instance of `AsyncBaseEventHandler`, the `Schedulable` is *running* for the purpose of setting the scheduler when it is attached to an `AsyncEvent`, even when `AsyncBaseEvent.isRunning()` would return `false` for that event.

Parameters

`scheduler`—A reference to the scheduler that will manage execution of this schedulable. `Null` is not a permissible value.

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null`, or the schedulable's existing parameter values are not compatible with `scheduler`. Also when this schedulable may not use the heap and `scheduler` is located in heap memory.

`IllegalAssignmentError`—when the schedulable cannot hold a reference to `scheduler` or the current `Schedulable` is running and its associated `SchedulingParameters` are incompatible with `scheduler`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

`IllegalTaskStateException`—when `scheduler` has scheduling or release parameters that are not compatible with the new scheduler and this schedulable is running.

Returns
`this`

Since RTSJ 2.0 returns itself

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public javax.realtime.Schedulable
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
```

```
MemoryParameters memoryParameters)
```

Description

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Returns

`this`

Since RTSJ 2.0

setSchedulingParameters(SchedulingParameters)

Signature

```
public javax.realtime.Schedulable
setSchedulingParameters(SchedulingParameters scheduling)
```

Description

Parameters

`scheduling`—A reference to the `SchedulingParameters` object. When `null`, the default value is governed by the associated scheduler; a new object is created when the default value is not `null`. (See `PriorityScheduler`.). When the Affinity is not defined in `scheduling`, then the affinity that will be used is the one of the creating Thread. However, this default affinity will not appear when calling `getSchedulingParameters`, unless explicitly set using this method.

Throws

`StaticIllegalArgumentException`—when `scheduling` is not compatible with the associated scheduler. Also when this schedulable may not use the heap and `scheduling` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `scheduling` or `scheduling` cannot hold a reference to `this`.

`IllegalTaskStateException`—when the task is active and the new scheduling parameters are not compatible with the current scheduler or when the task is active and the affinity in `scheduling` is not a subset of the affinity of `this` object's `RealtimeThreadGroup` or when the task is active and the affinity in `scheduling` is invalid.

Returns

`this`

Since RTSJ 2.0, method returns a reference to `this`.

setDaemon(boolean)

Signature

```
public final void
setDaemon(boolean on)
```

Description

Parameters

`on`—When `true`, marks this event handler as a daemon handler.

Throws

`IllegalThreadStateException`—when this schedulable is active.

`StaticSecurityException`—when the current schedulable cannot modify this event handler.

Since RTSJ 2.0

isDaemon

Signature

```
public final boolean
isDaemon()
```

Description

Returns

`true` when this event handler is a daemon handler; `false` otherwise.

Since RTSJ 2.0

getDispatcher

Signature

```
public javax.realtime.TimeDispatcher
getDispatcher()
```

Description

Returns

the time dispatcher use to dispatch clock events.

getQueueLength

Signature

```
public int
getQueueLength()
```

Description

Finds the current length of the event queue. The event queue holds the time and payload of all released events that are still outstanding. The queue may have a length of zero.

Returns

the queue length.

Since RTSJ 2.0 Inherited by AyncEventHandler

getMinConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)
```

Description

Determines the minimum CPU consumption of all completed releases. When `dest` is `null`, returns the CPU consumption in an otherwise unused `RelativeTime` instance in the current execution context. Otherwise, when `dest` is not `null`, returns the CPU consumption in `dest`

Parameters

`dest`—When not `null`, the object in which to return the result.

Returns

the minimum time consumed in any release.

getMinConsumption

Signature

```
public javax.realtime.RelativeTime
getMinConsumption()
```

Description

Same as `getMinConsumption(RelativeTime)` with a null argument.

Returns

the minimum time consumed in any release.

getMaxConsumption(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption(RelativeTime dest)
```

Description

Determines the maximum CPU consumption of all completed releases. When `dest` is `null`, returns the CPU consumption in an otherwise unused `RelativeTime` instance in the current execution context. Otherwise, when `dest` is not `null`, returns the CPU consumption in `dest`.

Parameters

`dest`—When not `null`, the object in which to return the result.

Returns

the maximum time consumed in any release.

getMaxConsumption

Signature

```
public javax.realtime.RelativeTime
getMaxConsumption()
```

Description

Same as `getMaxConsumption(RelativeTime)` with a null argument.

Returns

the maximum time consumed in any release.

mayUseHeap

Signature

```
public boolean
mayUseHeap()
```

Description

Determines whether or not this `schedulable` may use the heap.

Returns
`true` only when this `Schedulable` may allocate on the heap and may enter the `Heap`.

isInterrupted

Signature

```
public boolean
isInterrupted()
```

Description

Returns
`true` when and only when the generic `AsynchronouslyInterruptedException` is pending.

Since RTSJ 2.0

interrupt

Signature

```
public void
interrupt()
```

Description

Throws
`IllegalTaskStateException`—when `this` is not currently releasable, i.e., is disabled, not firable, its start method has not been called, or it has terminated.

Since RTSJ 2.0

isRousable

Signature

```
public boolean
isRousable()
```

Description

Determines whether or not it is possible for an interruptible to prematurely release the handler.

Returns
`true` when it is possible, otherwise `false`.

Since RTSJ 2.0 Inherited by AyncEventHandler

setRousable(boolean)

Signature

```
public javax.realtime.AsyncBaseEventHandler
setRousable(boolean value)
```

Description

Sets a state indicating whether or not a interrupt can prematurely release this handler.

Parameters

`value`—The new value of the wake by interrupt state.

Returns

`this`

Since RTSJ 2.0 Inherited by AyncEventHandler

awaken

Signature

```
public final void
awaken()
```

Description

Use internally to indicate a sleep period has ended.

See Section Schedulable.awaken()

subsumes(Schedulable)

Signature

```
public boolean
subsumes(Schedulable other)
```

Description

Returns

`true` when and only when this instance of `Schedulable` is more eligible than `other`.

Since RTSJ 2.0

run

Signature

```
public final void
run()
```

Description

Calls `handleAsyncEvent` repeatedly until the fire count reaches zero. The method is only to be used by the infrastructure, and should not be called by the application. The `handleAsyncEvent` method should be overridden instead.

The `handleAsyncEvent()` family of methods provides the equivalent functionality to `Runnable.run()` for asynchronous event handlers, including execution of the `logic` argument passed to this object's constructor. Applications should override the `handleAsyncEvent()` method instead of overwriting this method.

8.3.2.4 AsyncEvent

---

public class AsyncEvent

Inheritance

java.lang.Object
  AsyncBaseEvent
    AsyncEvent

Description

An asynchronous event can have a set of handlers associated with it, and when the event occurs, the `fireCount` of each handler is incremented, and the handlers are released (see `AsyncEventHandler`).

Since RTSJ 2.0 extends AsyncBaseEvent

8.3.2.4.1 Constructors

AsyncEvent

Signature

```
public
AsyncEvent()
```

Description

Creates a new `AsyncEvent` object.

8.3.2.4.2 Methods

---

fire

Signature

```
public void
fire()
```

Description

When enabled, release the asynchronous event handlers associated with this instance of `AsyncEvent`. When this object is disabled the method does nothing, i.e., it skips the release. When no handlers are attached, the release is ignored. This method does not suspend itself and has a runtime complexity of `O(n)`, where `n` is the number of attached handers. For an instance of `AsyncEvent` that has more than one instance of `AsyncEventHandler`,

- when one of these handlers throws an exception, all instances of `AsyncEventHandler` not affected by the exception must be released normally before the exception is propagated, and
- when more than one of these handlers throws an exception, the propagation of `MITViolationException` has precedence over `ArrivalTimeQueueOverflowException`, which has precedence over all others.

The later case can only occur when more than one of the handlers has a release parameters instance of type `SporadicParameters`, since only them can `MITViolationException` and `ArrivalTimeQueueOverflowException` be thrown.

Throws

`MITViolationException`—under the base priority scheduler's semantics when there is a handler associated with this event that has its MIT violated by the call to fire (and it has set the minimum interarrival time violation behavior to MITViolationExcept). Only the handlers which do not have their MITs violated are released in this situation.

`ArrivalTimeQueueOverflowException`—when the queue of release information, arrival time and payload, overflows. Only the handlers which do not cause this exception to be thrown are released in this situation. When fire is called from the infrastructure, such as for an `ActiveEvent`, this exception is ignored.

8.3.2.5 AsyncEventHandler

---

public class AsyncEventHandler

Inheritance

java.lang.Object
  AsyncBaseEventHandler
    AsyncEventHandler

Description

An asynchronous event handler encapsulates code that is released after an instance of `AsyncEvent` to which it is attached occurs.

It is guaranteed that multiple releases of an event handler will be serialized. It is also guaranteed that (unless the handler explicitly chooses otherwise) for each release of the handler, there will be one execution of the `AsyncEventHandler.handleAsyncEvent()` method. Control over the number of calls to `AsyncEventHandler.handleAsyncEvent()` is given by methods which

manipulate a `fireCount`. These may be called by the application via sub-classing and overriding `AsyncEventHandler.handleAsyncEvent()`.

Instances of `AsyncEventHandler` with a release parameter of type `SporadicParameters` or `AperiodicParameters` have a list of release times which correspond to the occurrence times of instances of `AsyncEvent` to which they are attached. The minimum interarrival time specified in `SporadicParameters` is enforced when a release time is added to the list. Unless the handler explicitly chooses otherwise, there will be one execution of the code in `AsyncEventHandler.handleAsyncEvent()` for each entry in the list.

The deadline and the time each release event causes the AEH to become eligible for execution are properties of the scheduler that controls the AEH. For the base scheduler, the deadline for each release event is relative to its fire time, and the release takes place at fire time but execution eligibility may be deferred when the queue's MIT violation policy is `SAVE`.

Handlers may do almost anything a realtime thread can do. They may run for a long or short time, and they may block. (Note, blocked handlers may hold system resources.) A handler may not use the `RealtimeThread.waitForNextRelease` method.

Normally, handlers are bound to an execution context dynamically when the instances of `AsyncEvent`s to which they are bound occur. This can introduce a (small) time penalty. For critical handlers that cannot afford the expense, and where this penalty is a problem, `BoundAsyncEventHandler`s can be used.

The scheduler for an asynchronous event handler is inherited from the task that created it. When created from a task that is not an instance of `Schedulable`, the scheduler is the current default scheduler.

The semantics for memory areas that were defined for realtime threads apply in the same way to instances of `AsyncEventHandler` They may inherit a scope stack when they are created, and the single parent rule applies to the use of memory scopes for instances of `AsyncEventHandler` just as it does in realtime threads.

Since RTSJ 2.0 extends AsyncBaseEventHandler.

8.3.2.5.1 Constructors

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  ReleaseParameters<?> release,
                  MemoryParameters memory,
```

```
                    MemoryArea area,
                    ConfigurationParameters config,
                    ReleaseRunner runner,
                    Runnable logic)
```

Description

Creates a handler with the given scheduling, release, memory, group, and configuration parameters to run the given logic.

Since RTSJ 2.0

Parameters

`scheduling`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `scheduling` is `null` and the creator is an instance of `Schedulable`, `SchedulingParameters` is a clone of the creator's value created in the same memory area as `this`. When `scheduling` is `null` and the creator is a task that is not an instance of `Schedulable`, the contents and type of the new `SchedulingParameters` object are governed by the associated scheduler. The Affinity of the newly-created handler will be set as follow:

- When defined, from SchedulingParameters.
- Otherwise, the Affinity will be inherited from the creating task.

In the case where the affinity is not explicitly set using the constructor or `AsyncBaseEventHandler.setSchedulingParameters(SchedulingParameters)`, the default affinity assigned to this Schedulable will not appear in the `SchedulingParameters` returned by `AsyncBaseEventHandler.getSchedulingParameters()`.

`release`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `release` is `null` the new `AsyncEventHandler` will use a clone of the default `ReleaseParameters` for the associated scheduler created in the memory area that contains the `AsyncEventHandler` object.

`memory`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `memory` is `null`, the new `AsyncEventHandler` receives `null` value for its memory parameters, and the amount or rate of memory allocation for the new handler is unrestricted.

`area`—The initial memory area of this handler.

`runner`—A pool of realtime threads to provide an execution context for this handler.

`logic`—The `Runnable` object whose `run()` method will serve as the logic for the new `AsyncEventHandler`. When `logic` is `null`, the `handleAsyncEvent()` method in the new object will serve as its logic.

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  ReleaseParameters<?> release,
                  MemoryParameters memory,
```

```
                    MemoryArea area,
                    Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)` with arguments `(scheduling, release, memory, area, null, null, logic)`.

Since RTSJ 2.0

AsyncEventHandler(SchedulingParameters, ReleaseParameters, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                    ReleaseParameters<?> release,
                    Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)` with arguments `(scheduling, release, null, null, null, null, logic)`.

Since RTSJ 2.0

AsyncEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                    ReleaseParameters<?> release)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)` with arguments `(scheduling, release, null, null, null, null, null)`

Since RTSJ 2.0

AsyncEventHandler(Runnable)

Signature

```
public
AsyncEventHandler(Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)` with arguments `(null, null, null, null, null, null, logic)`.

AsyncEventHandler

Signature

```
public
AsyncEventHandler()
```

Description

Creates an instance of `AsyncEventHandler` with default values for all parameters.

See Section AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Runnable)

8.3.2.5.2 Methods

---

handleAsyncEvent

Signature

```
public void
handleAsyncEvent()
```

Description

This method holds the logic which is to be executed when any `AsyncEvent` with which this handler is associated is fired. This method will be invoked repeatedly while `fireCount` is greater than zero.

The default implementation of this method invokes the `run` method of any non-null `logic` instance passed to the constructor of this handler.

This AEH acts as a source of "reference" for its initial memory area while it is released.

All throwables from (or propagated through) `handleAsyncEvent` are caught, a stack trace is printed and execution continues as if `handleAsyncEvent` had returned normally.

getPendingFireCount

Signature

```
protected int
getPendingFireCount()
```

Description

Returns
the value held by `fireCount`.

getAndDecrementPendingFireCount

Signature

```
protected int
getAndDecrementPendingFireCount()
```

Description

Returns
the value held by `fireCount` prior to decrementing it by one.

getAndClearPendingFireCount

Signature

```
protected int
getAndClearPendingFireCount()
```

Description

Returns
the value held by `fireCount` prior to setting the value to zero.

release

Signature

```
public void
release()
```

Description

Release this handler directly.

8.3.2.6 AsyncLongEvent

---

public class AsyncLongEvent

Inheritance
java.lang.Object
AsyncBaseEvent
AsyncLongEvent

Description

A new type of event that carries a long as a payload.

See Section AsyncEvent
Since RTSJ 2.0

8.3.2.6.1 Constructors

AsyncLongEvent

Signature

```
public
AsyncLongEvent()
```

Description

Creates a new `AsyncLongEvent` object.

8.3.2.6.2 Methods

---

handleAsyncEvent(long)

Signature

```
public void
handleAsyncEvent(long payload)
```

Description

This method holds the logic which is to be executed when any `AsyncEvent` with which this handler is associated is fired. This method will be invoked repeatedly while `fireCount` is greater than zero.

The default implementation of this method invokes the `run` method of any non-null `logic` instance passed to the constructor of this handler.

This AEH acts as a source of "reference" for its initial memory area while it is released.

All throwables from (or propagated through) `handleAsyncEvent` are caught, a stack trace is printed and execution continues as if `handleAsyncEvent` had returned normally.

fire(long)

Signature

```
public void
fire(long value)
throws MITViolationException,
       EventQueueOverflowException
```

Description

When enabled, releases the handlers associated with this instance of `AsyncLongEvent` with the `long` passed by `fire(long)`. When no handlers are attached or this object is disabled the method does nothing, i.e., it skips the release. For an instance of `AsyncEvent` that has more than one instance of `AsyncEventHandler`,

- when one of these handlers throws an exception, all instances of `AsyncEventHandler` not affected by the exception must be released normally before the exception is propagated, and
- when more than one of these handlers throws an exception, the propagation of `MITViolationException` has precedence over `ArrivalTimeQueueOverflowException`, which has precedence over all others.

The later case can only occur when more than one of the handlers has a release parameters instance of type `SporadicParameters`, since only them can `MITViolationException` and `ArrivalTimeQueueOverflowException` be thrown.

Parameters

`value`—The payload passed to the event.

Throws

`MITViolationException`—under the base priority scheduler's semantics, when there is a handler associated with this event that has its MIT violated by the call to fire (and it has set the minimum inter-arrival time violation behavior to MITViolationExcept). Only the handlers which do not have their MITs violated are released in this situation.

`EventQueueOverflowException`—when the queue of release information, arrival time and payload, overflows. Only the handlers which do not cause this exception to be thrown are released in this situation. When fire is called from the infrastructure, such as for an `ActiveEvent`, this exception is ignored.

8.3.2.7 AsyncLongEventHandler

---

public class AsyncLongEventHandler

Inheritance

java.lang.Object
  AsyncBaseEventHandler
    AsyncLongEventHandler

Description

A version of `AsyncBaseEventHandler` that carries a `long` value as payload.

Since RTSJ 2.0

8.3.2.7.1 Constructors

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, LongConsumer)

Signature

```
public
AsyncLongEventHandler(SchedulingParameters scheduling,
                      ReleaseParameters<?> release,
                      MemoryParameters memory,
                      MemoryArea area,
                      ConfigurationParameters config,
                      ReleaseRunner runner,
                      LongConsumer logic)
throws StaticIllegalArgumentException
```

Description

Creates an asynchronous event handler that receives a `Long` payload with each fire.

Parameters

`scheduling`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `scheduling` is `null` and the creator is an instance of `Schedulable`, `SchedulingParameters` is a clone of the creator's value created in the same memory area as `this`. When `scheduling` is `null` and the creator is a task that is not an instance of `Schedulable`, the contents and type of the new `SchedulingParameters` object are governed by the associated scheduler.

`release`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `release` is `null` the new `AsyncEventHandler` will use a clone of the default `ReleaseParameters` for the associated scheduler created in the memory area that contains the `AsyncEventHandler` object.

`memory`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `memory` is `null`, the new `AsyncEventHandler` receives `null` value for its memory parameters, and the amount or rate of memory allocation for the new handler is unrestricted.

`area`—The initial memory area of this handler.

`runner`—Logic to be executed by `handleAsyncEvent`

`logic`—The logic to run for each fire. When `logic` is `null`, the `handleAsyncEvent()` method in the new object will serve as its logic.

Throws

`StaticIllegalArgumentException`—when the event queue overflow policy is `QueueOverflowPolicy.DISABLE`.

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, LongConsumer)

Signature

```
public
AsyncLongEventHandler(SchedulingParameters scheduling,
                      ReleaseParameters<?> release,
                      LongConsumer logic)
throws StaticIllegalArgumentException
```

Description

Calling this constructor is equivalent to calling `AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, LongConsumer)` with arguments `(scheduling, release, null, null, null, null, logic)`.

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
AsyncLongEventHandler(SchedulingParameters scheduling,
                      ReleaseParameters<?> release)
throws StaticIllegalArgumentException
```

Description

Calling this constructor is equivalent to calling `AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, LongConsumer)` with arguments `(scheduling, release, null, null, null, null, null)`

AsyncLongEventHandler(LongConsumer)

Signature

```
public
AsyncLongEventHandler(LongConsumer logic)
```

Description

Calling this constructor is equivalent to calling `AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, LongConsumer)` with arguments `(null, null, null, null, null, null, logic)`.

AsyncLongEventHandler

Signature

```
public
AsyncLongEventHandler()
```

Description

Creates an instance of `AsyncLongEventHandler` (ALEH) with default values for all parameters.

See Section AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, LongConsumer)

8.3.2.7.2 Methods

---

handleAsyncEvent(long)

Signature

```
public void
handleAsyncEvent(long payload)
```

Description

This method holds the logic which is to be executed when any `AsyncEvent` with which this handler is associated is fired. This method will be invoked repeatedly while `fireCount` is greater than zero.

This ALEH is a source of reference for its initial memory area while this ALEH is released.

All throwables from (or propagated through) `handleAsyncEvent` are caught, a stack trace is printed and execution continues as if `handleAsyncEvent` had returned normally.

Parameters

`payload`—It is the long value associated with a fire.

peekPending

Signature

```
public long
peekPending()
throws StaticIllegalStateException
```

Description

Determines the next value queued for handling.

Throws

`StaticIllegalStateException`—when the fire count is zero.

Returns

the long value at the head of the queue of longs to be passed to `handleAsyncEvent(long)`.

release(long)

Signature

```
public void
release(long payload)
```

Description

Release this handler directly.

Parameters

`payload`—The long to be passed to the handler.

getPendingFireCount

Signature

```
protected int
getPendingFireCount()
```

Description

Returns

the value held by `fireCount`.

getAndDecrementPendingFireCount

Signature

```
protected int
getAndDecrementPendingFireCount()
```

Description

Returns

the value held by `fireCount` prior to decrementing it by one.

getAndClearPendingFireCount

Signature

```
protected int
getAndClearPendingFireCount()
```

Description

Returns

the value held by `fireCount` prior to setting the value to zero.

8.3.2.8 AsyncObjectEvent

---

public class AsyncObjectEvent<P>

Inheritance
java.lang.Object
AsyncBaseEvent
AsyncObjectEvent<P>

Description

A new type of event that carries an object as a payload.

See Section AsyncEvent
Since RTSJ 2.0

8.3.2.8.1 Constructors

AsyncObjectEvent

Signature

```
public
AsyncObjectEvent()
```

Description

Creates a new `AsyncObjectEvent` instance.

8.3.2.8.2 Methods

---

fire(P)

Signature

```
public void
fire(P value)
throws MITViolationException,
       EventQueueOverflowException,
       IllegalAssignmentError
```

Description

When enabled, fires this instance of `AsyncObjectEvent`. The asynchronous event handlers associated with this event will be released with the object passed by `fire`. When no handlers are attached or this object is disabled the method does nothing, i.e., it skips the release. For an instance of `AsyncEvent` that has more than one instance of `AsyncEventHandler`,

- when one of these handlers throws an exception, all instances of `AsyncEventHandler` not affected by the exception must be released normally before the exception is propagated, and
- when more than one of these handlers throws an exception, the propagation of `MITViolationException` has precedence over `ArrivalTimeQueueOverflowException`, which has precedence over all others.

The later case can only occur when more than one of the handlers has a release parameters instance of type `SporadicParameters`, since only them can `MITViolationException` and `ArrivalTimeQueueOverflowException` be thrown.

Parameters

`value`—The payload passed to the event.

Throws

`MITViolationException`—under the base priority scheduler's semantics when there is a handler associated with this event that has its MIT violated by the call to fire (and it has set the minimum inter-arrival time violation behavior to MITViolationExcept). Only the handlers which do not have their MITs violated are released in this situation.

`ArrivalTimeQueueOverflowException`—when the queue of releases information, arrival time and payload, overflows. Only the handlers which do not cause this exception to be thrown are released in this situation. When fire is called from the infrastructure, such as for an `ActiveEvent`, this exception is ignored.

`IllegalAssignmentError`—when `P` is not assignable the event queue of one of the associated handlers.

8.3.2.9 AsyncObjectEventHandler

---

public class AsyncObjectEventHandler<P>

Inheritance

java.lang.Object
  AsyncBaseEventHandler
    AsyncObjectEventHandler<P>

Description

A version of `AsyncBaseEventHandler` that carries an `Object` value as payload.

Since RTSJ 2.0

8.3.2.9.1 Constructors

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Consumer)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        ReleaseParameters<?> release,
                        MemoryParameters memory,
                        MemoryArea area,
                        ConfigurationParameters config,
                        ReleaseRunner runner,
                        java.util.function.Consumer<P> logic)
throws StaticIllegalArgumentException
```

Description

Creates an asynchronous event handler that receives a `P` payload with each fire.

Parameters

`scheduling`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `scheduling` is `null` and the creator is an instance of `Schedulable`, `SchedulingParameters` is a clone of the creator's value created in the same memory area as `this`. When `scheduling` is `null` and the creator is a task that is not an instance of `Schedulable`, the contents and type of the new `SchedulingParameters` object are governed by the associated scheduler.

`release`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `release` is `null` the new `AsyncEventHandler` will use a clone of the default `ReleaseParameters` for the associated scheduler created in the memory area that contains the `AsyncEventHandler` object.

`memory`—Parameter for scheduling the new handler (and possibly other instances of `Schedulable`). When `memory` is `null`, the new `AsyncEventHandler` receives `null` value for its memory parameters, and the amount or rate of memory allocation for the new handler is unrestricted.

`area`—The initial memory area of this handler.

`runner`—Logic to be executed by `handleAsyncEvent`

`logic`—The logic to run for each fire. When `logic` is `null`, the `handleAsyncEvent` method in the new object will serve as its logic.

Throws

`StaticIllegalArgumentException`—when the event queue overflow policy is `QueueOverflowPolicy.DISABLE`.

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, Consumer)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        ReleaseParameters<?> release,
                        java.util.function.Consumer<P> logic)
throws StaticIllegalArgumentException
```

Description

Calling this constructor is equivalent to calling `AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Consumer)` with arguments `(scheduling, release, null, null, null, logic)`.

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        ReleaseParameters<?> release)
throws StaticIllegalArgumentException
```

Description

Calling this constructor is equivalent to calling `AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Consumer)` with arguments `(scheduling, release, null, null, null, null, null)`

AsyncObjectEventHandler(Consumer)

Signature

```
public
AsyncObjectEventHandler(java.util.function.Consumer<P> logic)
```

Description

Calling this constructor is equivalent to calling `AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Consumer)` with arguments `(null, null, null, null, null, null, logic)`.

Parameters

`logic`—It is the function to call on the object received.

AsyncObjectEventHandler

Signature

```
public
AsyncObjectEventHandler()
```

Description

Creates an instance of `AsyncObjectEventHandler` (AOEH) with default values for all parameters.

See Section AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, ReleaseRunner, Consumer)

8.3.2.9.2 Methods

---

handleAsyncEvent(P)

Signature

```
public void
handleAsyncEvent(P value)
```

Description

This method holds the logic which is to be executed when any `AsyncEvent` with which this handler is associated is fired. This method will be invoked repeatedly while `fireCount` is greater than zero.

The default implementation of this method invokes the `run` method of any non-null `logic` instance passed to the constructor of this handler.

This AOEH is a source of reference for its initial memory area while this AOEH is released.

All throwables from (or propagated through) `handleAsyncEvent(P)` are caught, a stack trace is printed and execution continues as if `handleAsyncEvent(P)` had returned normally.

peekPending

Signature

```
public P
peekPending()
throws StaticIllegalStateException
```

Description

Determines the next value queued for handling.

Throws

`StaticIllegalStateException`—when the fire count is zero.

Returns

the object reference at the head of the queue of object references to be passed to `handleAsyncEvent`}.

release(P)

Signature

```
public void
release(P payload)
```

Description

Release this handler directly.

Parameters

`payload`—The Object to be passed to the handler.

getPendingFireCount

Signature

```
protected int
getPendingFireCount()
```

Description

Returns

the value held by `fireCount`.

getAndDecrementPendingFireCount

Signature

```
protected int
getAndDecrementPendingFireCount()
```

Description

Returns

the value held by `fireCount` prior to decrementing it by one.

getAndClearPendingFireCount

Signature

```
protected int
getAndClearPendingFireCount()
```

Description

Returns

the value held by `fireCount` prior to setting the value to zero.

8.3.2.10 BoundAsyncEventHandler

public class BoundAsyncEventHandler

Inheritance

java.lang.Object
AsyncBaseEventHandler
AsyncEventHandler
BoundAsyncEventHandler

Interfaces

javax.realtime.BoundSchedulable

Description

A bound asynchronous event handler is an instance of `AsyncEventHandler` that is permanently bound to a dedicated realtime thread. Bound asynchronous event handlers are for use in situations where the added timeliness is worth the overhead of dedicating an individual realtime thread to the handler. Individual server realtime threads can only be dedicated to a single bound event handler.

8.3.2.10.1 Constructors

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, RealtimeThreadGroup, ConfigurationParameters, Runnable)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       ReleaseParameters<?> release,
                       MemoryParameters memory,
                       MemoryArea area,
                       RealtimeThreadGroup group,
                       ConfigurationParameters config,
                       Runnable logic)
```

Description

Creates an instance of `BoundAsyncEventHandler` (BAEH) with the specified parameters.

Since RTSJ 2.0

Parameters

`scheduling`—A `SchedulingParameters` object which will be associated with the constructed instance. When `null`, and the creator is not an instance of `Schedulable`, a `SchedulingParameters` object is created which has the default `SchedulingParameters` for the scheduler associated with the current

thread. When `null`, and the creator is an instance of `Schedulable`, the `SchedulingParameters` are inherited from the current schedulable (a new `SchedulingParameters` object is cloned). The Affinity of the newly-created handler will be set as follows:

- When defined, from SchedulingParameters.
- When the creating task is in the RealtimeThreadGroup in parameters, or when no group are defined, the Affinity will be inherited from the creating Thread
- Otherwise, the Affinity will be inherited from the RealtimeThreadGroup in parameters. When it is not set, it will take the affinity of the group of the creating thread.

In all the cases where the affinity is not explicitly set using `AsyncBaseEventHandler.setSchedulingParameters(SchedulingParameters)`, the default affinity assigned to this Schedulable will not appear in the `SchedulingParameters` returned by `AsyncBaseEventHandler.getSchedulingParameters()`.

`release`—A `ReleaseParameters` object which will be associated with the constructed instance. When `null`, `this` will have default `ReleaseParameters` for the BAEH's scheduler.

`memory`—A `MemoryParameters` object which will be associated with the constructed instance. When `null`, `this` will have no `MemoryParameters` and the handler can access the heap.

`area`—The `MemoryArea` for `this`. When `null`, the memory area will be that of the current thread/schedulable.

`group`—A `RealtimeThreadGroup` object which will be associated with the constructed instance. When `null`, `this` will be associated with the creating thread's realtime thread group.

`config`—The `ConfigurationParameters` associated with `this` (and possibly other instances of `Schedulable`. When `config` is `null`, this `BoundAsyncEventHandler` will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

`logic`—The `Runnable` object whose `run()` method is executed by `AsyncEventHandler.handleAsyncEvent()`. When `null`, the default `handleAsyncEvent()` method invokes nothing.

Throws

`ProcessorAffinityException`—when the affinity in `SchedulingParameters` is invalid or not a subset of `this` group's affinity.

`StaticIllegalArgumentException`—when `config` is of type `javax.realtime.memory.ScopedConfigurationParameters` and `logic`, any parameter object, or `this` is in heap memory.

`IllegalAssignmentError`—when the new `AsyncEventHandler` instance cannot hold a reference to any value assigned to one of the `scheduling`, `release`, `memory`, or `group` parameters, or when those parameters cannot hold a reference to the new `AsyncEventHandler`. Also when the new `AsyncEventHandler` instance cannot hold a reference to values assigned to `area` or `logic`.

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, Runnable)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       ReleaseParameters<?> release,
                       Runnable logic)
```

Description

Creates an instance of `BoundAsyncEventHandler` with the specified parameters.

Equivalent to BoundAsyncEventHandler(scheduling, release, null, null, null, null, logic)

Since RTSJ 2.0

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       ReleaseParameters<?> release)
```

Description

Creates an instance of `BoundAsyncEventHandler` with the specified parameters.

Equivalent to `BoundAsyncEventHandler(scheduling, release, null, null, null, null, null)`

Since RTSJ 2.0

BoundAsyncEventHandler(Runnable)

Signature

```
public
BoundAsyncEventHandler(Runnable logic)
```

Description

Creates an instance of `BoundAsyncEventHandler` with the specified parameters.

Equivalent to `BoundAsyncEventHandler(null, null, null, null, null, null, logic)`

Since RTSJ 2.0

BoundAsyncEventHandler

Signature

```
public
BoundAsyncEventHandler()
```

Description

Creates an instance of `BoundAsyncEventHandler`.

Equivalent to `BoundAsyncEventHandler(null, null, null, null, null, null, null)`

8.3.2.11 BoundAsyncLongEventHandler

---

public class BoundAsyncLongEventHandler

Inheritance

java.lang.Object
AsyncBaseEventHandler
AsyncLongEventHandler
BoundAsyncLongEventHandler

Interfaces

javax.realtime.BoundSchedulable

Description

A bound asynchronous event handler is an instance of `AsyncLongEventHandler` that is permanently bound to a dedicated `RealtimeThread`. Bound asynchronous long event handlers are for use in situations where the added timeliness is worth the overhead of dedicating an individual realtime thread to the handler. Individual server realtime threads can only be dedicated to a single bound event handler.

Since RTSJ 2.0

8.3.2.11.1 Constructors

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, RealtimeThreadGroup, ConfigurationParameters, LongConsumer)

Signature

```
public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
                           ReleaseParameters<?> release,
                           MemoryParameters memory,
                           MemoryArea area,
                           RealtimeThreadGroup group,
                           ConfigurationParameters config,
                           LongConsumer logic)
```

Description

Creates an instance of `BoundAsyncEventHandler` (BAEH) with the specified parameters.

Parameters

`scheduling`—A `SchedulingParameters` object which will be associated with the constructed instance. When `null`, and the creator is not an instance of `Schedulable`, a `SchedulingParameters` object is created which has the default `SchedulingParameters` for the scheduler associated with the current thread. When `null`, and the creator is an instance of `Schedulable`, the `SchedulingParameters` are inherited from the current schedulable (a new `SchedulingParameters` object is cloned). The Affinity of the newly-created handler will be set as follow:

- When defined, from SchedulingParameters.
- When the creating task is in the RealtimeThreadGroup in parameters, or when no group are defined, the Affinity will be inherited from the creating Thread
- Otherwise, the Affinity will be inherited from the RealtimeThreadGroup in parameters. When it is not set, it will take the affinity of the group of the creating thread.

In all the cases where the affinity is not explicitly set using `AsyncBaseEventHandler.setSchedulingParameters(SchedulingParameters)`, the default affinity assigned to this Schedulable will not appear in the `SchedulingParameters` returned by `AsyncBaseEventHandler.getSchedulingParameters()`.

`release`—A `ReleaseParameters` object which will be associated with the constructed instance. When `null`, `this` will have default `ReleaseParameters` for the BAEH's scheduler.

`memory`—A `MemoryParameters` object which will be associated with the constructed instance. When `null`, `this` will have no `MemoryParameters` and the handler can access the heap.

`area`—The `MemoryArea` for `this`. When `null`, the memory area will be that of the current thread/schedulable.

`group`—A `RealtimeThreadGroup` object which will be associated with the constructed instance. When `null`, `this` will be associated with the creating thread's realtime thread group.

`config`—The `ConfigurationParameters` associated with `this`, and possibly other instances of `Schedulable`. When `config` is `null`, this `BoundAsyncEventHandler` will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

`logic`—The `LongConsumer` object whose `accept()` method is executed by `AsyncLongEventHandler.handleAsyncEvent(long)`. When `null`, the default `handleAsyncEvent(long)` method invokes nothing.

Throws

`ProcessorAffinityException`—when the Affinity in SchedulingParameters is invalid or not a subset of the groups `this` is associated to.

`StaticIllegalArgumentException`—when `config` is of type `javax.realtime.`

memory.ScopedConfigurationParameters and logic, any parameter object, or this is in heap memory.

IllegalAssignmentError—when the new AsyncEventHandler instance cannot hold a reference to any value assigned to one of the scheduling, release, memory, or group parameters, or when those parameters cannot hold a reference to the new AsyncEventHandler. Also when the new AsyncEventHandler instance cannot hold a reference to values assigned to area or logic.

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters, LongConsumer)

Signature

```
public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
                           ReleaseParameters<?> release,
                           LongConsumer logic)
```

Description

Creates an instance of BoundAsyncLongEventHandler. This constructor is equivalent to BoundAsyncLongEventHandler(scheduling, release, null, null, null, null, logic)

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
                           ReleaseParameters<?> release)
```

Description

Creates an instance of BoundAsyncLongEventHandler. Calling this constructor is equivalent to calling BoundAsyncLongEventHandler(scheduling, release, null, null, null, null, null)

BoundAsyncLongEventHandler(LongConsumer)

Signature

```
public
BoundAsyncLongEventHandler(LongConsumer logic)
```

Description

Creates an instance of BoundAsyncLongEventHandler. Calling this constructor is equivalent to calling BoundAsyncLongEventHandler(null, null, null, null, null, null, logic)

BoundAsyncLongEventHandler

Signature

```
public
BoundAsyncLongEventHandler()
```

Description

Creates an instance of `BoundAsyncLongEventHandler` using default values. Calling this constructor is equivalent to calling `BoundAsyncLongEventHandler(null, null, null, null, null, null, null)`

8.3.2.12 BoundAsyncObjectEventHandler

---

public class BoundAsyncObjectEventHandler<P>

Inheritance

java.lang.Object
  AsyncBaseEventHandler
    AsyncObjectEventHandler<P>
      BoundAsyncObjectEventHandler<P>

Interfaces

javax.realtime.BoundSchedulable

Description

A bound asynchronous event handler is an instance of `AsyncObjectEventHandler` that is permanently bound to a dedicated `RealtimeThread`. Bound asynchronous object event handlers are for use in situations where the added timeliness is worth the overhead of dedicating an individual realtime thread to the handler. Individual server realtime threads can only be dedicated to a single bound event handler.

Since RTSJ 2.0

8.3.2.12.1 Constructors

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, RealtimeThreadGroup, ConfigurationParameters, Consumer)

Signature

```
public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
                             ReleaseParameters<?> release,
                             MemoryParameters memory,
```

```
                                    MemoryArea area,
                                    RealtimeThreadGroup group,
                                    ConfigurationParameters config,
                                    java.util.function.Consumer<P> logic)
```

Description

Creates an instance of `BoundAsyncObjectEventHandler` which specifies all possible parameters. The newly-created handler inherits the affinity of its creator. The Affinity of the newly-created handler will be set as follow:

- When defined, from SchedulingParameters.
- When the creating task is in the RealtimeThreadGroup in parameters, or when no group are defined, the Affinity will be inherited from the creating Thread
- Otherwise, the Affinity will be inherited from the RealtimeThreadGroup in parameters. When it is not set, it will take the affinity of the group of the creating thread.

Parameters

`scheduling`—A `SchedulingParameters` object which will be associated with the constructed instance. When `null`, and the creator is not an instance of `Schedulable`, a `SchedulingParameters` object is created which has the default `SchedulingParameters` for the scheduler associated with the current thread. When `null`, and the creator is an instance of `Schedulable`, the `SchedulingParameters` are inherited from the current schedulable (a new `SchedulingParameters` object is cloned). The Affinity of the newly-created handler will be set as follow:

- When defined, from SchedulingParameters.
- When the creating task is in the RealtimeThreadGroup in parameters, or when no group are defined, the Affinity will be inherited from the creating Thread
- Otherwise, the Affinity will be inherited from the RealtimeThreadGroup in parameters. When it is not set, it will take the affinity of the group of the creating thread.

In all the cases where the affinity is not explicitly set using `AsyncBaseEventHandler.setSchedulingParameters(SchedulingParameters)`, the default affinity assigned to this Schedulable will not appear in the `SchedulingParameters` returned by `AsyncBaseEventHandler.getSchedulingParameters()`.

`release`—A `ReleaseParameters` object which will be associated with the constructed instance. When `null`, `this` will have default `ReleaseParameters` for the BAEH's scheduler.

`memory`—A `MemoryParameters` object which will be associated with the constructed instance. When `null`, `this` will have no `MemoryParameters` and the handler can access the heap.

`area`—The `MemoryArea` for `this`. When `null`, the memory area will be that of the current thread/schedulable.

`group`—A `RealtimeThreadGroup` object which will be associated with the constructed instance. When `null`, `this` will be associated with the creating thread's realtime thread group.

`config`—The `ConfigurationParameters` associated with `this`, and possibly other instances of `Schedulable`. When `config` is `null`, this `BoundAsyncEventHandler` will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

`logic`—The `Consumer` object whose `accept()` method is executed by `AsyncObjectEventHandler.handleAsyncEvent`. When `null`, the default `handleAsyncEvent` method invokes nothing.

Throws

`ProcessorAffinityException`—when the Affinity in SchedulingParameters is invalid or not a subset of the groups `this` is associated to.

`StaticIllegalArgumentException`—when `config` is of type `javax.realtime.memory.ScopedConfigurationParameters` and `logic`, any parameter object, or `this` is in heap memory.

`IllegalAssignmentError`—when the new `AsyncEventHandler` instance cannot hold a reference to any value assigned to one of the `scheduling`, `release`, `memory`, or `group` parameters, or when those parameters cannot hold a reference to the new `AsyncEventHandler`. Also when the new `AsyncEventHandler` instance cannot hold a reference to values assigned to `area` or `logic`.

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, Consumer)

Signature

```
public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
                             ReleaseParameters<?> release,
                             java.util.function.Consumer<P> logic)
```

Description

Creates an instance of `BoundAsyncObjectEventHandler`. This constructor is equivalent to `BoundAsyncObjectEventHandler(scheduling, release, null, null, null, null, logic)`

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
                             ReleaseParameters<?> release)
```

Description

Creates an instance of `BoundAsyncObjectEventHandler`. Calling this constructor is equivalent to calling `BoundAsyncObjectEventHandler(scheduling, release, null, null, null, null, null)`

BoundAsyncObjectEventHandler(Consumer)

Signature

```
public
BoundAsyncObjectEventHandler(java.util.function.Consumer<P> logic)
```

Description

Creates an instance of `BoundAsyncObjectEventHandler`. Calling this constructor is equivalent to calling `BoundAsyncObjectEventHandler(null, null, null, null, null, null, logic)`

BoundAsyncObjectEventHandler

Signature

```
public
BoundAsyncObjectEventHandler()
```

Description

Creates an instance of `BoundAsyncObjectEventHandler` using default values. This constructor is equivalent to `BoundAsyncObjectEventHandler(null, null, null, null, null, null, null)`

8.3.2.13 FirstInFirstOutReleaseRunner

---

public class FirstInFirstOutReleaseRunner

Inheritance

java.lang.Object
  ReleaseRunner
    FirstInFirstOutReleaseRunner

Description

The default `ReleaseRunner` that uses a pool of FIFO scheduled realtime threads to run handlers. This reduces the amount of threads required for handling events compared with bounding a thread to each handler. It also supports handlers that suspend themselves, e.g., by calling the `Object.wait()` method. The size of the pool of threads is based on the number of handlers, the number of priorities in use, and the number of cpus available. For systems with many `AsyncBaseEventHandler` instances, there can be significantly fewer threads to run releases of those handlers in the system.

Since RTSJ 2.0

8.3.2.13.1 Constructors

FirstInFirstOutReleaseRunner(ConfigurationParameters, RealtimeThreadGroup, IntBinaryOperator)

Signature

```
public
FirstInFirstOutReleaseRunner(ConfigurationParameters config,
                             RealtimeThreadGroup group,
                             IntBinaryOperator sizer)
```

Description

Create a release runner which maintains a pool of threads to run releases of `AsyncBaseEventHandler` instances. The threads in the pool all run in a given `RealtimeThreadGroup` instance. The thread pool size is determined by the binary function `sizer`. When `sizer` is `null`, a reasonable default is provided.

Parameters

`config`—the ConfigurationParameters object to use for all handler run from this pool, which means for each thread in the pool.

`group`—for the pool threads.

`sizer`—A binary function from the number of handlers and the number of priorities of those handles to the number of threads in the pool. It may use global information, such as the number of available CPUs. It may also ignore its arguments.

FirstInFirstOutReleaseRunner(ConfigurationParameters)

Signature

```
public
FirstInFirstOutReleaseRunner(ConfigurationParameters config)
```

Description

Same as `FirstInFirstOutReleaseRunner(ConfigurationParameters, RealtimeThreadGroup, IntBinaryOperator)` with arguments {(config, null, null)}.

8.3.2.13.2 Methods

getConfigurationParameters

Signature

```
public javax.realtime.ConfigurationParameters
getConfigurationParameters()
```

Description

Returns
those parameters.

release(Schedulable)

Signature

```
protected final void
release(Schedulable handler)
```

Description

Parameters
`handler`—The handler to be released.

attach(Schedulable)

Signature

```
protected final void
attach(Schedulable handler)
throws StaticIllegalStateException
```

Description

Attach a handler from this runner, so it will be released. Adjusts the number of threads for running handlers accordingly.

Parameters
`handler`—to be removed.
Throws
`StaticIllegalArgumentException`—When `handler` is null

detach(Schedulable)

Signature

```
protected final void
detach(Schedulable handler)
throws StaticIllegalStateException
```

Description

Detach a handler from this runner, so it will no longer be released. Adjusts the number of threads for running handlers accordingly.

Parameters

`handler`—to be detached.

Throws

`StaticIllegalArgumentException`—When `handler` is null

8.3.2.14 ReleaseRunner

---

public abstract class ReleaseRunner

Inheritance

java.lang.Object
  ReleaseRunner

Description

Manages a pool of threads to execute asynchronous event handler releases. The implementer is responsible for maintaining the pool of threads and ensuring they all have at least the desired `ConfigurationParameters`, `RealtimeThreadGroup`, and `Affinity`.

The other parameters for instances of `Schedulable` can either be set for each release or be configurable for the pool. In the latter case, one should not be able to associate a handler with the runner that has an incompatible parameter set. These other parameters are `SchedulingParameters`, `ReleaseParameters`, and `MemoryParameters`, as well as the `MemoryArea` in which the release should take place.

The default release runner, `FirstInFirstOutReleaseRunner`, sets these other parameters on the releasing thread at each release. Since there may be a performance penalty for doing this, an application can define its own release runners for commonly occurring cases of these parameters. It is then up to the application to ensure that handlers are matched to the correct release runner.

Since RTSJ 2.0

8.3.2.14.1 Constructors

ReleaseRunner(RealtimeThreadGroup)

Signature

```
protected
ReleaseRunner(RealtimeThreadGroup group)
```

Description

Enables creating a subclass of this class.

8.3.2.14.2 Methods

getRealtimeThreadGroup

Signature

```
protected javax.realtime.RealtimeThreadGroup
getRealtimeThreadGroup()
```

Description

Determine the `RealtimeThreadGroup` instance used.

Returns

the `RealtimeThreadGroup` instance used by all threads used for running releases.

getConfigurationParameters

Signature

```
public abstract javax.realtime.ConfigurationParameters
getConfigurationParameters()
```

Description

Get the `ConfigurationParameters` object used for all threads provided by this release runner.

Returns

those parameters.

release(Schedulable)

Signature

```
protected abstract void
release(Schedulable handler)
```

Description

Finds a thread and has it call the `Schedulable.run()` method. Care should be exercised when implementing this method, since it adds to both the latency and jitter of releasing events. The caller must guarantee that releases of any given handler are always executed in order.

This method should only be called from the infrastructure.

Parameters

`handler`—The handler to be released.

attach(Schedulable)

Signature

```
protected abstract void
attach(Schedulable handler)
throws StaticIllegalStateException,
       ProcessorAffinityException
```

Description

Notifies this runner that the handler is now associated with it. Any compatibility check should be done here.

This method should only be called from the infrastructure.

Parameters

`handler`—The handler to be attached

Throws

`StaticIllegalStateException`—when `handler` is already attached.

`ProcessorAffinityException`—when `handler` is has an illegal affinity.

detach(Schedulable)

Signature

```
protected abstract void
detach(Schedulable handler)
throws StaticIllegalStateException
```

Description

Notifies this runner that the handler is no longer associated with it.

This method should only be called from the infrastructure.

Parameters

`handler`—The handler to be removed

Throws

`StaticIllegalStateException`—when `handler` is not attached.

8.4 Rationale

The design of the asynchronous event handling facilities was intended to provide the necessary functionality while allowing efficient implementations and catering for a variety of realtime applications. In particular, in some realtime systems there may be a large number of potential events and event handlers (numbering in the thousands or perhaps even the tens of thousands), although at any given time only a small number will be used. Thus it would not be appropriate to dedicate a realtime thread to each event handler. The `RTSJ` addresses this issue by allowing the programmer to specify an event handler either as not bound to a specific realtime thread (the class `AsyncBaseEventHandler`) or alternatively as bound to a dedicated realtime thread (a instance of `BoundSchedulable`). The `RTSJ` does not define at what point

an unbound event handler is bound to a realtime thread for its execution. Events are dataless: the fire method does not pass any data to the handler. This was intentional in the interest of simplicity and efficiency.

Chapter 9

Time

Realtime systems must be able to handle both very short time durations and very long ones. They also need to distinguish between relative time—a duration of time—and absolute time. Simply using a primitive integral value, such as int or long, does not provide the necessary range. Floating point primitive values, such as float and double, do not provide the necessary precision. Nor do they provide any type safety. This specification addresses this by requiring three time classes: `HighResolutionTime`, `AbsoluteTime`, and `RelativeTime`, where `HighResolutionTime` is the parent class of the other two.

Instances of `HighResolutionTime` may not be created, as the class exists to provide a common parent type for the other two classes. An instance of `AbsoluteTime` encapsulates an absolute time. An instance of `RelativeTime` encapsulates a point in time that is relative to some other absolute time value, which can be used to describe a time duration.

All methods returning a time object come in both allocating and nonallocating forms. The classes

- enable describing a point in time with up to nanosecond accuracy and precision (actual accuracy and precision is dependent on the precision of the underlying system),
- enable the distinction between absolute points in time, and times relative to some starting point or a time duration, and
- provide simple arithmetic operations for using them.

All time handling is based on these classes.

9.1 Definitions

Time Object — An instance of `AbsoluteTime` or `RelativeTime`. A *time object* is always associated with some `Chronograph`. By default, it is associated with the realtime clock.

Universal epoch — The time at which the universal clock began ticking, defined by fiat as January 1, 1970 00:00:00 UTC.

Epoch — The date and time relative to which times on a `RTSJ Chronograph c` are determined. The epoch for a chronograph is defined in terms of the Universal epoch, and is represented as the time elapsed on the Universal clock since the

Universal epoch at the time that `c` would have returned a time stamp of 0 ms and 0 ns.

Time Value Representation — A compound format composed of 64 bits of millisecond timing, and 32 bits of nanoseconds within a millisecond. The millisecond constituent uses the 64 bits of a Java `long` while the nanosecond constituent uses the 32 bits of a Java `int`.

Normalized (Canonical) Time Value — Unique values for the millisecond and nanosecond components of a point in time, including the case of 0 milliseconds or 0 nanoseconds, and a negative time value, according to the following four constraints:

1. when both millisecond and nanosecond components are nonzero, they have the same sign;
2. the algebraic time values of the time object is the algebraic sum of the two components;
3. the millisecond component represents the algebraic number of milliseconds in the time object, within a range of $[-2^{63}, 2^{63} - 1]$; and
4. the nanosecond component represents the algebraic number of nanoseconds within a millisecond in the time object, that is $[-10^6 + 1, 10^6 - 1]$.

Instances of HighResolutionTime classes always hold a normalized form of a time value. Values that cannot be normalized are not valid; for example, (`MAX_LONG` milliseconds, `MAX_INT` nanoseconds) cannot be normalized and is an illegal value.

The following table has examples of normalized representations.

Table 9.1: Examples of Normalized Times

time in ns	millis	nanos
2000000	2	0
1999999	1	999999
1000001	1	1
1	0	1
0	0	0
-1	0	-1
-999999	0	-999999
-1000000	-1	0
-1000001	-1	-1

9.2 Semantics

The points below define the general semantics of the time classes. Semantics specific to particular classes, constructors, methods, and fields are in the class description and the constructor, method, and field detail sections.

1. All time objects must maintain nanosecond precision and report their values in terms of millisecond and nanosecond constituents.

2. Time objects can be constructed from other time objects, from millisecond/-nanosecond values, from a `java.util.Date`, or obtained as a result of invocations of methods on instances of the `Chronograph` interface.
3. Time objects maintain and report time values in normalized form, but the normalized form is not required for input parameter values. This enables computation to be performed individually with the constituent time parts, using the full *signed* range and restrictions of the underlying type.
   (a) Normalization is accomplished upon method invocation by methods that accept a time object represented with individual component parts, and executed as if the following hold.
      i. The nanosecond parameter value, which may be negative, is algebraically added to the scaled millisecond parameter value. The sign of the result provides the sign for any nonzero resulting component.
      ii. The absolute of the result is then partitioned, giving the number of integral milliseconds for the millisecond component, while the remaining fractional part provides the number of nanoseconds for the nanosecond component.
      iii. The resulting components are then represented, and reported when necessary, with the above computed sign.
   (b) Normalization is also performed on the result of operations by methods that perform time object addition and subtraction. Operations are executed using the appropriate arithmetic precision. If the final result of an operation can be represented in normalized form, then the operation must not throw arithmetic exceptions while producing intermediate results.
   (c) The results of time objects operations and the normalization of results of operations performed with millis and nanos, individually as Java `long` and Java `int` types respectively, are not always equivalent. This is due to the possibility of overflow for nanos values outside of the normalized nanosecond range, that is $[-10^6 + 1, 10^6 - 1]$, when performing operations as `int` types, while the same values could be handled with no overflow in time object operations.
   (d) When invoking setter methods that take as a parameter only one of the two time value components, the other component has implicitly the value of 0.
4. Although logically a negative time may represent time before the epoch or a negative time interval involved in time operations, an `Exception` may be thrown if a negative absolute time or a negative time interval is given as a parameter to methods. In general, the time values accepted by a method may be a subset of the full time values range, and depend on the method.
5. A *time object* is always associated with a `Chronograph`. By default it is associated with the realtime clock. Chronographs are involved both in the setting as well as the usage of time objects, for example in comparisons.
6. Methods are provided to facilitate the handling of time objects generically via the `HighResolutionTime` class. These methods enable converting, according to a `Chronograph`, between `AbsoluteTime` objects and `RelativeTime` objects. These methods also enable changing the `Chronograph` association of a time

object. Note that the conversions depend on the time at which they are performed. The semantics of these operations are listed in the following table:

Table 9.2: Semantics of Time Conversion

Chronograph association & conversion `this has chronograph_a & ms,ns`	**returned/updated object**
`an_absolute.absolute(chronograph_a)`	`chronograph_a` `ms,ns`
`an_absolute.absolute(chronograph_b)`	`chronograph_b` `ms,ns`
`an_absolute.absolute(null)`	`realtime_clock` `ms,ns`
`an_absolute.relative(chronograph_a)`	`chronograph_a` `chronograph_a.getTime().subtract(ms,ns)`
`an_absolute.relative(chronograph_b)`	`chronograph_b` `chronograph_b.getTime().subtract(ms,ns)`
`an_absolute.relative(null)`	`realtime_clock` `realtime_clock.getTime().subtract(ms,ns)`
`a_relative.relative(chronograph_a)`	`chronograph_a` `ms,ns`
`a_relative.relative(chronograph_b)`	`chronograph_b` `ms,ns`
`a_relative.relative(null)`	`realtime_clock` `ms,ns`
`a_relative.absolute(chronograph_a)`	`chronograph_a` `chronograph_a.getTime().add(ms,ns)`
`a_relative.absolute(clock_b)`	`chronograph_b` `chronograph_b.getTime().add(ms,ns)`
`a_relative.absolute(null)`	`realtime_clock` `realtime_clock.getTime().add(ms,ns)`

7. Time objects must implement the `Comparable` interface.

9.3 javax.realtime

9.3.1 Classes

9.3.1.1 AbsoluteTime

---

public class AbsoluteTime

Inheritance

java.lang.Object
  HighResolutionTime<AbsoluteTime>
    AbsoluteTime

Description

An object that represents a specific point in time given by milliseconds plus nanoseconds past some point in time fixed by its `Chronograph`. For the universal clock, the fixed point is the Epoch (January 1, 1970, 00:00:00 GMT). The correctness of the Epoch as a time base depends on the realtime clock synchronization with an external world time reference. This representation was designed to be compatible with the standard Java representation of an absolute time in the `java.util.Date` class.

A time object in normalized form represents negative time when both components are nonzero and negative, or one is nonzero and negative and the other is zero. For `add` and `subtract` negative values behave as they do in arithmetic.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

9.3.1.1.1 Constructors

AbsoluteTime(long, int, Chronograph)

Signature

```
public
AbsoluteTime(long millis,
             int nanos,
             Chronograph chronograph)
throws StaticIllegalArgumentException
```

Description

Constructs an `AbsoluteTime` object with time millisecond and nanosecond components past the epoch for `Chronograph`.

The value of the `AbsoluteTime` instance is based on the parameter `millis` plus the parameter `nanos`. The construction is subject to `millis` and `nanos` parameters normalization. When, after normalization, the time object is negative, the time represented by this is time before `this` chronograph's `epoch`.

The chronograph association is made with the `Chronograph` parameter. When `Chronograph` is `null` the association is made with the default realtime clock.

Note that the start of a chronograph's epoch is an attribute of the chronograph. It is defined as the Epoch (00:00:00 GMT on Jan 1, 1970) for the calendar clock, but other classes of chronograph may define other epochs.

Since RTSJ 2.0

Parameters

`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.

`chronograph`—Provides the time reference for the newly constructed object. The realtime clock is used when this argument is `null`.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(long, int)

Signature

```
public
AbsoluteTime(long millis,
             int nanos)
throws StaticIllegalArgumentException
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(millis, nanos, null)`

Parameters

`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(Date, Chronograph)

Signature

```
public
AbsoluteTime(Date date,
             Chronograph chronograph)
throws StaticIllegalArgumentException
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(date.getTime(), 0, chronograph)`.

Warning: While the `date` is used to set the milliseconds component of the new `AbsoluteTime` object (with nanoseconds component set to 0), the new object represents the `date` only when the `Chronograph` parameter has an `epoch` equal to Epoch.

The time reference is given by the `Chronograph` parameter. When `Chronograph` is `null` the association is made with the default realtime clock.

Since RTSJ 2.0

Parameters

`date`—The `java.util.Date` representation of the time past the `epoch`.

`chronograph`—Provides the time reference for the newly constructed object.

Throws

`StaticIllegalArgumentException`—when the `date` parameter is `null`.

AbsoluteTime(Date)

Signature

```
public
AbsoluteTime(Date date)
throws StaticIllegalArgumentException
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(date.getTime(), 0, null)`.

Parameters

`date`—The `java.util.Date` representation of the time past the `epoch`.

Throws

`StaticIllegalArgumentException`—when the `date` parameter is `null`.

AbsoluteTime(AbsoluteTime)

Signature

```
public
AbsoluteTime(AbsoluteTime time)
throws StaticIllegalArgumentException
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(time.getMilliseconds(), time.getNanoseconds(), time.getChronograph())`.

Parameters

`time`—The `AbsoluteTime` object which is the source for the copy.

Throws

`StaticIllegalArgumentException`—when the `time` parameter is `null`.

AbsoluteTime(Chronograph)

Signature

```
public
AbsoluteTime(Chronograph chronograph)
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(0, 0, chronograph)`.

Since RTSJ 2.0

Parameters

`chronograph`—Provides the time reference for the newly constructed object.

AbsoluteTime

Signature

```
public
AbsoluteTime()
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the argument list `(0, 0, null)`.

9.3.1.1.2 Methods

---

absolute(Chronograph)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)
```

Description

Creates a copy of `this` modified when necessary to have the specified chronograph association. A new object is allocated for the result. This method is the implementation of the `abstract` method of the `HighResolutionTime` base class. No conversion into `AbsoluteTime` is needed in this case. The result is associated with the `Chronograph` passed as a parameter. When `Chronograph` is `null`, the association is made with the default realtime clock.

Parameters

`chronograph`—It is used only as the new time reference associated with the result, since no conversion is needed.

Returns

The copy of `this` in a newly allocated `AbsoluteTime` object, associated with the `Chronograph` parameter.

Since RTSJ 2.0

absolute(Chronograph, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
         AbsoluteTime dest)
```

Description

Copies `this` into `dest`, when necessary modified to have the specified chronograph association. A new object is allocated for the result. This method is the implementation of the `abstract` method of the `HighResolutionTime` base class. No conversion into `AbsoluteTime` is needed in this case. The result is associated with the `Chronograph` passed as a parameter. When `Chronograph` is `null`, the association is made with the default realtime clock.

Parameters

`chronograph`—It is used only as the new time reference associated with the result, since no conversion is needed.

`dest`—the instance to fill.

Returns

The copy of `this` in a newly allocated `AbsoluteTime` object, associated with the `Chronograph` parameter.

Since RTSJ 2.0

relative(Chronograph)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph)
```

Description

Converts the time of `this` to a relative time, using the given instance of `Chronograph` to determine the current time. The calculation is the current time indicated by the given instance of `Chronograph` subtracted from the time given by `this`. When `Chronograph` is `null`, the default realtime clock is assumed. A destination object is allocated to return the result. The time reference of the result is given by the `Chronograph` passed as a parameter.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into relative time, and the new chronograph association for the result.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the `RelativeTime` conversion in a newly allocated object, associated with the `Chronograph` parameter.

Since RTSJ 2.0

relative(Chronograph, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph,
         RelativeTime dest)
```

Description

Converts the time of `this` to a relative time, using the given instance of `Chronograph` to determine the current time. The calculation is the current time indicated by the given instance of `Chronograph` subtracted from the time given by `this`. When `Chronograph` is `null`, the default realtime clock is assumed. When `dest` is not `null`, the result is placed in it and returned. Otherwise, a new object is allocated for the result. The time reference of the result is given by the `Chronograph` passed as a parameter.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into relative time, and the new chronograph association for the result.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the `RelativeTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object, associated with the `Chronograph` parameter.

add(long, int)

Signature

```
public javax.realtime.AbsoluteTime
add(long millis,
    int nanos)
throws ArithmeticException
```

Description

Creates a new object representing the result of adding `millis` and `nanos` to the values from `this` and normalizing the result. The result will have the same chronograph association as `this`.

Parameters

`millis`—The number of milliseconds to be added to `this`.

`nanos`—The number of nanoseconds to be added to `this`.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `AbsoluteTime` object whose time is the normalization of `this` plus `millis` and `nanos`.

add(long, int, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
add(long millis,
    int nanos,
    AbsoluteTime dest)
throws ArithmeticException
```

Description

Returns an object containing the value resulting from adding `millis` and `nanos` to the values from `this` and normalizing the result. When `dest` is not `null`, the result is placed in it and returned. Otherwise, a new object is allocated for the result. The result will have the same chronograph association as `this`, and the chronograph association with `dest` is ignored.

Parameters

`millis`—The number of milliseconds to be added to `this`.

`nanos`—The number of nanoseconds to be added to `this`.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` plus `millis` and `nanos` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

add(RelativeTime)

Signature

```
public javax.realtime.AbsoluteTime
add(RelativeTime time)
throws ArithmeticException,
       StaticIllegalArgumentException
```

Description

Creates a new instance of `AbsoluteTime` representing the result of adding `time` to the value of `this` and normalizing the result. The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result.

Parameters

`time`—The time to add to `this`.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `AbsoluteTime` object whose time is the normalization of `this` plus the parameter `time`.

add(RelativeTime, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
add(RelativeTime time,
    AbsoluteTime dest)
throws ArithmeticException,
       StaticIllegalArgumentException
```

Description

Returns an object containing the value resulting from adding `time` to the value of `this` and normalizing the result. When `dest` is not `null`, the result is placed in it and returned. Otherwise, a new object is allocated for the result. The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result. The `Chronograph` associated with the `dest` parameter is ignored.

Parameters

`time`—The time to add to `this`.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` plus the `RelativeTime` parameter `time` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

getDate

Signature

```
public java.util.Date
getDate()
throws StaticUnsupportedOperationException
```

Description

Converts the time given by `this` to a `Date` format. Note that `Date` represents time as milliseconds so the nanoseconds of `this` will be lost.

Throws

`StaticUnsupportedOperationException`—when the `Chronograph` associated with `this` does not have the concept of date.

Returns

a newly allocated `Date` object with a value of the time past the Epoch represented by `this`.

set(Date)

Signature

```
public javax.realtime.AbsoluteTime
set(Date date)
throws StaticIllegalArgumentException
```

Description

Changes the time represented by `this` to that given by the parameter. Note that `Date` represents time as milliseconds so the nanoseconds of `this` will be set to 0. The chronograph association is implicitly made with the default realtime clock.

Parameters

`date`—A reference to a `Date` which will become the time represented by `this` after the completion of this method.

Throws

`StaticIllegalArgumentException`—when the parameter `date` is `null`.

Returns

`this`

Since RTSJ 2.0 returns itself

subtract(AbsoluteTime)

Signature

```
public javax.realtime.RelativeTime
subtract(AbsoluteTime time)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Creates a new instance of `RelativeTime` representing the result of subtracting `time` from the value of `this` and normalizing the result. The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result.

Parameters

`time`—The time to subtract from `this`.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `RelativeTime` object whose time is the normalization of `this` minus the `AbsoluteTime` parameter `time`.

subtract(AbsoluteTime, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
subtract(AbsoluteTime time,
         RelativeTime dest)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Returns an object containing the value resulting from subtracting `time` from the value of `this` and normalizing the result. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result. The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result. The `Chronograph` associated with the `dest` parameter is ignored.

Parameters

`time`—The time to subtract from `this`.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` minus the `AbsoluteTime` parameter `time` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

subtract(RelativeTime)

Signature

```
public javax.realtime.AbsoluteTime
subtract(RelativeTime time)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Creates a new instance of `AbsoluteTime` representing the result of subtracting `time` from the value of `this` and normalizing the result. The `Chronograph`

associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result.

Parameters

`time`—The time to subtract from `this`.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `AbsoluteTime` object whose time is the normalization of `this` minus the parameter `time`.

subtract(RelativeTime, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
subtract(RelativeTime time,
         AbsoluteTime dest)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Returns an object containing the value resulting from subtracting `time` from the value of `this` and normalizing the result. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result. The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter must be the same, and such association is used for the result. The `Chronograph` associated with the `dest` parameter is ignored.

Parameters

`time`—The time to subtract from `this`.

`dest`—When `dest` is not `null`, the result is placed there and returned.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` minus the `RelativeTime` parameter `time` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a printable string of the time given by `this`.

The string shall be a decimal representation of the milliseconds and nanosecond values; formatted as follows "(2251 ms, 750000 ns)"

Returns

a String object converted from the time given by `this`.

9.3.1.2 HighResolutionTime

---

public abstract class HighResolutionTime<T extends HighResolutionTime<T>>

Inheritance

java.lang.Object
HighResolutionTime<T extends HighResolutionTime<T>>

Interfaces

`Comparable`
`Cloneable`

Description

Class `HighResolutionTime` is the base class for `AbsoluteTime` and `RelativeTime`. It can be used to express time with nanosecond resolution. This class is never used directly; it is abstract and has no public constructor. Instead, one of its subclasses `AbsoluteTime` or `RelativeTime` should be used. When an API is defined that has a `HighResolutionTime` as a parameter, it can take either an absolute or a relative time and will do something appropriate.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

9.3.1.2.1 Methods

---

waitForObject(Object, HighResolutionTime)

Signature

```
public static boolean
waitForObject(Object target,
              HighResolutionTime<?> time)
```

```
throws InterruptedException,
       IllegalMonitorStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException
```

Description

Behaves like `target.wait()` but with the enhancement that it waits with a precision of `HighResolutionTime` and returns true when the associated notify was received, false when timeout occured. As for `target.wait()`, there is the possibility of spurious wakeup behavior.

The wait `time` may be relative or absolute, and it is controlled by the `clock` associated with it. When the wait `time` is relative, then the calling thread is blocked waiting on `target` for the amount of time given by `time`, and measured by the associated `clock`. When the wait `time` is absolute, then the calling thread is blocked waiting on `target` until the indicated `time` value is reached by the associated `clock`.

Parameters

`target`—The object for which to wait. The current thread must have a lock on the object.

`time`—The time for which to wait. When it is `RelativeTime(0,0)` then wait indefinitely. When it is `null` then wait indefinitely.

Throws

`InterruptedException`—when this schedulable is interrupted by `RealtimeThread.interrupt` or `AsynchronouslyInterruptedException.fire` while it is waiting.

`StaticIllegalArgumentException`—when `time` represents a relative time less than zero.

`IllegalMonitorStateException`—when `target` is not locked by the caller.

`StaticUnsupportedOperationException`—when the wait operation is not supported using the `clock` associated with `time`.

Returns

`true` when the notify was received before the timeout; `false` otherwise.

Since RTSJ 2.0 updated to add a return value.

equals(T)

Signature

```
public boolean
equals(T time)
```

Description

Proves if the argument `time` has the same type and values as `this`.

Equality includes `Chronograph` association.

Parameters

`time`—Value to be compared with `this`.

Returns

`true` when the parameter `time` is of the same type and has the same values as `this`, as well as the same `Chronograph` association.

Since RTSJ 2.0

getClock

Signature

```
public javax.realtime.Clock
getClock()
throws StaticUnsupportedOperationException
```

Description

Gets the reference to the `clock` associated with `this`.

Throws

`StaticUnsupportedOperationException`—when the time is based on a `Chronograph` that is not a `Clock`.

Returns

a reference to the `clock` associated with `this`.

Since RTSJ 1.0.1

getChronograph

Signature

```
public final javax.realtime.Chronograph
getChronograph()
```

Description

Gets a reference to the `Chronograph` associated with `this`.

Returns

a reference to the `Chronograph` associated with `this`.

Since RTSJ 2.0

getMilliseconds

Signature

```
public final long
getMilliseconds()
```

Description

Gets the milliseconds component of `this`.

Returns

the milliseconds component of the time represented by `this`.

getNanoseconds

Signature

```
public final int
getNanoseconds()
```

Description

Gets the nanoseconds component of `this`.

Returns

the nanoseconds component of the time represented by `this`.

set(T)

Signature

```
public T extends javax.realtime.HighResolutionTime<T>
set(T time)
```

Description

Changes the value represented by `this` to that of the given `time`. The `Chronograph` associated with `this` is set to be the `Chronograph` associated with the `time` parameter.

Parameters

`time`—The new value for `this`.

Throws

`StaticIllegalArgumentException`—when the parameter `time` is `null`.

`ClassCastException`—when the type of `this` and the type of the parameter `time` are not the same.

Returns

`this`

Since RTSJ 1.0.1 The description of the method in 1.0 was erroneous.
Since RTSJ 2.0 returns itself

set(Chronograph, long, int)

Signature

```
public T extends javax.realtime.HighResolutionTime<T>
set(Chronograph chronograph,
    long millis,
    int nanos)
throws StaticIllegalArgumentException
```

Description

Sets the all components of `this`. The setting is subject to parameter normalization. When after normalization the time is negative, the time represented by `this` is set to a negative value, but note, negative times are not supported everywhere. For instance, a negative relative time is an invalid value for a periodic thread's period.

Parameters

`chronograph`—The time reference for the other components of `this` set during the call call.

`millis`—The desired value for the millisecond component of `this` at the completion of the call. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this` at the completion of the call. The actual value is the result of parameter normalization.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component while normalizing.

Returns

`this`

Since RTSJ 2.0 returns itself

set(long, int)

Signature

```
public T extends javax.realtime.HighResolutionTime<T>
set(long millis,
    int nanos)
throws StaticIllegalArgumentException
```

Description

Sets the millisecond and nanosecond components of `this`. The setting is subject to parameter normalization. When after normalization the time is negative then the time represented by `this` is set to a negative value, but note that negative times are not supported everywhere. For instance, a negative relative time is an invalid value for a periodic thread's period.

Parameters

`millis`—The desired value for the millisecond component of `this` at the completion of the call. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this` at the completion of the call. The actual value is the result of parameter normalization.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component while normalizing.

Returns

`this`

Since RTSJ 2.0 returns itself

set(long)

Signature

```
public T extends javax.realtime.HighResolutionTime<T>
set(long millis)
```

Description

Sets the millisecond component of `this` to the given argument, and the nanosecond component of `this` to 0. This method is equivalent to `set(millis, 0)`.

Parameters

`millis`—This value shall be the value of the millisecond component of `this` at the completion of the call.

Returns

`this`

Since RTSJ 2.0 returns itself

hashCode

Signature

```
public int
hashCode()
```

Description

Returns a hash code for this object in accordance with the general contract of `Object.hashCode`. Time objects that are equal, as defined by `equals`, have the same hash code.

Returns

the hashcode value for this instance.

clone

Signature

```
public java.lang.Object
clone()
```

Description

Returns a clone of `this`. This method should behave effectively as when it constructed a new object with the visible values of `this`. The new object is created in the current allocation context.

Since RTSJ 1.0.1

compareTo(T)

Signature

```
public int
compareTo(T time)
```

Description

Compares `this HighResolutionTime` with the specified `HighResolutionTime time`.

Parameters

`time`—To be compared with the time of `this`.

Throws

`ClassCastException`—when the `time` parameter is not of the same class as `this`.

`StaticIllegalArgumentException`—when the `time` parameter is not associated with the same chronograph as `this`, or when the `time` parameter is `null`.

Returns

a negative integer, zero, or a positive integer as this object is less than, equal to, or greater than `time`.

Since RTSJ 2.0

equals(Object)

Signature

```
public boolean
equals(Object object)
```

Description

Determined whether or not the argument `object` has the same type and values as `this`.

Equality includes `Chronograph` association.

Parameters

`object`—Value to be compared with `this`.

Returns

`true` when the parameter `object` is of the same type and has the same values as `this`, as well as the same `Chronograph` association.

absolute(Chronograph, AbsoluteTime)

Signature

```
public abstract javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
         AbsoluteTime dest)
```

Description

Converts the time of `this` to an absolute time, using the given instance of `Chronograph` to determine the current time when necessary. When `Chronograph` is `null` the default realtime clock is assumed. When `dest` is not `null`, the result is placed in it and returned. Otherwise, a new object is allocated for the result. The chronograph association of the result is the `Chronograph` passed as a parameter. See the subclass comments for more specific information.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into absolute time, and the new chronograph association for the result.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Returns

the `AbsoluteTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. It is associated with the `Chronograph` parameter.

absolute(Chronograph)

Signature

```
public abstract javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)
```

Description

Converts the time of `this` to an absolute time, using the given instance of `Chronograph` to determine the current time when necessary. When `Chronograph` is `null` the realtime clock is assumed.

A destination object is allocated to return the result. The chronograph association of the result is the `Chronograph` passed as a parameter. See the subclass comments for more specific information.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into absolute time, and the new chronograph association for the result.

Returns

the `AbsoluteTime` conversion in a newly allocated object, associated with the `Chronograph` parameter.

relative(Chronograph, RelativeTime)

Signature

```
public abstract javax.realtime.RelativeTime
relative(Chronograph chronograph,
         RelativeTime dest)
```

Description

Converts the time of `this` to a relative time, using the given instance of `Chronograph` to determine the current time when necessary. When `Chronograph` is `null` the realtime clock is assumed. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result. The chronograph association of the result is the `Chronograph` passed as a parameter. See the subclass comments for more specific information.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into relative time, and the new chronograph association for the result.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Returns

the `RelativeTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

Since RTSJ 2.0

relative(Chronograph)

Signature

```
public abstract javax.realtime.RelativeTime
relative(Chronograph chronograph)
```

Description

Converts the time of `this` to a relative time, using the given instance of `Chronograph` to determine the current time when necessary. When `Chronograph` is `null` the realtime clock is assumed. A destination object is allocated to return the result. The chronograph association of the result is the `Chronograph` passed as a parameter. See the subclass comments for more specific information.

Parameters

`chronograph`—The instance of `Chronograph` used to convert the time of `this` into relative time, and the new chronograph association for the result.

Returns

the `RelativeTime` conversion in a newly allocated object, associated with the `Chronograph` parameter.

Since RTSJ 2.0

9.3.1.3 RelativeTime

---

public class RelativeTime

Inheritance

java.lang.Object
  HighResolutionTime<RelativeTime>
    RelativeTime

Description

An object that represents a time interval milliseconds/10^3 + nanoseconds/10^9 seconds long. It generally is used to represent a time relative to now.

The time interval is kept in normalized form. The range goes from `[(-`2^{63}`)` milliseconds `+ (-`10^6`+1)` nanoseconds] to `[(`2^{63}`-1)` milliseconds `+ (`10^6`-1)` nanoseconds].

A negative interval relative to now represents time in the past. For `add` and `subtract`, negative values behave as they do in arithmetic.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

9.3.1.3.1 Constructors

RelativeTime(long, int, Chronograph)

Signature

```
public
RelativeTime(long millis,
             int nanos,
             Chronograph chronograph)
throws StaticIllegalArgumentException
```

Description

Constructs a `RelativeTime` object representing an interval based on the parameter `millis` plus the parameter `nanos`. The construction is subject to `millis` and `nanos` parameter normalization. When there is an overflow in the millisecond component when normalizing then an `StaticIllegalArgumentException` will be thrown.

The chronograph association is made with the `chronograph` parameter. When `chronograph` is `null` the association is made with the default realtime clock.

Since RTSJ 2.0

Parameters

`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.

`chronograph`—The time reference of the newly constructed object. Defaults to the realtime clock when `null`.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

RelativeTime(long, int)

Signature

```
public
RelativeTime(long millis,
             int nanos)
throws StaticIllegalArgumentException
```

Description

Equivalent to `RelativeTime(long, int, Chronograph)` with argument list `(millis, nanos, null)`.

Parameters

`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

RelativeTime(RelativeTime)

Signature

```
public
RelativeTime(RelativeTime time)
```

Description

Equivalent to `RelativeTime(long, int, Chronograph)` with argument list `(time.getMilliseconds(), time.getNanoseconds(), time.getChronograph())`.

Parameters

`time`—The `RelativeTime` object which is the source for the copy.

RelativeTime(Chronograph)

Signature

```
public
RelativeTime(Chronograph chronograph)
```

Description

Equivalent to `RelativeTime(long, int, Chronograph)` with argument list `(0, 0, chronograph)`.

Since RTSJ 2.0

Parameters

`chronograph`—The time reference for the newly constructed object.

RelativeTime

Signature

```
public
RelativeTime()
```

Description

Equivalent to `RelativeTime(long, int, Chronograph)` with argument list `(0, 0, null)`.

9.3.1.3.2 Methods

absolute(Chronograph)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)
```

Description

Since RTSJ 2.0

See Section HighResolutionTime.absolute(Chronograph)

absolute(Chronograph, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
         AbsoluteTime dest)
```

Description

Since RTSJ 2.0

See Section HighResolutionTime.absolute(Chronograph, AbsoluteTime)

relative(Chronograph)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph)
```

Description

Since RTSJ 2.0

See Section HighResolutionTime.relative(Chronograph)

relative(Chronograph, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph,
         RelativeTime dest)
```

Description

Since RTSJ 2.0

See Section HighResolutionTime.relative(Chronograph, RelativeTime)

add(long, int)

Signature

```
public javax.realtime.RelativeTime
add(long millis,
    int nanos)
throws ArithmeticException
```

Description

Creates a new object representing the result of adding `millis` and `nanos` to the values from `this` and normalizing the result. The result will have the same chronograph association as `this`. An `ArithmeticException` is when the result does not fit in the normalized format.

Parameters

`millis`—The number of milliseconds to be added to `this`.

`nanos`—The number of nanoseconds to be added to `this`.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `RelativeTime` object whose time is the normalization of `this` plus `millis` and `nanos`.

add(long, int, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
add(long millis,
    int nanos,
    RelativeTime dest)
throws ArithmeticException
```

Description

Returns an object containing the value resulting from adding `millis` and `nanos` to the values from `this` and normalizing the result. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result. The result will have the same chronograph association as `this`, and the chronograph association with `dest` is ignored.

Parameters

`millis`—The number of milliseconds to be added to `this`.

`nanos`—The number of nanoseconds to be added to `this`.

`dest`—When `dest` is not `null`, the result is placed there and returned.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` plus `millis` and `nanos` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

add(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
add(RelativeTime time)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Creates a new instance of `RelativeTime` representing the result of adding `time` to the value of `this` and normalizing the result.

The chronograph associated with `this` and the `clock` associated with the `time` parameter are expected to be the same, and such association is used for the result.

Parameters

`time`—The time to add to `this`.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `RelativeTime` object whose time is the normalization of `this` plus the parameter `time`.

add(RelativeTime, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
add(RelativeTime time,
    RelativeTime dest)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Returns an object containing the value resulting from adding `time` to the value of `this` and normalizing the result. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result.

The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are expected to be the same, and such association is used for the result.

The `Chronograph` associated with the `dest` parameter is ignored.

Parameters

`time`—The time to add to `this`.

`dest`—When `dest` is not `null`, the result is placed there and returned.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` plus the `RelativeTime` parameter `time` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

subtract(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
subtract(RelativeTime time)
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Creates a new instance of `RelativeTime` representing the result of subtracting `time` from the value of `this` and normalizing the result.

The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are expected to be the same, and such association is used for the result.

Parameters

`time`—The time to subtract from `this`.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

a new `RelativeTime` object whose time is the normalization of `this` minus the parameter `time`.

subtract(RelativeTime, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
subtract(RelativeTime time,
         RelativeTime dest)
```

```
throws StaticIllegalArgumentException,
       ArithmeticException
```

Description

Returns an object containing the value resulting from subtracting the value of `time` from the value of `this` and normalizing the result. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result.

The `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are expected to be the same, and such association is used for the result.

The `Chronograph` associated with the `dest` parameter is ignored.

Parameters

`time`—The time to subtract from `this`.

`dest`—When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result.

Throws

`StaticIllegalArgumentException`—when the `Chronograph` associated with `this` and the `Chronograph` associated with the `time` parameter are different, or when the `time` parameter is `null`.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the result of the normalization of `this` minus the `RelativeTime` parameter `time` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

scale(int)

Signature

```
public javax.realtime.RelativeTime
scale(int factor)
```

Description

Changes the length of this relative time by multiplying it by `factor`.

Parameters

`factor`—Value by which to increase the time interval.

Returns

a new object with `value` of this scaled by `factor`.

Since RTSJ 2.0

scale(int, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
scale(int factor,
      RelativeTime time)
```

Description

Sets `time` to the value of `this` time multiplied by `factor`.

Parameters

`factor`—Value by which to increase the time in `this`.

`time`—Where to store the result.

Returns

`time` with the value of `this` scaled by `factor`

Since RTSJ 2.0

compareToZero

Signature

```
public int
compareToZero()
```

Description

Compares `this` to relative time zero returning the result of the comparison. Equivalent to constantZero.compareTo(this)

Returns

negative when `this` is less than zero, 0, when it is equal to zero and a positive when `this` is greater than zero.

Since RTSJ 2.0

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a printable string of the time given by `this`.

The string shall be a decimal representation of the milliseconds and nanosecond values; formatted as follows "(2251 ms, 750000 ns)"

Returns

a String object converted from the time given by `this`.

9.4 Rationale

Time is the essence of realtime systems, and a method of expressing absolute time with sub-millisecond precision is an absolute minimum requirement. Expressing time in terms of nanoseconds has precedent and allows the implementation to provide time-based services, such as timers, using whatever precision it is capable of while the application requirements are expressed to an arbitrary level of precision.

The standard Java `java.util.Date` class uses milliseconds as its basic unit in order to provide sufficient range for a wide variety of applications. Realtime programming generally requires finer resolution, and nanosecond resolution is fine enough for most purposes, but even a 64 bit realtime clock based in nanoseconds would have insufficient range in some situations, so a compound format composed of 64 bits of millisecond timing, and 32 bits of nanoseconds within a millisecond, was chosen.

The expression of millisecond and nanosecond constituents is consistent with other Java interfaces.

The expression of relative times allows for time-based metaphors such as deadline-based periodic scheduling where the cost of the task is expressed as a relative time and deadlines are usually represented as times relative to the beginning of the period.

Chapter 10

Clocks and Timers

In order to reason about time, the RTSJ needs not only to be able to express times and calculate with them, but it also needs to be able to determine the current time and allow actions to be performed when a given time is reached. For this purpose, the specification defines one interface and four classes: `Chronograph`, `Clock`, `Timer`, `PeriodicTimer`, `and OneShotTimer`.

A chronograph is used to measure time, whereas a clock is used to both measure time and react to its passage: a clock can get the current time and it can trigger timing events. At least one instance of the abstract `Clock` class, which implements `Chronograph`, is provided by the implementation, the system *realtime clock*, and this instance is made available as a singleton. The creation and use of other clocks and chronographs are discussed later (see Section 10.2.2).

The `Timer` classes provide the means of executing code at a particular point in time or repeatedly at a given interval. `Timer` is an abstract class and consequently only its subclasses can be instantiated. The `Timer` class provides the interface and underlying implementation for both one-shot and periodic timers. Instances of `OneShotTimer` and `PeriodicTimer` can be created and rescheduled specifying the initial firing time either as an `AbsoluteTime` or as a `RelativeTime`, to be considered from the application of the start command. The `PhasingPolicy` class defines the relationship between a `PeriodicTimer`'s start time and its first release time when the start time is in the past.

By attaching an `AsyncBaseEventHandler` to a `Timer`, the program can cause the release of the handler at a given time or after a given interval. An instance of `OneShotTimer` describes an event that is to be triggered at most once, unless restarted after expiration. It may be used as the source for time-outs and watchdog timing. An instance of `PeriodicTimer` fires on a periodic schedule. The period for a `PeriodicTimer` is always specified as a `RelativeTime`.

10.1 Definitions

Timing Mechanism — Something capable of representing and following the progress of time, by means of time values.

Chronograph — A passive timing mechanism, which can only provide the current time.

Clock — An active timing mechanism, which can both provide the current time and cause some action when a particular time is reached. All clocks are, by definition, chronographs, but not necessarily vice versa.

Monotonically Increasing Timing Mechanism — A timing mechanism whose time values never decrease. Monotonicity is a Boolean property, while time synchronization, uniformity, and accuracy are characteristics that depend on agreed tolerances. All monotonic clocks referenced in this specification are monotonically increasing timing mechanisms.

Time Synchronization — A relation between two timing mechanisms. Two chronographs are synchronized when the difference between their time values is less than some specified offset. Synchronization in general degrades with time, and may be lost, given a specified offset.

Accuracy — The agreement between a chronograph and the true value that it measures, e.g., absolute wall clock time.

Resolution — The minimal time value interval that can be represented by the clock model.

Precision — The smallest tick size that a particular chronograph will observe.

Uniformity — In this context, the measurement of the progress of time at a consistent rate, with a tolerance on the variability. Uniformity is affected by two other factors, *jitter* and *stability*.

Jitter — The distribution of the differences between when events are actually fired or noticed by the software and when they should have really occurred according to time in the real-world. Jitter might be caused by short-term and noncumulative small time variation due to noise sources, such as thermal noise.

Stability — The resistance to jitter, in this case temporal jitter. Lack of stability can account for large and often cumulative variations, due to such occurrences such as supply voltage and temperature change.

Drift — The rate of change of the cumulative variation between two timing mechanisms.

Counting Time — The time accumulated by a `Timer`, while *active*, when created or rescheduled using a `RelativeTime` to specify the initial firing or skipping time. *Counting Time* is zeroed at the beginning of an activation and when rescheduled, while *active*, before the initial firing or skipping of an activation.

10.2 Semantics

The semantics of chronographs, clocks and timers are not simply functional. Temporal attributes dominate their behavior; therefore, the interaction between classes is critical to the overall understanding of the API. The class descriptions as well as their constructor, method, and field documentation given later provide detailed semantics to support the overall behavior.

10.2.1 Clock Model

Clocks and chronographs are backed by a physical means of measuring time. In practice, each one is driven by an oscillator that has susceptible variation due to its

environment. There is always some difference between the desired frequency and the actual frequency of the oscillator, which is a major reason of synchronization loss. The RTSJ Clock model must take this variability into account and therefore establishes several invariants and expectations that can be relied upon by RTSJ applications and in turn must be provided by RTSJ implementations.

1. The *resolution* of the RTSJ Clock model is 1 nanosecond. This is the smallest unit of time that can be represented by a chronograph or timer via `HighResolutionTime` and its subclasses.
2. The *accuracy* of RTSJ definable chronographs and clocks is outside the scope of this specification. Accuracy is heavily dependent on hardware capabilities and platform characteristics. RTSJ providers and system integrators should characterize accuracy where possible.
3. The *precision* of RTSJ definable clock and chronograph (and, by proxy, the precision of the timers associated with clocks) are defined in terms of nanoseconds per observable tick, and provided to the application programmer via the various precision setters on `Clock` and `Chronograph`.
4. The realtime clock shall be monotonically increasing, and other clocks and chronographs should be monotonically increasing as well. Where the universal clock needs to be resynchronized with the external environment, this should be at the expense of its uniformity rather than its monotonicity.
5. Time values returned by a chronograph should not be assumed to be comparable to the time values from another chronograph unless the user has platform-specific knowledge that the chronographs are compatible, except under specific circumstances described below.
6. The system or any other realtime clock is not necessarily synchronized with the external world, and the correctness of the epoch as a time base depends on such synchronization. It is as uniform and accurate as allowed by the underlying hardware.

If two Chronograph objects are both referenced to real time and return a value from `getEpochOffset()`, then time values from those Chronographs can be compared by applying their respective corrections. As documented in the `getEpochOffset()` method, its return value represents the offset of the associated Chronograph from the universial clock Epoch. However, the results of any such comparison must be treated with caution as the accuracy of the two Chronograph objects may be different.

The RTSJ Clock model is designed for maximum utility and predictability on monotonically increasing timing mechanisms. Clocks that do not have this property may display certain inconsistencies in the event of reverse discontinuities. In particular, any the following may occur.

1. When a `OneShotTimer` is set on a nonmonotonic `Clock`, that clock experiences a reverse discontinuity, and that timer has already fired, but the reverse discontinuity would cause its expiry time to occur again, the timer will not fire again.
2. When a `PeriodicTimer` is set on a nonmonotonic `Clock`, that clock experiences a reverse discontinuity, and that timer has already fired for time T but the reverse discontinuity would cause time T to occur again, the handler for time T will not be released again for time T. This may mean that the elapsed

wall clock time between two firings of the `PeriodicTimer` exceeds the period *without the release of an associated miss handler or other detection*, as the next firing will happen when the clock reaches $T + P$, where P is the period of the timer.

3. When a `Timer` is set on a nonmonotonic `Clock` and that clock experiences a reverse discontinuity while that timer is scheduled for release at time T, but the reverse discontinuity causes time T to be "pushed back" with respect to wall clock time, the `Timer` will not fire until time T is reached on the clock and the elapsed wall clock time to T will be of longer duration than it was when the timer was set.

Forward *or* reverse discontinuities on a Clock may cause races for `Timer` releases occurring very close to the time of the discontinuity. Therefore, the default realtime clock should increment as consistently as possible under the design constraints of the system.

10.2.2 Clocks and Timables

A `Clock` is the basic mechanism of measuring time and triggering events based on the passage of time. Both a Timer and a RealtimeThread with PeriodicParameters can request a signal from the clock when a given time is reached. That signal should come as close to the actual time requested as possible. A schedulable uses a clock to implement the realtime sleep methods. `HighResolutionTime` also defines `waitForObject` with a timeout with a clock. Each clock instance shall be capable of reporting the achievable resolution of timers based on that clock. Each implementation shall have a default realtime clock that is used whenever no other clock is specified. An application can also define additional clocks, including a UTC.

10.2.2.1 Timable

A `Timer` uses a clock to measure time, which informs the timer's `TimeDispatcher` when the time has elapsed (relative time) or has been reached (absolute time). The `TimeDispatcher` causes the release of any `AsyncEventHandler` associated with the `Timer`. In the context of a `Timer`, *triggering* is the action performed by a `TimeDispatcher` that informs the `Timer` that it is time to *fire* or *skip*, where skip causes the normal action of fire not to be carried out.

A `Timer` is an `ActiveEvent`. This means that is has an associated dispatcher called `TimeDispatcher`. As with other active events, the application can either use the default dispatcher or create a new one with its own priority and affinity.

A `Timer` is *active* when it has been started and not stopped since last started and it has a time in the future at which it is expected to fire or skip, else it is *not active*.

In the context of a `Timer`, *enabling* causes the `Timer` to fire when it is triggered, while *disabling* causes the `Timer` to skip when it is triggered. Enabling and disabling act as a mask over firing.

The behavior of a `OneShotTimer` is that of a `Timer` that does not automatically reschedule its triggering after an initial triggering, regardless of whether it fires or skips, i.e., is *active* but *disabled* when triggered. It is specified using an initial firing time.

The behavior of a `PeriodicTimer` is that of a `Timer` that automatically reschedules after each triggering, regardless of whether the triggering results in a fire or a skip due to being disabled when triggered. It is specified using an initial firing time and an interval or period used for the self-rescheduling.

Both `OneShotTimer` and `PeriodTimer` are given an initial firing time. A `PeriodicTimer` receives two clock references, within two `HighResolutionTimer` objects, which must be to the same clock. Thus the specification of the initial firing time and the interval or period must refer to the same clock.

A `RealtimeThread` with `PeriodicParameters` acts analogously to a `PeriodicTimer` with a single `AsyncEventHandler`. A `Clock` is to signal its `TimeDispatcher` to release the thread from its `waitForNextRelease` method. When a release happens before the thread reaches its call to `waitForNextRelease`, the thread simply continues, otherwise it waits for its release.

Both `Timer` and `RealtimeThread` have a `fire` method for this signaling. They both implement the `AsyncTimable` interface, a child interface of `Timable`. `Timable` is used for implementing application-defined clocks.

A `Clock` can also be used to provide pauses in execution of any `Schedulable` through a realtime `sleep` method, hence they are also classified as timables under the `Timable` interface. A `Schedulable` has a `TimeDispatcher` to manage sleeping.

Since `RealtimeThread` supports both sleep, as a `Schedulable`, and release behavior, as a `AsyncTimable`, a single interface is insufficient. Instead, both `Schedulable` and `AyncTimable` are children of `Timable`. Note that how the time out on `waitForObject` is handle is unspecified, since it is not visible to the application programer.

10.2.2.2 Dispatching

At any given time, a `Timable`, `AsyncTimer` or `Schedulable`, has at most one clock associated with it, on which the measurement of time for blocking is based. Each clock maintains a list of times, called alarms, that are provided to it from timables. The clock is armed with the next alarm. When that time arrives, the clock signals the `TimeDispatcher` associated with the alarm to signal its timable that the time has arrived.

In the case of a timer, the dispatcher triggers the timer thereby indicating it should fire or skip. In the case of a schedulable, the dispatcher triggers the schedulable to wake up from its sleep. Figure 10.1 illustrates how a timer interacts with an application-defined clock and Figure 10.2 depicts the same for using realtime sleep in a schedulable.

In each case, an external schedulable, depicted on the right, initializes the objects involved. A `TimeDispatcher` and a `Clock` are created. These are used when creating the `Timable` as illustrated with step one and two respectively in both diagrams. A developer can always use a pre-existing clock or dispatcher instead of creating new ones.

Each timable acts as if it had an internal object, depicted as an instance of `Alarm`, to manage the relationship between a timable and its dispatcher and clock. Alarm is shown simply to illustrate this relationship. It is created, as shown in step three in both diagrams, when the timable is created and it represents the next alarm that

Figure 10.1: Sequence Diagram for Using a Timer

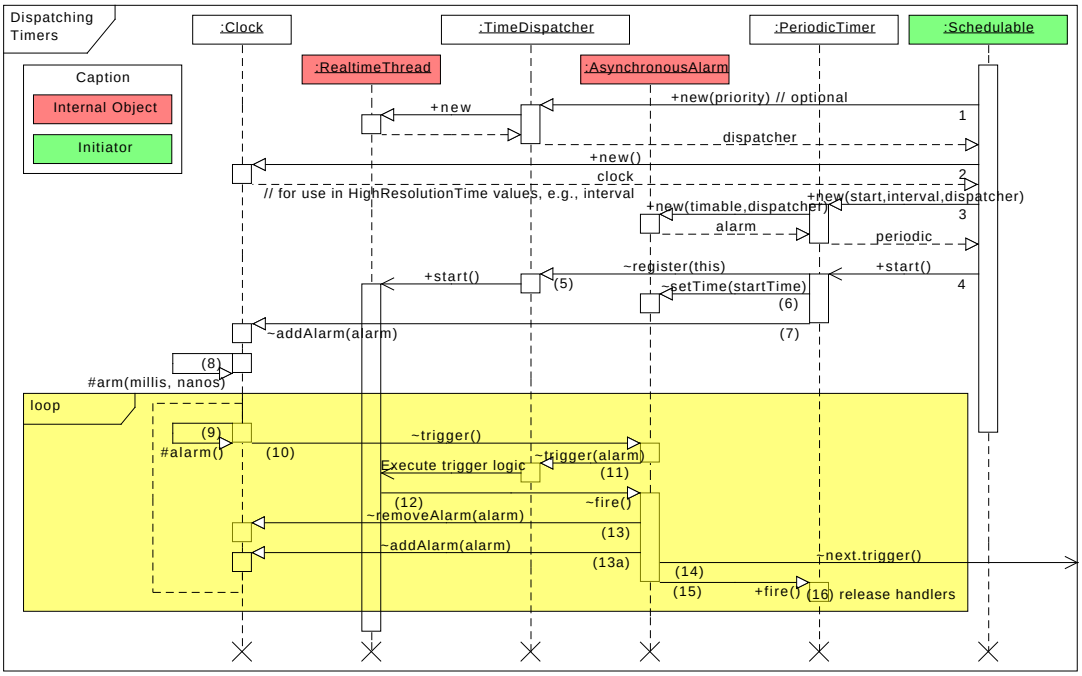
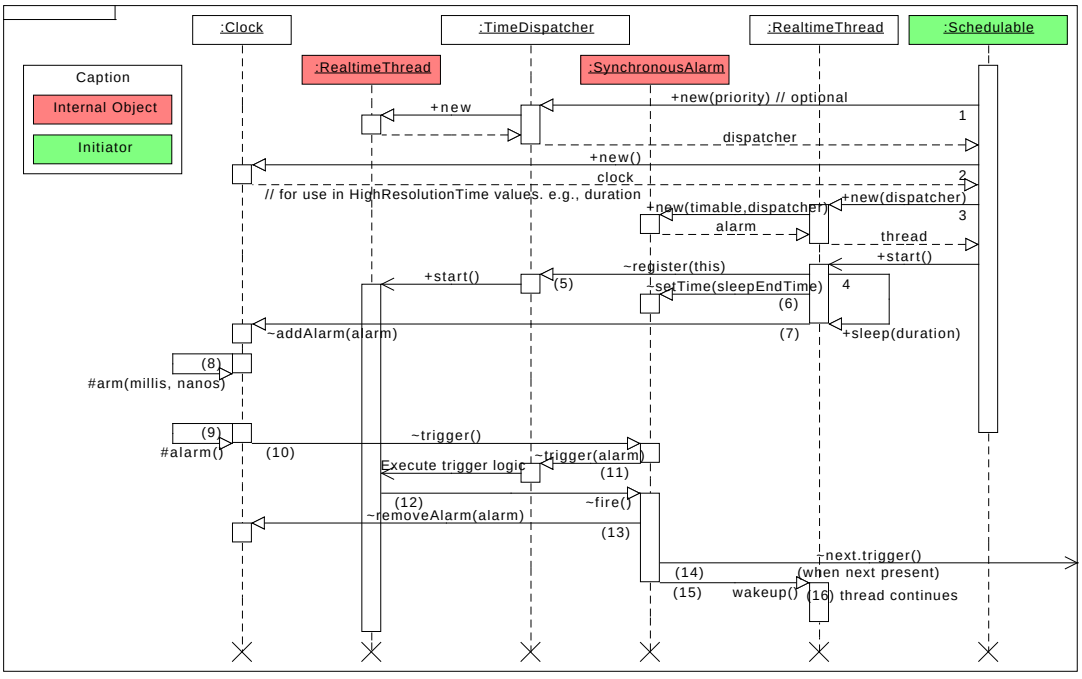


Figure 10.2: Sequence Diagram for Realtime Sleep



the timable should receive: either a fire for a time, or a wake up call for a realtime sleep on a schedulable.

At step four, the two sequences diverge. The application starts a timer with the start method, but a thread must call a realtime sleep method. In both cases, step four sets the timing in motion.

Steps (5) through (8) set up the time interval. When initiating the trigger for the first time, step (5) registers the timable with its dispatcher. Later starts or sleeps skip this step. Then the time is set in the alarm and the alarm is added to the clock.

When the new alarm is the next alarm to be triggered, the clock arranges to signal that time as in step (8). When the alarm is added anywhere else in the clock queue, step (8) is delayed until the removal of an alarm causes the added alarm to reach the top of the queue.

When the alarm time is reached, step (9), the clock triggers the alarm by calling trigger on the alarm event, step (10). This in turn triggers the dispatcher, step (11). This is an asynchronous call that causes the dispatcher's thread to take over control from the clocks interrupt handler.

In step (12), the dispatcher thread removes the alarm from the clock queue, possibly causing a new alarm to become active. In the periodic thread case, the alarm is rescheduled by incrementing the time in the alarm by the interval and adding it back into the queue. In all other cases, no new alarm is set.

In step (13) any subsequent alarms that were scheduled are also kicked off. The Clock queue is a two dimensional queue that is organized by the time of the alarm and, within any given time, the priority order, highest to lowest, of the dispatchers associated with the alarms. The trigger in step (10) always goes to the alarm with the highest priority dispatcher.

Finally in step (14), the dispatcher fires the alarm which results its timable being fired or woken-up. In the case of a timer, this causes all its handlers to be released or, in the case of a schedulable, a sleep being woken up; this is marked as (15) in the diagrams.

`Clocks` and `TimeDispatchers` may be shared among as many timables as the needs of the application dictate. Different dispatchers can be used with a given clock and a dispatcher can service different clocks. The dispatcher should be chosen based on its priority and affinity, whereas a clock should be chosen based on the temporal reference, where the temporal reference may or may not be associated with clock time. For instance, one could use a clock to represent the rotation of a shaft.

10.2.3 Modeling Timers

A timer must be associated with a clock. That clock acts as if it provides an interrupt to each of its timers at the next instance of time at which the timer should do something. In other words, a clock fires its timer at a requested time. Timers can be modeled as counters, or as comparators.

10.2.3.1 Counter Model

In the timer model, a timer can be viewed as if every clock interrupt increments a count up to the firing count, initially given by either an instance of `RelativeTime` or computed as the difference between an instance of `AbsoluteTime` and a semantically specified "now" (using the same clock).

1. `start` is understood as defining "now" and start counting, `stop` is understood as stop counting. `start` after `stop` may be understood as start counting again from where stopped, or start from scratch after resetting the count.
2. In both cases, a delay is introduced.
3. An `RTSJ Timer`, when using the counter model, resets the count when it is restarted after being stopped.
4. When a `Timer` is created or rescheduled using a `RelativeTime` to specify the initial alarm time, the `RTSJ` keeps the specified initial trigger time as a `RelativeTime` and behaves according to the counter model.

10.2.3.2 Comparator Model

In the comparator model, a timer can be viewed as if every clock interrupt forces a comparison between an absolute time and a firing time, initially given either as an instance of AbsoluteTime or computed as the sum of an instance of `RelativeTime` and a semantically specified "now" (using the same clock).

1. In this model, `start` is understood as start comparing, and possibly the first `start` is understood as defining "now". `stop` is understood as stop comparing. `start` after `stop` may be understood as start comparing again.
2. In this case, no delay is introduced.
3. When a `Timer` is created or rescheduled using an `AbsoluteTime` to specify the initial triggering time, the `RTSJ` keeps the specified initial firing time as an `AbsoluteTime` and uses the comparator model.

10.2.3.3 Triggering

A clock signals to the associated timable that its alarm time has been reached by triggering the dispatcher associated with the timable. This trigger causes the dispatcher to fire the associated timer. When the timer is active, it releases its handlers and is said to be fired. When the timer is inactive, nothing happens and it is said to be skipped. A stopped timer is never triggered. For this it must be running.

10.2.3.4 Behavior of Timers

There are two kinds of timers defined: `OneShotTimer` and `PeriodicTimer`. As their names imply, the first is used to mark a single time interval and the second is to mark a regularly repeating time interval.

The `OneShotTimer` class shall ensure that each instance is fired at most once at the time specified unless restarted after expiration.

The `PeriodicTimer` class shall enable the period of a timer to be expressed in terms of a `RelativeTime`. The initial firing of a `PeriodicTimer` occurs in response to the invocation of its `start` method, in accordance with the start time passed to its constructor. The `PhasingPolicy` class defines the relationship between the timer's start time and its first firing when the start time is in the past. This initial firing or skipping, may be rescheduled by a call to the `reschedule` method, in accordance with the time passed to that method.

Given an instance of `PeriodicTimer`, let S be the effective time, as an absolute time, at which the initial firing or skipping of a `PeriodicTimer` is scheduled to occur:

1. when the start, or reschedule, time was given as an absolute time, A, and that time is in the future when the timer is made active, then S equals A, otherwise
2. when the absolute time has passed when the timer is made active, then S depends on the phasing mode of that instance of `PeriodicTimer`.

The firings of a `PeriodicTimer` are scheduled to occur according to $S + nT$, for $n = 0, 1, 2, ...$ where S is as just specified, and T is the interval of the periodic timer.

For all timers, when the start or reschedule time is given as a relative time, R, S equals the time at which the *counting time*, started when the timer was made *active*, equals R. The transition to *not-active* by this timer causes the *counting time* to reset, effectively preventing this kind of timer from firing immediately, unless given a time value of 0.

When in a *not-active* state a `Timer` retains the parameters given at construction time or the parameters it had at de-activation time. Those are the parameters that will be used upon invocation of `start` while in that state, unless the parameters are explicitly changed before that, using `reschedule` and `setInterval` as appropriate.

When a `Timer` object is allocated in a scoped memory area, then it will increment the reference count associated with that area. Such a reference count will only be decremented when the `Timer` object is destroyed. (See semantics in the *Memory* chapter for details.) A `Timer` object will not fire before its due time.

The states of a `Timer` are essentially the same as for an `ActiveEvent` as depicted in Figure 8.4. The main difference is that the time used for the next fire may be either an absolute time or a relative time. Figure 10.3 reflects this difference in a UML state diagram.

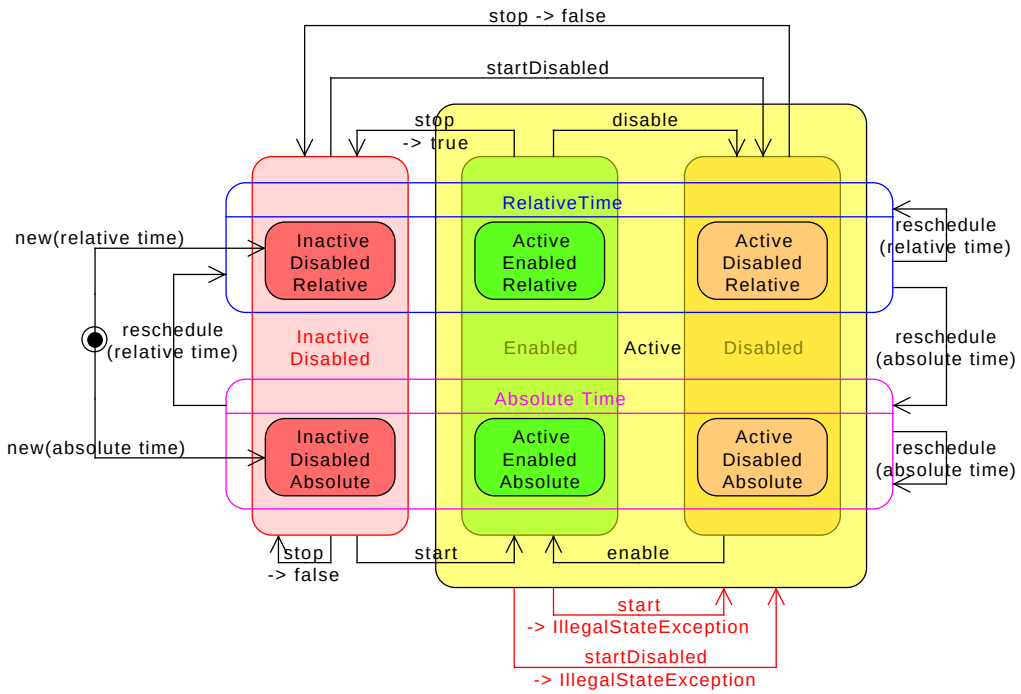
10.2.3.5 Phasing

Phasing comes into play only when a periodic timer (with period T) starts after its initial time. This can happen when an absolute start time (A) is specified and the start method is called after that time. It is used to determine the effective start time S:

1. S is the next multiple of $A + nT$, when phasing is `ADJUST_FORWARD`,
2. S is the most recent multiple of $A + nT$, when phasing is `ADJUST_BACKWARD`,
3. S is "now," when phasing is `ADJUST_TO_START`, and
4. S is undefined and an exception it thrown when phasing is `STRICT_PHASING`.

The default phasing is `ADJUST_TO_START`.

Figure 10.3: States of a Timer[1]



10.3 javax.realtime

10.3.1 Interfaces

10.3.1.1 AsyncTimable

---

public interface AsyncTimable

Interfaces

javax.realtime.Timable

Description

A common type for `Timer` and `RealtimeThread` to indicate that they can be associated with a `Clock` and released by time events on that clock.

Since RTSJ 2.0

[1] Note that the semantics of the fire transition differ among the subclasses of `Timer`.

10.3.1.1.1 Methods

fire

Signature

```
public void
fire()
```

Description

Called by the dispatcher associated with `this` to indicate that a time event has occured.

10.3.1.2 Chronograph

public interface Chronograph

Description

The interface for all devices that support the measurement of time with great accuracy.

Since RTSJ 2.0

10.3.1.2.1 Methods

getEpochOffset

Signature

```
public javax.realtime.RelativeTime
getEpochOffset()
throws StaticUnsupportedOperationException,
       UninitializedStateException
```

Description

Determines the difference between the epoch of this clock from the Epoch. For the UTC, the result is always a `RelativeTime` value equal to zero. For other clocks, it is a value representing the difference between zero on that clock and zero on the UTC measured on the UTC, where a positive epoc is later than the EPOC.

Throws

`StaticUnsupportedOperationException`—when the chronograph does not have the concept of date.

UninitializedStateException—when UTC time is not yet available.

Returns

a newly allocated RelativeTime object in the current execution context with the UTC as its chronograph and containing the time when this chronograph was zero.

getEpochOffset(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getEpochOffset(RelativeTime dest)
throws StaticUnsupportedOperationException,
       UninitializedStateException
```

Description

Determines the difference between the epoch of this clock from the Epoch. For the UTC, the result is always a RelativeTime value equal to zero. For other clocks, it is a value representing the difference between zero on that clock and zero on the UTC measured on the UTC.

Parameters

dest—An instance of RelativeTime object which will be updated in place.

Throws

StaticUnsupportedOperationException—when the chronograph does not have the concept of date.

UninitializedStateException—when UTC time is not yet available.

Returns

the instance of RelativeTime passed as parameter, or a new object when dest is null. The returned object represents the time differnce between its associated chronograph and the Epoch.

getTime

Signature

```
public javax.realtime.AbsoluteTime
getTime()
```

Description

Determines the current time. This method returns an absolute time value representing the chronograph's notion of absolute time. For chronographs that do not measure calendar time, this absolute time may not represent a wall clock time.

Returns

a newly allocated instance of AbsoluteTime in the current allocation context, representing the current time. The returned object has the chronograph from this.

getTime(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getTime(AbsoluteTime dest)
```

Description

Obtains the current time. The time represented by the given `AbsoluteTime` is changed at some time between the invocation of the method and the return of the method. This method will return an absolute time value that represents this chronographs's notion of the absolute time. For chronographs that do not measure calendar time, this absolute time may not represent a wall clock time.

Parameters

`dest`—The instance of `AbsoluteTime` object which will be updated in place.

Returns

the instance of `AbsoluteTime` passed as parameter, or a new object when `dest` is `null`. The returned object represents the current time and is associated with `this` chronograph.

isUpdated

Signature

```
public boolean
isUpdated()
```

Description

Determine whether or not this time keeper is asynchronously synchronized with an external time source. Synchronization requires the ability to adjust the time to compensate for drift. For example, a UTC is continually synchronized with an external time source, but realtime clocks are not.

Returns

`true` for chronographs that are synchronized and `false` otherwise.

lastSynchronized

Signature

```
public javax.realtime.AbsoluteTime
lastSynchronized()
throws StaticUnsupportedOperationException
```

Description

Determine the last time this chronograph was synchronized. It is the same as calling `lastSynchronized(AbsoluteTime)` with `null` as an argument.

Throws

`StaticUnsupportedOperationException`—when the chronograph will never be updated, i.e., is never synchronized with an external time source.

Returns
a newly allocated time value holding last synchronized time.

lastSynchronized(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
lastSynchronized(AbsoluteTime result)
throws StaticUnsupportedOperationException
```

Description

Determine the last time this chronograph was synchronized with an external time source.

Parameters
`result`—a time object to hold the result.
Throws
`StaticUnsupportedOperationException`—when the chronograph will never be updated, i.e., is never synchronized with an external time source.

Returns
when `result` is `null`, a newly allocated time value holding the value corresponding to the last synchronized time; otherwise `result` updated with that current value.

getQueryPrecision

Signature

```
public javax.realtime.RelativeTime
getQueryPrecision()
```

Description

Obtains the precision with which time can be read, i.e., the nominal interval between ticks. It is the same as calling `getQueryPrecision(RelativeTime)` with `null` as an argument.

Returns
a newly allocated time value holding the read precision.

getQueryPrecision(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getQueryPrecision(RelativeTime dest)
```

Description

Obtains the precision with which time can be read, i.e., the nominal interval between ticks.

Parameters
`dest`—The time object in which to return the results.
Returns
the read precision in `dest`, when `dest` is not `null`, or in a newly created object otherwise.

10.3.1.3 Timable

---

public interface Timable

Interfaces
javax.realtime.Releasable

Description

A type for all classes that can use a `Clock` for timing, either for being woken, as from a sleep or timeout, or for being released at a given time on the clock.

Since RTSJ 2.0

10.3.1.3.1 Methods

---

getDispatcher

Signature

```
public javax.realtime.TimeDispatcher
getDispatcher()
```

Description

Gets the dispatcher associated with this Timable.

Returns
the time dispatcher use to dispatch clock events.

10.3.2 Classes

10.3.2.1 Clock

---

public abstract class Clock

Inheritance
java.lang.Object
  Clock

Interfaces

javax.realtime.Chronograph

Description

A clock marks the passing of time. It has a concept of now that can be queried through `Clock.getTime()`, and it can have events queued on it which will be fired when their appointed time is reached.

Note that while all `Clock` implementations use representations of time derived from `HighResolutionTime`, which expresses its time in milliseconds and nanoseconds, a particular `Clock` may track time that is not delimited in seconds or not related to wall clock time in any particular fashion (*e.g.,* revolutions or event detections). In this case, the `Clock`'s timebase should be mapped to milliseconds and nanoseconds in a manner that is computationally appropriate.

10.3.2.1.1 Constructors

Clock

Signature

```
public
Clock()
```

Description

Constructor for the abstract class.

10.3.2.1.2 Methods

getRealtimeClock

Signature

```
public static javax.realtime.Clock
getRealtimeClock()
```

Description

There is always at least one clock object available: the system realtime clock. This clock is monotonically increasing and does not need to start at the Epoch. On a POSIX system, it is equivalent to `CLOCK_MONOTONIC`. It is the default `Clock`.

Returns

the singleton instance of the default `Clock`

setRealtimeClock(Clock)

Signature

```
public static void
setRealtimeClock(Clock clock)
```

Description

Sets the system default realtime clock.

Parameters

`clock`—To be used for the realtime clock. When `null`, the default realtime clock is set to the original system default.

getUniversalClock

Signature

```
public static javax.realtime.Clock
getUniversalClock()
throws StaticUnsupportedOperationException,
       UninitializedStateException
```

Description

A means of obtaining the Universal Time, which has no summer or winter time. Local time can be obtained by adding the appropriate time zone offset. Such a time source is not available on all systems and may take a while to set up on some systems which support it. It is not guarenteed to be monotonic.

Throws

`StaticUnsupportedOperationException`—when the system does not support UTC.

`UninitializedStateException`—when UTC time is not yet available.

Returns

a Clock that tracts UTC, such as the POSIX `CLOCK_REALTIME`, when the timezone is set to UTC.

Since RTSJ 2.0

setUniversalClock(Clock)

Signature

```
public static void
setUniversalClock(Clock clock)
```

Description

Sets the system default universal clock.

Parameters

`clock`—To be used for the universal clock. When `null`, the default universal clock is set to the original system default.

Since RTSJ 2.0

getEpochOffset

Signature

```
public javax.realtime.RelativeTime
getEpochOffset()
throws StaticUnsupportedOperationException,
       UninitializedStateException
```

Description

Determines the difference between the epoch of this clock from the Epoch. For the UTC, the result is always a `RelativeTime` value equal to zero. For other clocks, it is a value representing the difference between zero on that clock and zero on the UTC measured on the UTC, where a positive epoc is later than the EPOC.

Throws

`StaticUnsupportedOperationException`—when the chronograph does not have the concept of date.

`UninitializedStateException`—when UTC time is not yet available.

Since RTSJ 1.0.1

getDrivePrecision

Signature

```
public javax.realtime.RelativeTime
getDrivePrecision()
```

Description

Gets the precision of the clock for driving events, the nominal interval between ticks that can trigger an event. It is the same as calling `getDrivePrecision(RelativeTime)` with `null` as its argument.

Returns

a value representing the drive precision.

Since RTSJ 2.0

getDrivePrecision(RelativeTime)

Signature

```
public abstract javax.realtime.RelativeTime
getDrivePrecision(RelativeTime dest)
```

Description

Gets the precision of the clock for driving events, the nominal interval between ticks that can trigger an event. The result may be larger than that of `Chronograph.getQueryPrecision(RelativeTime)`.

Parameters

`dest`—To return the relative time value in `dest`. When `dest` is `null`, it allocates a new `RelativeTime` instance to hold the returned value.

Returns

`dest` set to values representing the drive precision.

Since RTSJ 2.0

getQueryPrecision

Signature

```
public javax.realtime.RelativeTime
getQueryPrecision()
```

Description

Returns

a newly allocated time value holding the read precision.

getTime

Signature

```
public javax.realtime.AbsoluteTime
getTime()
```

Description

Returns

a newly allocated instance of `AbsoluteTime` in the current allocation context, representing the current time. The returned object has the chronograph from `this`.

getTime(AbsoluteTime)

Signature

```
public abstract javax.realtime.AbsoluteTime
getTime(AbsoluteTime dest)
```

Description

Obtains the current time. The time represented by the given `AbsoluteTime` is changed at some time between the invocation of the method and the return of the method. This method will return an absolute time value that represents this chronographs's notion of the absolute time. For chronographs that do not measure calendar time, this absolute time may not represent a wall clock time.

Parameters

`dest`—The instance of `AbsoluteTime` object which will be updated in place.

Returns

the instance of `AbsoluteTime` passed as parameter, or a new object when `dest` is `null`. The returned object represents the current time and is associated with `this` chronograph.

Since RTSJ 1.0.1 The return value is updated from `void` to `AbsoluteTime`.
Since RTSJ 2.0 When dest is `null`, a new object is allocated, when not chronograph is overwritten with `this`.

triggerAlarm

Signature

```
protected final void
triggerAlarm()
```

Description

Code in the abstract base `Clock` is called by a subclass to signal that the time of the next alarm has been reached. It will trigger a `TimeDispatcher`, which in turn will cause a `AsyncTimable.fire()` or `Schedulable.awaken()` to be called depending on the kind of `Timable` associated with the alarm.

This method should be implemented with a runtime complexity not exceeding O(1). Implementations exceeding this bound shall explicitly document the complexity their implementation. **Since** RTSJ 2.0

setAlarm(long, int)

Signature

```
protected abstract void
setAlarm(long milliseconds,
         int nanoseconds)
```

Description

Implemented by subclasses to set the time for the next alarm. When there is an alarm outstanding when called, the subclass must override the old time. This should never be called from application or library code. It is intended to be called only from the `javax.realtime` package.

Parameters

`milliseconds`—The millisecond part of an absolute time for the next alarm.

`nanoseconds`—The nanosecond part of an absolute time for the next alarm.

Since RTSJ 2.0

clearAlarm

Signature

```
protected abstract void
clearAlarm()
```

Description

Implemented by subclasses to cancel the current outstanding alarm.

Since RTSJ 2.0

10.3.2.2 OneShotTimer

---

public class OneShotTimer

Inheritance
java.lang.Object
AsyncBaseEvent
AsyncEvent
Timer
OneShotTimer

Description

A timed `AsyncEvent` that is driven by a `Clock`. It will fire once, when the clock time reaches the time-out time, unless restarted after expiration. When the timer is *disabled* at the expiration of the indicated time, the firing is lost (*skipped*). After expiration, the `OneShotTimer` becomes *not-active* and *disabled*. When the clock time has already passed the time-out time, it will fire immediately after it is started or after it is rescheduled while *active*.

Semantics details are described in the `Timer` pseudocode and compact graphic representation of state transitions.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

10.3.2.2.1 Constructors

OneShotTimer(HighResolutionTime, TimeDispatcher)

Signature

```
public
OneShotTimer(HighResolutionTime<?> time,
             TimeDispatcher dispatcher)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       IllegalAssignmentError
```

Description

Creates an instance of `OneShotTimer`, based on the given `clock`, that will execute its `fire` method according to the given time. The `Clock` association of the parameter `time` is ignored.

Since RTSJ 2.0
Parameters

`time`—The time used to determine when to fire the event. A `time` value of `null` is equivalent to a `RelativeTime` of 0, and in this case the `Timer` fires immediately upon a call to `start()`.

`dispatcher`—The `dispatcher` used to interface between this `timer` and its associated clock. When `null`, the system default dispatcher is used.

Throws

`StaticIllegalArgumentException`—when `time` is a `RelativeTime` instance less than zero.

`StaticUnsupportedOperationException`—when the `Chronograph` associated with `time` is not a `Clock`.

`IllegalAssignmentError`—when this `OneShotTimer` cannot hold references to `time`, `handler`, or `clock`.

OneShotTimer(HighResolutionTime, AsyncEventHandler)

Signature

```
public
OneShotTimer(HighResolutionTime<?> time,
             AsyncEventHandler handler)
```

Description

The equivalent of calling `OneShotTimer(HighResolutionTime, TimeDispatcher)` with arguments `time, null` followed by a call to `setHandler(handler)`.

Parameters

`time`—Time to release its handlers.

`handler`—Handler to be released.

10.3.2.2.2 Methods

---

fire

Signature

```
public void
fire()
```

Description

This should not be called for application code, except for emulation. The fire method is reserved for the use of the system. When `this` is enabled, it releases all handlers and then calls `Timer.stop()`. When distabled, but active, it only calls `Timer.stop()`. Otherwise it does nothing.

Since RTSJ 2.0 moved here from Timer, since `OneShotTimer` and `PeriodicTimer` have slightly different semantics.

10.3.2.3 PeriodicTimer

public class PeriodicTimer

Inheritance

java.lang.Object
  AsyncBaseEvent
    AsyncEvent
      Timer
        PeriodicTimer

Description

An `AsyncEvent` whose `fire` method is executed periodically according to the given parameters. The clock associated with the `Timer` start time must be identical to the the clock associated with the `Timer interval`

The first firing is at the beginning of the first interval.

When an interval greater than 0 is given, the timer will fire periodically. When an interval of 0 is given, the `PeriodicTimer` will only fire once, unless restarted after expiration, behaving like a `OneShotTimer`. In all cases, when the timer is *disabled* when the firing time is reached, that particular firing is lost (*skipped*). When *enabled* at a later time, it will fire at its next scheduled time.

When the clock time has already passed the beginning of the first period, the `PeriodicTimer` will first fire according to the `PhasingPolicy`.

Semantics details are described in the `Timer` pseudo-code and compact graphic representation of state transitions.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

10.3.2.3.1 Constructors

PeriodicTimer(HighResolutionTime, RelativeTime, TimeDispatcher)

Signature

```
public
PeriodicTimer(HighResolutionTime<?> start,
              RelativeTime interval,
              TimeDispatcher dispatcher)
throws StaticIllegalArgumentException,
       IllegalAssignmentError,
       StaticUnsupportedOperationException
```

Description

Creates a timer that executes its fire method periodically.

Since RTSJ 2.0

Parameters

`start`—The time that specifies when the first interval begins, based on the clock associated with it. The first firing of the timer is modified according to the `PhasingPolicy` when the timer is started. A `start` value of `null` is equivalent to a `RelativeTime` of 0.

`interval`—The period of the timer. Its usage is based on the clock specified by the `clock` parameter. When `interval` is zero or `null`, the period is ignored and the firing behavior of the `PeriodicTimer` is that of a `OneShotTimer`.

`dispatcher`—The dispatcher to use for triggering this event.

Throws

`StaticIllegalArgumentException`—when `start` or `interval` is a `RelativeTime` instance with a value less than zero; or the clocks associated with `start` and `interval` are not the identical.

`IllegalAssignmentError`—when this `PeriodicTimer` cannot hold references to `handler`, `clock` and `interval`.

`StaticUnsupportedOperationException`—when the `Chronograph` associated with `time` is not a `Clock`.

PeriodicTimer(HighResolutionTime, RelativeTime, AsyncEventHandler)

Signature

```
public
PeriodicTimer(HighResolutionTime<?> start,
              RelativeTime interval,
              AsyncEventHandler handler)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Creates a timer that executes its fire method periodically. Equivalent to `PeriodicTimer(start, interval, handler, null)`.

10.3.2.3.2 Methods

---

addHandler(AsyncBaseEventHandler)

Signature

```
public void
addHandler(AsyncBaseEventHandler handler)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Add a handler to the set of handlers associated with this event. It overrides the method in `AsyncBaseEvent` to allow the use of handlers with `PeriodicParameters`, but these parameters must match the period of this timer, otherwise `StaticIllegalArgumentException` is thrown.

Parameters

`handler`—A new handler to add to the list of handlers already associated with `this`. When `handler` is already associated with the event, the call has no effect.

Throws

`StaticIllegalArgumentException`—when `handler` is `null` or the handler has `PeriodicParameters` with a period that does not match the period of `this`.

`IllegalAssignmentError`—when this `AsyncEvent` cannot hold a reference to `handler`.

Since RTSJ 2.0

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(AsyncBaseEventHandler handler)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Associates a new handler with this event and removes all existing handlers. It overrides the method in `AsyncBaseEvent` to allow the use of handlers with `PeriodicParameters`, but these parameters must match the period of this timer, otherwise `StaticIllegalArgumentException` is thrown.

Parameters

`handler`—The instance of `AsyncBaseEventHandler` to be associated with `this`. When `handler` is `null`, no handler will be associated with `this`, i.e., behave effectivelthe effect is as when `setHandler(null)` invokes `removeHandler(AsyncBaseEventHandler)` for each associated handler.

Throws

`StaticIllegalArgumentException`—when `handler` has `PeriodicParameters` with a period that does not match the period of `this`.

`IllegalAssignmentError`—when this `AsyncEvent` cannot hold a reference to `handler`.

Since RTSJ 2.0

start(PhasingPolicy)

Signature

```
public void
start(PhasingPolicy phasingPolicy)
throws LateStartException,
       StaticIllegalArgumentException
```

Description

Starts the timer with the specified `PhasingPolicy`.

Parameters

`phasingPolicy`—Determines what happens when the start is too late.

Throws

`LateStartException`—when this method is called after its absolute start time and the `phasingPolicy` is `PhasingPolicy.STRICT_PHASING`.

`StaticIllegalArgumentException`—when the start time of this timer is not an absolute time, or `phasingPolicy` is `null`.

Since RTSJ 2.0

start(boolean, PhasingPolicy)

Signature

```
public void
start(boolean disabled,
      PhasingPolicy phasingPolicy)
throws LateStartException,
       StaticIllegalArgumentException
```

Description

Starts the timer with the specified `PhasingPolicy` and the specified disabled state.

Parameters

`disabled`—It determines the mode of start: `true` for enabled and `false` for disabled for consistency with `Timer.start(boolean)`.

`phasingPolicy`—It determines what happens when the start is too late.

Throws

`LateStartException`—when this method is called after its absolute start time and the `phasingPolicy` is `PhasingPolicy.STRICT_PHASING`.

`StaticIllegalArgumentException`—when the start time of this timer is not an absolute time, or `phasingPolicy` is `null`.

Since RTSJ 2.0

getClock

Signature

```
public javax.realtime.Clock
getClock()
```

```
    throws StaticIllegalStateException
```

Description

Each instance can only be associated with a single clock, which this method can obtain.

Throws

`StaticIllegalStateException`—when `this` has been destroyed.

Returns

the instance of `Clock` that is associated with `this`.

Since RTSJ 1.0.1

createReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
createReleaseParameters()
```

Description

Creates a release parameters object with new objects containing copies of the values corresponding to this timer. When the `PeriodicTimer` interval is greater than 0, creates a `PeriodicParameters` object with a start time and period that correspond to the next firing (or skipping) time, and interval, of this timer. When the interval is 0, creates an `AperiodicParameters` object, since in this case the timer behaves like a `OneShotTimer`.

When this timer is active, then the start time is the next firing (or skipping) time returned as an `AbsoluteTime`. Otherwise, the start time is the initial firing (or skipping) time, as set by the last call to `Timer.reschedule`, or when there was no such call, by the constructor of this timer.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

a new release parameters object with new objects containing copies of the values corresponding to this timer. When the interval is greater than zero, returns a new instance of `PeriodicParameters`. When the interval is zero returns a new instance of `AperiodicParameters`.

getFireTime

Signature

```
public javax.realtime.AbsoluteTime
getFireTime()
throws ArithmeticException,
       StaticIllegalStateException
```

Description

Gets the time at which this PeriodicTimer is next expected to fire or to skip. When the PeriodicTimer is *disabled*, the returned time is that of the skipping or firing. When the PeriodicTimer is *not-active* it throws StaticIllegalStateException.

Throws

ArithmeticException—when the result does not fit in the normalized format.

StaticIllegalStateException—when this Timer has been *destroyed*, or when it is *not-active*.

Returns

the absolute time at which this is next expected to fire or to skip, in a newly allocated AbsoluteTime object. When the timer has been created or re-scheduled (see Timer.reschedule(HighResolutionTime)) using an instance of RelativeTime for its time parameter, then it will return the sum of the current time and the RelativeTime remaining time before the timer is expected to fire/skip. Within a periodic timer activation, the returned time is associated with the start clock before the first fire (or skip) time, and associated with the interval clock otherwise.

getFireTime(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getFireTime(AbsoluteTime dest)
```

Description

Gets the time at which this PeriodicTimer is next expected to fire or to skip. When the PeriodicTimer is *disabled*, the returned time is that of the skipping. When the PeriodicTimer is *not-active* it throws StaticIllegalStateException.

Parameters

dest—The instance of AbsoluteTime which will be updated in place and returned. The clock association of the dest parameter is ignored. When dest is null, a new object is allocated for the result.

Throws

ArithmeticException—when the result does not fit in the normalized format.

StaticIllegalStateException—when this Timer has been *destroyed*, or when it is *not-active*.

Returns

the instance of AbsoluteTime passed as parameter, with time values representing the absolute time at which this is expected to fire or to skip. When the dest parameter is null, the result is returned in a newly allocated object. When the timer has been created or re-scheduled (see Timer.reschedule(HighResolutionTime)) using an instance of RelativeTime for its time parameter then it will return the sum of the current time and

the `RelativeTime` remaining time before the timer is expected to fire/skip. Within a periodic timer activation, the returned time is associated with the start clock before the first fire (or skip) time, and associated with the interval clock otherwise.

Since RTSJ 1.0.1

getInterval

Signature

```
public javax.realtime.RelativeTime
getInterval()
```

Description

Gets the interval of `this Timer`.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

the `RelativeTime` instance assigned as this periodic timer's interval by the constructor or `setInterval(RelativeTime)`.

setInterval(RelativeTime)

Signature

```
public javax.realtime.PeriodicTimer
setInterval(RelativeTime interval)
```

Description

Resets the `interval` value of `this`.

Parameters

`interval`—A `RelativeTime` object which is the interval used to reset this Timer. A `null interval` is interpreted as `RelativeTime(0,0)`.
The `interval` does not affect the first firing (or skipping) of a timer's activation. At each firing (or skipping), the next fire (or skip) time of an *active* periodic timer is established based on the `interval` currently in use. Resetting the `interval` of an *active* periodic timer only affects future fire (or skip) times after the next.

Throws

`StaticIllegalArgumentException`—when `interval` is a `RelativeTime` instance with a value less than zero, or the clock associated with `interval` is different to the clock associated with `this`.

`IllegalAssignmentError`—when this `PeriodicTimer` cannot hold a reference to `interval`.

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

`this`

fire

Signature

```
public void
fire()
```

Description

This should not be called for application code, except for emulation. The fire method is reserved for the use of the system. When `this` is enabled, it releases all handlers and then reschedules itself for the next period without changing state. When distabled, but active, it simply reschedules itself. Otherwise it does nothing.

Since RTSJ 2.0 moved here from Timer, since `OneShotTimer` and `PeriodicTimer` have slightly different semantics.

10.3.2.4 TimeDispatcher

---

public class TimeDispatcher

Inheritance

java.lang.Object
ActiveEventDispatcher<TimeDispatcher, Timable>
TimeDispatcher

Description

A dispatcher for time events: `Timer` and `RealtimeThread.sleep`.

Since RTSJ 2.0

10.3.2.4.1 Constructors

TimeDispatcher(SchedulingParameters, RealtimeThreadGroup)

Signature

```
public
TimeDispatcher(SchedulingParameters schedule,
               RealtimeThreadGroup group)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

`schedule`—It gives the parameters for scheduling this dispatcher

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of `group` does not correspond to a valid affinity.

TimeDispatcher(SchedulingParameters)

Signature

```
public
TimeDispatcher(SchedulingParameters schedule)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

`schedule`—It gives the parameters for scheduling this dispatcher

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of the current rhread groupo does not correspond to a valid affinity.

10.3.2.4.2 Methods

---

setDefaultDispatcher(TimeDispatcher)

Signature

```
public static void
setDefaultDispatcher(TimeDispatcher dispatcher)
```

Description

Sets the system default time dispatcher.

Parameters

`dispatcher`—To be used when no dispatcher is provided. When `null`, the default time dispatcher is set to the original system default.

register(Timable)

Signature

```
public void
register(Timable target)
throws RegistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Registers a `Timable` with this dispatcher.

Parameters

`target`—To be registered

Throws

`RegistrationException`—when `target` is already registered.

`StaticIllegalStateException`—when this object has been destroyed.

`StaticIllegalArgumentException`—when `target` is not stopped.

deregister(Timable)

Signature

```
public void
deregister(Timable target)
throws DeregistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Deregisters a `Timable` from this dispatcher.

Parameters

`target`—to be deregistered

Throws

`DeregistrationException`—when `target` is not already registered.

`StaticIllegalStateException`—when this object has been destroyed.

`StaticIllegalArgumentException`—when `target` is not stopped.

destroy

Signature

```
public void
destroy()
throws StaticIllegalStateException
```

Description

Releases all resources thereby making the dispatcher unusable.

Throws

`StaticIllegalStateException`—when called on a dispatcher that has one or more registered `Timable` objects.

10.3.2.5 Timer

---

public abstract class Timer

Inheritance

java.lang.Object
  AsyncBaseEvent
    AsyncEvent
      Timer

Interfaces

javax.realtime.AsyncTimable
javax.realtime.ActiveEvent

Description

A *timer* is a timed event that measures time according to a given `Clock`. This class defines basic functionality available to all timers. Applications will generally use either `PeriodicTimer` to create an event that is fired repeatedly at regular intervals, or `OneShotTimer` for an event that just fires once at a specific time. A timer is always associated with at least one `Clock`, which provides the basic facilities of something that ticks along following some time line (realtime, CPU-time, user-time, simulation-time, etc.). All timers are created *disabled* and do nothing until `start()` is called.

10.3.2.5.1 Constructors

Timer(HighResolutionTime, TimeDispatcher)

Signature

```
protected
Timer(HighResolutionTime<?> time,
      TimeDispatcher dispatcher)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       IllegalAssignmentError
```

Description

Creates a timer that fires according to the given `time` based on the `Clock` associated with `time` and is dispatched by the specified `dispatcher`.

Since RTSJ 2.0

Parameters

`time`—The parameter used to determine when to fire the event. A `time` value of `null` is equivalent to a `RelativeTime` of 0, and in this case the `Timer` fires immediately upon a call to `start()`.

`dispatcher`—The object used to interface between this `timer` and its associated clock. When `null`, the system default dispatcher is used.

Throws

`StaticIllegalArgumentException`—when `time` is a negative `RelativeTime` value.

`StaticUnsupportedOperationException`—when `time` has a `Chronograph` is not a `clock`.

`IllegalAssignmentError`—when this `Timer` cannot hold references to `handler` and `clock`.

Timer(HighResolutionTime)

Signature

```
protected
Timer(HighResolutionTime<?> time)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       IllegalAssignmentError
```

Description

Creates a timer that fires according to the given `time` based on the `Clock` associated with `time` and is dispatched by the system default dispatcher.

This is equivalent to `Timer(time, null)`.

Since RTSJ 2.0

Parameters

`time`—The parameter used to determine when to fire the event. A `time` value of `null` is equivalent to a `RelativeTime` of 0, and in this case the `Timer` fires immediately upon a call to `start()`.

Throws

`StaticIllegalArgumentException`—when `time` is a negative `RelativeTime` value.

`StaticUnsupportedOperationException`—when `time` has a `Chronograph` is not a `clock`.

`IllegalAssignmentError`—when this `Timer` cannot hold references to `handler` and `clock`.

Timer(HighResolutionTime, Clock, AsyncEventHandler)

Signature

```
protected
Timer(HighResolutionTime<?> time,
      Clock clock,
      AsyncEventHandler handler)
```

```
    throws StaticIllegalArgumentException,
           StaticUnsupportedOperationException,
           IllegalAssignmentError
```

Description

Creates a timer that fires according to the given `time`, which must be based on the supplied `Clock` `clock` (if any), and is handled by the specified `AsyncEventHandler` `handler`. The system default dispatcher will be used.

This constructor is slated for deprecation in a future release, and a constructor that does not receive a `Clock` argument should be used in preference.

Parameters

`time`—The parameter used to determine when to fire the event. A `time` value of `null` is equivalent to a `RelativeTime` of 0, and in this case the `Timer` fires immediately upon a call to `start()`.

`clock`—The clock on which to base this timer. When `null`, the clock associated with `time` is used.

`handler`—The default `handler` to use for this event. When `null`, no `handler` is associated with the timer and nothing will happen when this event fires unless a `handler` is subsequently associated with the timer using the `addHandler()` or `setHandler()` method.

Throws

`StaticIllegalArgumentException`—when `time` is a negative `RelativeTime` value or the supplied `clock` is not the `Clock` associated with `time`.

`StaticUnsupportedOperationException`—when `time` has a `Chronograph` that is not an instance of `Clock`.

`IllegalAssignmentError`—when this `Timer` cannot hold references to `handler` and `clock`.

10.3.2.5.2 Methods

---

getClock

Signature

```
public javax.realtime.Clock
getClock()
throws StaticIllegalStateException
```

Description

Obtains the instance of `Clock` on which this `timer` is based.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

the instance of `Clock` associated with this `Timer`.

getStart

Signature

```
public javax.realtime.HighResolutionTime<?>
getStart()
```

Description

Gets the start time of this `Timer`. Note that the start time uses copy semantics, so changes made to the value returned by this method do not affect the start time of this `Timer`.

Returns

a reference to the time (or start) parameter used when constructing this `Timer`, ensuring the content has the original values.

Since RTSJ 2.0

getEffectiveStartTime

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStartTime()
throws StaticIllegalStateException,
       ArithmeticException
```

Description

Returns a newly-created time representing the time when the timer actually started, or when the timer has been rescheduled, the effective start time after the reschedule.

Throws

`StaticIllegalStateException`—when the timer is not active or has been destroyed.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the time `this` actually started.

Since RTSJ 2.0

getEffectiveStartTime(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStartTime(AbsoluteTime dest)
throws StaticIllegalStateException,
       ArithmeticException
```

Description

Updates `dest` to represent the time when the timer actually started, or when the timer has been rescheduled, the effective start time after the reschedule. When `dest` is `null`, behaves as if `getEffectiveStartTime()` had been called.

Parameters

`dest`—An object used to store the time `this` actually started.

Throws

`StaticIllegalStateException`—when the timer is not active or has been destroyed.

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the time when the timer actually started, or when it has been rescheduled, the effective start time after the reschedule.

Since RTSJ 2.0

getFireTime

Signature

```
public javax.realtime.AbsoluteTime
getFireTime()
throws StaticIllegalStateException,
       ArithmeticException
```

Description

Gets the time at which this `Timer` is expected to fire. When the `Timer` is *disabled*, the returned time is that of the skipping or the firing. When the `Timer` is *not-active*, it throws `StaticIllegalStateException`.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

`StaticIllegalStateException`—when this `Timer` has been *destroyed*, or when it is *not-active*.

Returns

the absolute time at which `this` is expected to fire (release handlers or skip), in a newly allocated `AbsoluteTime` object. When the timer has been created or re-scheduled (see `Timer.reschedule`) using an instance of `RelativeTime` for its time parameter, then it will return the sum of the current time and the `RelativeTime` remaining time before the timer is expected to fire/skip. The clock association of the returned time is the clock on which `this` timer is based.

getFireTime(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getFireTime(AbsoluteTime dest)
throws StaticIllegalStateException,
       ArithmeticException
```

Description

Gets the time at which this `Timer` is expected to fire. When the `Timer` is *disabled*, the returned time is that of the skipping or the firing. When the `Timer` is *not-active* it throws `StaticIllegalStateException`.

Parameters

`dest`—The instance of `AbsoluteTime` which will be updated in place and returned. The clock association of the `dest` parameter is ignored. When `dest` is `null`, a new object is allocated for the result.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

`StaticIllegalStateException`—when this `Timer` has been *destroyed*, or when it is *not-active*.

Returns

the instance of `AbsoluteTime` passed as parameter, with time values representing the absolute time at which `this` is expected to fire (release its handlers or skip). When the `dest` parameter is `null`, the result is returned in a newly allocated object. When the timer has been created or rescheduled (see `Timer.reschedule`) using an instance of `RelativeTime` for its time parameter then it will return the sum of the current time and the `RelativeTime` remaining time before the timer is expected to fire. The clock association of the returned time is the clock on which `this` timer is based.

Since RTSJ 1.0.1

getDispatcher

Signature

```
public javax.realtime.TimeDispatcher
getDispatcher()
```

Description

Returns

the time dispatcher use to dispatch clock events.

setDispatcher(TimeDispatcher)

Signature

```
public javax.realtime.TimeDispatcher
setDispatcher(TimeDispatcher dispatcher)
```

Description

Returns

the dispatcher associated with this event.

isActive

Signature

```
public boolean
isActive()
```

Description

Determines the activation state of this happening, i.e., it has been started.

Returns

`true` when active, `false` otherwise.

Since RTSJ 2.0

isRunning

Signature

```
public boolean
isRunning()
throws StaticIllegalStateException
```

Description

Determines if `this` is *active* and is *enabled* such that when the given time occurs it will fire the event. Given the `Timer` current state it answers the question *"Is firing expected?"*.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

`true` when the timer is *active* and *enabled*; otherwise `false`, when the timer has either not been *started*, it has been *started* but it is *disabled*, or it has been *started* and is now *stopped*.

handledBy(AsyncEventHandler)

Signature

```
public boolean
handledBy(AsyncEventHandler handler)
throws StaticIllegalStateException
```

Description

Parameters

`handler`—An event handler to be added to the Timer

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

`true` when `handler` is associated with `this`, otherwise `false`.

Since RTSJ 1.0.1

createReleaseParameters

Signature

```
public javax.realtime.ReleaseParameters<?>
createReleaseParameters()
throws StaticIllegalStateException
```

Description

Creates a `ReleaseParameters` object appropriate to the timing characteristics of this event. The default is the most pessimistic: `AperiodicParameters`. This is typically called by code that is setting up a `handler` for this event that will fill in the parts of the release parameters for which it has values, e.g. cost.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

a newly created `ReleaseParameters` object.

enable

Signature

```
public void
enable()
throws StaticIllegalStateException
```

Description

Re-enables this timer after it has been *disabled*. (See `Timer.disable()`.) When the `Timer` is already *enabled*, this method does nothing. When the `Timer` is *not-active*, this method does nothing.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

disable

Signature

```
public void
disable()
throws StaticIllegalStateException
```

Description

Disables this timer, preventing it from firing. It may subsequently be re-*enabled*. When the timer is *disabled* when its fire time occurs, then it will not release its handlers. However, a *disabled* timer created using an instance of `RelativeTime` for its time parameter continues to count while it is *disabled*, and no changes take place in a *disabled* timer created using an instance of `AbsoluteTime`. In both cases the potential firing is simply masked, or skipped. When the timer is subsequently re-*enabled* before its fire time or(?) it is *enabled* when its fire time

occurs, then it will fire. It is important to note that this method does not delay the time before a possible firing. For example, when the timer is set to fire at time 42 and the `disable()` is called at time 30 and `enable()` is called at time 40 the firing will occur at time 42 (not time 52). These semantics imply also that firings are not queued. Using the above example, when enable was called at time 43 no firing will occur, since at time 42 `this` was *disabled*. When the `Timer` is already *disabled*, whether it is *active* or *inactive*, this method does nothing.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

start

Signature

```
public void
start()
throws StaticIllegalStateException
```

Description

Starts this timer. A timer starts measuring time from when it is started; this method makes the timer *active* and *enabled*.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*, or when this timer is already *active*.

start(boolean)

Signature

```
public void
start(boolean disabled)
throws StaticIllegalStateException
```

Description

Starts this timer. A timer starts measuring time from when it is started. When `disabled` is `true` starts the timer making it *active* in a *disabled* state. When `disabled` is `false` this method behaves like the `start()` method.

Parameters

`disabled`—When `true`, the timer will be *active* but *disabled* after it is started. When `false` this method behaves like the `start()` method.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*, or when this timer is *active*.

Since RTSJ 1.0.1

stop

Signature

```
public boolean
stop()
throws StaticIllegalStateException
```

Description

Stops a timer when it is *active* and changes its state to *inactive* and *disabled*.

Throws

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

Returns

`true` when `this` was *enabled* and `false` otherwise.

reschedule(HighResolutionTime)

Signature

```
public void
reschedule(HighResolutionTime<?> time)
throws StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Changes the scheduled time for this event. This method can take either an `AbsoluteTime` or a `RelativeTime` for its argument, and the `Timer` will behave as if created using that type for its `time` parameter. The rescheduling will take place between the invocation and the return of the method.

Note that while the scheduled time is changed as described above, the rescheduling itself is applied only on the first firing (or on the first skipping when *disabled*) of a timer's activation. When `reschedule` is invoked after the current activation timer's firing, then the rescheduled `time` will be effective only upon the next `start` or `startDisabled` command (which may need to be preceded by a `stop` command).

When `reschedule` is invoked with a `RelativeTime time` on an *active* timer before its first firing/skipping, then the rescheduled firing/skipping `time` is relative to the time of invocation.

Parameters

`time`—The time to reschedule for this event firing. When `time` is `null`, the previous time is still the time used for the `Timer` firing.

Throws

`StaticIllegalArgumentException`—when `time` is a negative `RelativeTime` value.

`StaticIllegalStateException`—when this `Timer` has been *destroyed*.

10.4 Rationale

Clocks differ because of monotonicity, synchronization, jitter, stability, accuracy, precision, and resolution. There are many possible subclasses of clocks: realtime clocks, user time clocks, simulation time clocks, wall clocks.

The idea of using multiple clocks may at first seem strange, but it enables the developer to accommodated systems with different resources. For instance, most systems have an on board clock, which is provided as the default clock through the operation system. This clock is the natural clock to use for the `RTSJ` default clock, but this clock may not be stable or accurate enough for a given application. The clock API can be used to provide a second realtime clock that is based on an external clock source which can provide the needed accuracy and stability. For example, this could be taken from an external board with a hardware oscillator, a timing circuit that can generate an interrupt, and a small battery. A more exotic example would be to associate a clock with an object that rotates, where one degree is a second, a minute, or an hour depending on the rotation speed and accuracy needed, so long as the clock can trigger something at some fraction of a turn. Without a triggering mechanism, it could still be a chronograph.

The importance of the use of one-shot timers for time-out behavior and the vagaries in the execution of code prior to starting the timer for short time-outs dictate that the triggering of the timer should be guaranteed. The problem is exacerbated for periodic timers, where the importance of the periodic triggering outweighs the precision of the start time. In such cases, it is also convenient to allow, for example, a relative time of zero to be used as the start time.

Clock resolution is a complicated topic, and clock implementations may have differing precision for different purposes. For example, a clock for interacting with humans need much less precision than for controlling the opening and closing of values on an internal combustion engine. In this case, their relationship to wall clock time may vary as well.

The precision of time returned by a hardware clock device when queried may be greater than the precision at which that device can supply interrupts. (Consider, for example, a high precision off-chip realtime clock device connected via a shared serial bus.) A different device may provide pulse-per-second interrupts of very high precision, but be unable to interrupt on any other interval. The `RTSJ Clock` class provides two representation of precision: `getDrivePrecision()` and `getQueryPrecision` inherited from `Chronograph`. Clocks should behave as if their tick (`setAlarm()`) precision is the same as returned by `getResolution()`.

Chapter 11

Alternative Memory Areas

Conventional Java uses a single heap for storing all objects. The thread stacks hold only primitive objects and references to objects. This is fine for desktop and server systems, where there are no realtime, locality, or isolation requirements. Even for most realtime systems, a single heap is usually also sufficient when used in conjunction with a deterministic garbage collector. For all other situations, this specification defines classes directly related to memory and memory management. These classes provide a more generalized means of memory management than is available in a conventional Java VM.

In conventional Java, all of the memory needed for the allocation of an object is taken from a garbage-collected heap. The `RTSJ` generalizes the concept of a heap to that of a *memory area*. A memory area consists of two components: a Java object that manages the memory area and the *allocation area*, which is the actual region of memory from which objects are allocated. Every thread and schedulable has a *current allocation context*. This context is the memory area which manages the allocation area used when the thread or schedulable requests memory allocation using the Java `new` operator.

There are three types of memory area, distinguished by object lifetime semantics, defined by the `RTSJ`.

- Heap memory—the Java heap. Unreachable objects are collected by a garbage collector. Individual schedulables can specify their rate of allocation of objects on the heap.
- Immortal memory—an area defined by the JVM in which allocated objects might never be collected. Access to the memory area must be independent of garbage collection activity. Individual schedulables can specify the maximum amount of memory they need in immortal memory.
- Scoped memory—multiple areas that can be created by the application; objects are collected in scoped memory when there are no schedulables currently active in that area and it is not pinned. These allow objects with well-defined lifetimes to be created and efficiently collected in an easily-identified group.

Given that objects can now be created in multiple memory areas, it is necessary to ensure that an object cannot reference another object that might be collected at an earlier time. For example, an object in immortal memory (that is never collected) must not be allowed to reference an object in scoped memory. This is because the

scoped memory object will be collected when the scope is not pinned and there is no schedulable active in its associated allocation area, rendering the immortal object's reference to the scoped memory object invalid. For this reason, the RTSJ defines some memory assignment rules that are checked by the JVM on every object assignment. If the program violates the memory assignment rules, an exception is thrown.

Physical Memory

In embedded systems it is often the case that multiple directly addressable memory types are available to the application. For example, SRAM, DRAM, and Flash memory may all fall within the processor address space. Moreover, as the JVM implementer may require the VM to be portable between systems within the same processor family, the VM itself may not have detailed knowledge of the underlying memory architecture. The RTSJ therefore provides a framework with which the embedded systems integrator can define memory characteristics and specify ranges of physical addresses that support those memory characteristics. These physical memory regions can be allocated as either immortal or scoped memory areas.

Pinnable Memory

RTSJ 2.0 adds a new type of scoped memory called *pinnable memory*. This memory area is designed to support the producer consumer pattern. Here one set of tasks is responsible for producing some data to be consumed by another set of tasks. Usually, the second set cannot enter the area until the first is finished. However, with normal scopes, this would result in the data being lost. A developer must have a special thread, referred to as a wedge thread, to keep the scope alive. With pinnable memory, a wedge thread is no longer necessary. A pinnable scope can simply be pinned. The area is not collected until no threads are in the scope and the scope is unpinned.

Stacked Memory

RTSJ 2.0 also adds a new type of scoped memory called *stacked memory*. Stacked memory enables systems to maintain predictable memory performance over a long period of time while still releasing memory at runtime. The older scoped memory interfaces left sufficient ambiguity in the specification that the user may not have been able to sufficiently characterize internal and external fragmentation upon creating or destroying scoped memory areas. The `StackedMemory` class provides a safe interface for creating and releasing scopes with a set of rules under which the VM must guarantee fragmentation-free behavior with predictable memory overhead. These guarantees are provided by constraining the order in which an application may enter `StackedMemory` areas, as well as the manner in which they may be arranged on the scope stack. These constraints are enforced by the implementation.

Memory Groups

Analogous to `ProcessingGroups`, memory groups provide a means of partitioning memory between groups. Each group may have its use of backing store limited.

Currently, only backing store is considered, but future version of the specification may do more.

Summary

In summary, the classes and interfaces defined in this chapter enable

1. the definition of regions of memory outside of the conventional Java heap;
2. the definition of regions of scoped memory, that is, memory regions with a limited lifetime;
3. the definition of regions of memory containing objects whose lifetime matches that of the application;
4. the definition of regions of memory mapped to specific physical addresses with specific virtual memory characteristics;
5. the specification of maximum memory area consumption and maximum allocation rates for individual schedulables;
6. the programmer to query information characterizing the behavior of the garbage collection algorithm, and to some limited ability, alter the behavior of that algorithm.

11.1 Definitions

Allocation Context — An abstraction representing memory from which a new object can be allocated. In conventional Java, this is the Java heap. The `MemoryArea` class is the base class representing all allocation contexts in the `RTSJ`, of which the heap (represented by `HeapMemory`) is just one type.

Current Allocation Context — The memory area which will be used when object allocation is requested in the currently active thread of control.

Allocation Area — The area of memory that is managed by a `MemoryArea` from which objects are allocated. The allocation area for an extraheap memory area is logically and physically separate from the Java heap.

Backing Store — A range of memory addresses from which the allocation area of a `MemoryArea` is drawn. There are several backing stores: the global backing store for general scoped memory, the host backing store used for stacked memory, which is taken directly or indirectly from the global backing store, the backing store used for physical memory areas, and the backing stores for the default heap and immortal memory areas[1].

Explicit Initial Memory Area — A memory area given to a constructor of a `Schedulable` type, when it is created.

Execution Context — A memory area upon which execution is dependent. This includes areas in which a `Schedulable` or `ActiveEvent` is allocated. In order to prevent references from becoming invalid, the memory associated with an execution context may not be reclaimed. The following conditions cause a memory area to be an execution context:

[1]The backing store for the default heap and immortal memory areas are identical to their allocation contexts

1. it contains a `Thread` instance that has been started but have not terminated (including the `RealtimeThread` instances contained by `ActiveEventDispatcher` instances),
2. it contains an `ActiveEvent` instance that is active,
3. it contains a firable asynchronous event handler[2],
4. it is on the scope stack inherited by one of the schedulable or event types listed above from the schedulable that created it, or
5. it is on the scope stack of an active schedulable beyond its inherited stack.

Default Initial Memory Area — The initial memory area for a schedulable is *default* when it is the memory area in which the schedulable was created.

Inner Memory Area — A memory area on a scope stack that is closer to the current allocation context of the stack's `Schedulable` than another memory area. It can also refers to a scoped memory with a greater nesting count in a scoped memory tree.

Memory Assignment Rules — The rules for when a reference to an object may be saved in another object. In general, an object created in a memory area may only be stored in the current memory area or a more deeply nested memory area (scoped memory). For these rules, instances of @code HeapMemory and `ImmortalMemory` are equivalent.

Outer Memory Area — A memory area on a scope stack that is further from the current allocation context of the stack's `Schedulable` than another memory area. It can also refers to a scoped memory with a greater nesting count in a scoped memory tree.

Portal — A location for storing a reference to an object allocated in an instance of `ScopedMemory` settable on that instance. A portal can be used to pass information between instances of `Schedulable` executing in a given area.

Perennial Memory — all memory areas whose contents can be unexceptionally referenced. In other words, any memory area can store a reference to an object stored in one of these areas. This includes all concrete memory areas in the core package. Only memory areas of this type can be a root for a scope stack.

Primordial Scope — An imaginary scope used as the parent for an instance of `ScopedMemory` which is in use and has been entered directly from a perennial memory. It is used distinguish between instances of `ScopedMemory` area that has no parent because it is not active on any scope stack and one that has no parent because it is the first `ScopedMemory` area on a scope stack. Hence, there is no memory area that corresponds to the primordial scope.

Root `StackedMemory` — A `StackedMemory` that has a parent which is not of type `StackedMemory`.

Scope Stack — A sequence of the memory areas an instance of `Schedulable` has entered, in order of entry, where the first entered is the bottom of the stack and the last entered is the top. Not all memory areas on a scope stack are scoped memories.

Scope Tree — A set of scoped memories with the same root scoped memory. The transitive closure of the parents of any scope in the tree contains that root scoped memory.

[2]Defined in Section 8.1

Realtime Task — Any task except instances of `java.lang.Thread`. Instances of `Realtime`, `AsyncBaseEventHandler`, `InterruptServiceRoutine`, and `Dispatcher` are all realtime tasks.

11.2 Semantics

The classes `MemoryArea`, `HeapMemory`, and `ImmortalMemory` are part of the base module and the semantics below that apply to those modules must be fulfilled by all `RTSJ` implementations. The rest of the features described here belong to the Alternative Memory Areas Module introduced in Section 3.2.2.2 and are only required for implementations that include that module. The following lists define the general semantics of the classes of this section. Semantics of particular classes, constructors, methods, and fields are detailed further on, in the sections describing those classes, constructors, methods, and fields.

11.2.1 Allocation Execution Time

The following two requirements apply to allocation in any memory area, including the heap.

1. All nondeprecated `MemoryArea` classes are required to have allocation times linear in the size of the object being allocated. Ignoring performance variations due to hardware caches or similar optimizations and ignoring the execution time of any static initializers, the linear time attribute requires the execution time of `new` to be bounded by a polynomial, $f(n)$, where n is the size of the object and for all $n > 0$, $f(n) \leq Cn$ for some constant C.
2. The execution time of object constructors and time spent in class loading and static initialization are not governed by the bounds on object allocation in this specification, but setting default initial values for fields in the instance (as specified in *The Java Virtual Machine Specification*, Second Edition, section 2.5.1, "Each class variable, instance variable, and array component is initialized with a default value when it is created.") is considered part of object allocation and included in the time bound.

11.2.2 Allocation Context

The following requirements apply to the allocation context represented by a memory area.

1. A memory area is represented by an instance of a subclass of the `MemoryArea` class. When a memory area, m, is entered by calling `m.enter` (or another method from the family of enter-like methods defined in `MemoryArea` or its subclasses), m becomes the *allocation context* of the current schedulable object. When control returns from the `enter` method, the allocation context is restored to the value it had immediately before `enter` was called.
2. When a memory area, m, is entered by calling m's `executeInArea` method, m becomes the current allocation context of the current schedulable. When

control returns from the `executeInArea` method, the allocation context is restored to the value it had before `executeInArea` was called.

3. The initial allocation context for a schedulable is the memory area that was designated the *initial memory area* when the schedulable was constructed. This initial allocation context becomes the current allocation context for that schedulable when the schedulable object first becomes eligible for execution. For instances of `AsyncBaseEventHandler`, the initial allocation context is the same on each release; for realtime threads, in releases subsequent to the first, the allocation context is the same as it was when the realtime thread became *blocked-for-release-event*.
4. All object allocation through the `new` keyword will use the current allocation context, but note that allocation can be performed in a specific memory area using the `newInstance` and `newArray` methods on `MemoryArea`.
5. Instances of `schedulables` behave as if they stored their memory area context in a structure called the *scope stack*. This structure is manipulated by the instantiation of a schedulable, and the following methods from `MemoryArea` and its subclasses: all the `enter` and `joinAndEnter` methods, `executeInArea`, and both `newInstance` methods. See the semantics in Maintaining the Scope Stack for details.
6. The `executeInArea`, `newInstance`, and `newArray` methods, when invoked on an instance of `ScopedMemory` require that instance to be on the current schedulable's scope stack.
7. An instance of `ScopedMemory` is said to be *in use* when it has a positive reference count as defined by semantic 1 below.

11.2.3 Backing Stores

Every `MemoryArea` has a notional *backing store*, which is a range of memory addresses from which its allocation area, i.e., the memory range from which objects in it are allocated, is drawn. In the case of Physical Memory, these addresses may be explicitly managed by the programmer, while in other cases they are hidden by the virtual machine and `RTSJ` implementation. The `RTSJ` gives the programmer tools to manage the backing store as a limited system resource via the `ScopedMemory` class and its descendants and the `ScopedMemoryParameters` class.

Besides the backing stores for the memory areas provided by the core module, heap and immortal, whose backing stores are fixed or at least predefined at startup, two types of backing store may be available for allocating to newly created memory areas: global backing store and physical backing store. All memory area created via the physical memory factory use the physical memory backing store. All other instances of `ScopedMemory` other than of type `StackedMemory` and root instance of `StackedMemory` take their backing stores from the global backing store that represents system memory available for use as `RTSJ` memory area allocation areas.

Access to this finite global resource by individual instances of `Schedulable` is controlled by their associated `ScopedMemoryParameters`. Once a given `Schedulable`'s budget of global backing store has been allocated, attempts to allocate from the global backing store over that budget will result in an exception.

11.2.4 The Parent Scope

The following requirements apply to a scope's parent.

1. Instances of `ScopedMemory` have special semantics, including a definition of *parent*. If a `ScopedMemory` object is neither in use nor the initial memory area for a schedulable, it has no *parent* scope.
   (a) When a `ScopedMemory` object becomes in use, its parent is the nearest `ScopedMemory` object outside it on the current scope stack. If there is no outside `ScopedMemory` object in the current scope stack, the parent is the *primordial scope* which is not actually a memory area, but only a marker that constrains the parentage of `ScopedMemory` objects.
   (b) At construction of a schedulable, if the initial memory area has no parent, the initial memory area is assigned the parent it will have when the schedulable is in execution. This rule determines the initial memory area's parent until the schedulable object is de-allocated or, in the case of a `RealtimeThread`, it completes execution.
2. Instances of `ScopedMemory` must satisfy the *single parent rule*, which requires that each scoped memory has a unique parent as defined in semantic 1.

11.2.5 Memory Areas and Schedulables

The following requirements govern the relationship between memory and execution.

1. Pushing a scoped memory onto a scope stack is always subject to the single parent rule.
2. Each schedulable has a default initial memory area which is that object's initial allocation context. The default initial memory area is the current allocation context in effect during execution of the schedulable's constructor, but a schedulable may supply constructors with an explicit initial memory area that override the default.
3. A Java thread cannot have a scope stack; consequently it can only be created and execute within heap or immortal memory. The thread starts execution with its allocation context set to the memory area containing the `Thread` object. An attempt to create a Java thread in a scoped memory area throws `IllegalAssignmentError`.
4. A Java thread may use `executeInArea`, and the `newInstance` and `newArray` methods from the `ImmortalMemory` and `HeapMemory` classes. These methods enable it to execute with an immortal current allocation context, but semantic of item 3 above applies even during execution of these methods.

11.2.6 Scoped Memory Reference Counting

The following requirements apply to references to scoped memory.

1. Each instance of the class `ScopedMemory`, or its subclasses, must maintain a reference count which is greater than zero when and only when it is an *execution context* or more exactly, the reference count is the number of causes for a given memory area to be an execution context.

2. Each instance of the `PinnableMemory` class must support a pinned count. This count is incremented for each call of the `pin` method and decremented for each call of the `unpin` method. The count is always greater than or equal to zero (that is, calling the `unpin` method has no effect if the count equals zero).
3. When the reference count for an instance of the class `ScopedMemory` is ready to be decremented from one to zero and the pinned count (if present) is equal to zero, all unfinalized objects within that area are considered ready for finalization.
   (a) When after the finalizers for all such unfinalized objects in the scoped memory area run to completion, the reference count for the memory area is still ready to be decremented to zero, and the pinned count is still equal to zero, any newly created unfinalized objects are considered ready for finalization and the process is repeated until no new objects are created or the scoped memory's reference count is no longer ready to be decremented from one to zero.
   (b) When the scope contains no unfinalized objects and its reference count is ready to be decremented from one to zero and the pinned count is equal to zero, any asynchronous event in the scope is no longer treated as a source of fireability for asynchronous event handlers.
   (c) When that action causes object creation in the scope, the finalization process resumes from the beginning;
   (d) When the reference count is no longer ready to be decremented to zero, the finalization process terminates.
   (e) Otherwise, the reference count is decremented to zero and the memory scope is emptied of all objects.
   (f) The process of scope finalization starts when the scope's reference count is about to go to zero with a zero pin count and continues until the scope is emptied or the process is terminated because the reference count is no longer about to go to zero.
4. When the pinned count is ready to go to zero and the reference count is zero, all unfinalized objects within that area are considered ready for finalization, and the same semantics as 3 above applies.
5. The `RTSJ` implementation must behave effectively as if during the finalization process the schedulable executing the finalization of a scope holds a synchronized lock that must also be acquired
   (a) to increase the reference count when entering the scope,
   (b) to increase the reference count during startup for a thread with the finalizing scope as its explicit initial memory area, and
   (c) to increase the reference count while making firable an asynchronous event handler with the scope as its explicit initial memory area.
6. Although the steps in scope finalization are ordered, no order is specified for finalization of objects or for disarming fireability of asynchronous event handlers. The objects may be processed in any order or concurrently, but at no time may a scope's reference count be reduced to zero while it has one or more child scopes. This semantic is a special case of the finalization implementation specified in *The Java Language Specification*, second edition, section 12.6.1.

7. Finalization may start when all unfinalized objects in the scope are ready for finalization. Finalizers are executed with the current allocation context set to the finalizing scope and are executed by the schedulable in control of the scope when its reference count is ready to be decremented from one to zero. If finalizers are executed because a realtime thread terminates or an `AsyncEventHandler` becomes unfirable, that realtime thread or `AsyncEventHandler` is considered in control of the scope and must execute the finalizers.
8. From the time objects in a scope are deleted until the portal on the scope is successfully set to a reference value (not null) with `setPortal`, the value returned by `getPortal` on that scoped memory object must be `null`.

11.2.7 Immortal Memory

Immortal memory is provides an ability to run without a heap. This is only really useful when the alternate memory module is used. The following requirements apply to immortal memory.

1. Objects created in any immortal memory area are unexceptionally referencable from all Java threads, and all schedulables, and the allocation and use of objects in immortal memory is never subject to garbage collection delays.
2. An implementation may execute finalizers for immortal objects when it determines that the application has terminated. Finalizers will be executed by a thread or schedulable whose current allocation context is not scoped memory. Regardless of any call to `runFinalizersOnExit`, except as required to support the base Java platform, the system need not execute finalizers for immortal objects that remain unfinalized when the JVM begins termination.

The following addition requirements take effect when the alternate memory module is used, effectively, when immortal meory has a size greater than zero.

3. Class objects, the associated static memory, and interned Strings behave effectively as if they were allocated in immortal memory with respect to memory reference and assignment rules, and preemption delays by schedulables which may not access the heap. This means that class objects may not be moved once created.
4. When classes allocated in heap memory may be moved by the grabage collector, static initializers are executed effectively as if the current thread performed `ImmortalMemory.instance().executeInArea(r)` where `r` is a `Runnable` that executes the <`clinit`> method of the class being initialized.
5. These last two rules alway apply for classes in a package annotated with the `ClassAllocation` annotation and has a value of `MemoryAreaType.IMMORTAL`, which is the default.
6. Classes allocated in pavkages annotated with the `ClassAllocation` annotation and a value of `MemoryAreaType.HEAP` are always allocated on the heap.
7. When the value is `MemoryAreaType.Perennial`, the implementor can decide, based on at least grabage collector behavior, which area to use for class allocation and initialization,[3]

[3]The value `MemoryAreaTye.SCOPED` is undefined and provided for future extension.

11.2.8 Maintaining Referential Integrity

The following rules apply to references to objects in scoped memory.

1. Memory assignment rules placed on reference assignments prevent the creation of dangling references, and thus maintain the referential integrity of the Java runtime. The restrictions are listed in the following table. Both `Immortal-`

Table 11.1: Memory Area Referencing Restrictions

Stored in Area	**Reference to Object in Heap**	**Reference to Object in Immortal**	**Reference to Object in Scoped**	**null**
Perennial-Memory	Permit	Permit	Forbid	Permit
Scoped-Memory	Permit	Permit	Permit from same or less deeply nested scope	Permit
Local Variable	Permit	Permit	Permit	Permit

`Memory` and `HeapMemory` are types of `PerennialMemory`. All subclasses of `ScopedMemory` and `PerennialMemory` are equivalent to their respective base class for the purposes of this table.

2. An implementation must ensure that the above checks are performed for each assignment statement before the statement is executed, either by runtime checks or by static analysis of the application logic. Checks for operations on local variables are not required because a potentially invalid reference would be captured by the other checks before it reached a local variable.

11.2.9 Object Initialization

The current allocation context in a constructor for an object is the memory area in which the object is allocated. For `new`, this is the current allocation context when `new` was called. For members of the `m.newInstance` family, the current allocation context is memory area *m*.

11.2.10 Maintaining the Scope Stack

This section describes maintenance of a data structure that is called the *scope stack*. Implementations are not required to use a stack or implement the algorithms given here. It is only required that an implementation behave with respect to the ordering and accessibility of memory scopes effectively as if it implemented these algorithms. The scope stack is implicitly visible through the memory assignment rules, and the stack is explicitly visible through the `visitRootScopes(Consumer<ScopedMemory>)` and `visitNestedScopes(Consumer<ScopedMemory>)` methods on `ScopedMemory`.

Four operations affect the scope stack: the `enter` methods defined in `MemoryArea` and its subclasses, instantiation of a new `Schedulable`, the `executeInArea` method in `MemoryArea`, and the new instance methods in `MemoryArea`.

1. The memory area at the top of a schedulable object's scope stack is the schedulable's current allocation context.
2. For an instance of `Schedulable`, n_4, created by task t, the scope stack of n_t is determined by both t and n_t:
   (a) when n_t is created in a heap or immortal memory area, n_t is created with a scope stack containing only that heap or immortal memory area,
   (b) when the memory area of t is a `ScopedMemory` instance, n_t acquires a copy of the scope stack associated with t at the time n_t is constructed, including all entries from up to and including the memory area containing n_t; and
   (c) when n_t has an explicit initial memory area, *ima*, then *ima* is pushed on n_t's newly-created scope stack, e.g., a task executing with the scope stack $A \rightarrow B \rightarrow C$ creates a new Schedulable instance s with initial memory area D which is not currently in use, s gets the scope stack $A \rightarrow B \rightarrow C \rightarrow D$.
3. When a memory area, `ma` is entered by calling a `ma.enter` method, `ma` is pushed onto the scope stack of the current schedulable and becomes its *allocation context*. When control returns from the `enter` method, the allocation context is popped from the scope stack
4. When a memory area, `ma`, is entered by calling `ma`'s `executeInArea` method or one of the `ma.newInstance` methods, the scope stack before the method call is preserved and replaced with a scope stack constructed as follows:
   (a) when `ma` is a scoped memory area, the new scope stack is a copy of the schedulable's previous scope stack up to and including `ma`, and
   (b) when `ma` is not a scoped memory area, the new scope stack includes only `ma`.

   When control returns from the `executeInArea` method, the scope stack is restored to the value it had before `ma.executeInArea` or `ma.newInstance` was called.

For the purposes of these algorithms, stacks grow *up*. One should also note that the representative algorithms ignore important issues like freeing objects in scopes.

1. In every case, objects in a scoped memory area are eligible to be freed when the reference count for the area is zero after finalizers for that scope are run.
2. Informally, any objects in a scoped memory area *must* be freed and their finalizers run before the reference count for the memory area is incremented from zero to one.

11.2.11 The `enter` Method

For `ma.enter(logic)`:

```
1  push ma on the scope stack belonging to the current schedulable
2     -- which may throw ScopedCycleException
3  execute logic.run method
4  pop ma from the scope stack
```

11.2.12 The executeInArea or newInstance Methods

For `ma.executeInArea(logic)`, `ma.newInstance()`, or `ma.newArray()`:

```
1  if ma is an instance of PerennialMemory,
2      start a new scope stack containing only ma.
3      make the new scope stack the scope stack for the current
4         schedulable.
5  else if ma is in the scope stack for the current schedulable,
6      start a new scope stack containing ma and all
7         scopes below ma on the scope stack.
8      make the new scope stack the scope stack for the current
9         schedulable.
10 else
11     throw InaccessibleAreaException, execute logic.run,
12         or construct the object.
13     restore the previous scope stack for the current
           schedulable.
14     discard the new scope stack.
15 end
```

11.2.13 Constructor Methods for Schedulables

For construction of a schedulable in memory area `cma` with initial memory area of `ima`:

```
1  if cma is an instance of PerennialMemory,
2      create a new scope stack containing cma.
3  else
4      start a new scope stack containing the entire
5          current scope stack.
6
7  if ima != cma
8      push ima on the new scope stack
9          -- which may throw ScopedCycleException.
```

The above pseudocode illustrates a straightforward implementation of this specification's semantics, but any implementation that behaves effectively like this one with respect to reference count values of zero and one is permissible. An implementation may be eager or lazy in maintenance of its reference count provided that it correctly implements the semantics for reference counts of zero and one.

11.2.14 The Single Parent Rule

Every push of a scoped memory type on a scope stack must obey the single parent rule. This enforces the invariant that every scoped memory area has no more than one parent.

The parent of a scoped memory area is identified by the following rules:

1. when the memory area is not currently on any scope stack, it has no parent;

2. when the memory area is the first scoped memory area on a scope stack, i.e., it was entered from an instance of a `PerennialMemory`, its parent is the *primordial scope*,
3. otherwise, the parent is the first scoped memory area outside it on the scope stack, i.e., the scope from which this scope was entered.

Only scoped memory areas are visible to the single parent rule.

The operational effect of the single parent rule is that when a scoped memory area has a parent, the only legal change to that value is to `null`, i.e.,"no parent." Thus an ordering imposed by the first assignments of parents of a series of nested scoped memory areas is the only nesting order allowed until control leaves the scopes; then a new nesting order is possible. Thus, a schedulable attempting to enter a scope can only do so by entering in the established nesting order.

11.2.15 Scope Tree Maintenance

The single parent rule is enforced effectively as if there were a tree with the primordial scope at its root, and other nodes corresponding to every scoped memory area currently on any schedulable's or interrupt service routine's memory area stack.

Each scoped memory has a reference to its parent memory area, `ma.parent`. The parent reference may indicate a specific scoped memory area, no parent, or the primordial parent.

When a scoped memory area is the explicit initial memory area of a schedulable or an interrupt service routine that has not terminated, it is referred to as *reserved*. A reserved area with a reference and pin count of zero does not have any objects allocated in it, but it is in a scope stack as long as the schedulable or interrupt service routine is active. Since it is possible for more than one schedulable to have the same explicit initial memory area, the memory area must behave as if a reference count for reservation is also maintained.

11.2.15.1 Pushing a MemoryArea onto the Scope Stack

The following procedure could be used to maintain the scope tree and ensure that push operations on a schedulable's or ISR's memory area stack does not violate the single parent rule.

```
1  preconditions
2
3    ma.parent is set to the correct parent (either a scoped
4    memory area or the primordial scope) or to null (no parent).
5
6    t.scopeStack is the scope stack of the current schedulable or
         ISR
7
8  Action
9
10   if ma is scoped,
11       parent = findFirstScope(t.scopeStack).
12   if ma.parent == null
13       ma.parent = parent.
```

```
14   else if ma.parent != parent
15       throw ScopedCycleException.
16   else
17       t.scopeStack.push(ma).
```

`findFirstScope` is a convenience function that looks down the scope stack for the next entry that is a reference to an instance of `ScopedMemoryArea`.

```
1 findFirstScope(scopeStack)
2 {
3   for s = top of scope stack to bottom of scope stack
4   {
5     if s is an instance of scopedMemory
6       return s.
7   }
8   return primordial scope.
9 }
```

11.2.15.2 Popping a MemoryArea off the Scope Stack

```
1   ma = t.scopeStack.pop.
2   if ma is scoped
3       if !(ma.in_use || (ma.reserve_count > 0))
4           ma.parent = null.
```

11.2.15.3 Reservation Management

Reservation management is separate from managing the scope stack for a schedulable or ISR. Reservations are maintained in order to constrain the code locations at which an exception may be thrown due to violations of the single parent rule with respect to explicit initial scoped memory areas (EISMAs). With the `RTSJ` reservation management semantics, such exceptions will always be thrown at the explicit invocation of configuration methods. When a realtime thread with an EISMA is created, an ASEH with an EISMA is added to an ASE, or an `InterruptServiceRoutine` is registered with an interrupt, the following happens atomically with respect to other tasks in the VM:

```
1 ma = t.eisma // explicit initial scoped memory area
2
3 if (ma.parent == null),
4   ma.parent = findFirstScope(t.scopeStack)
5   ma.reserve_count++. // should now be equal one
6 else if (ma == findFirstScope(t.scopeStack)),
7   ma.reserve_count++. // should now be greater than zero
8 else
9   throw ScopedCycleException.
```

When a realtime thread with an EISMA terminates, an ASEH is removed from

an ASE, or an `InterruptServiceRoutine` is unregistered, the following happens atomically with respect to other tasks in the VM:

```
1 ma = t.eisma // explicit initial scoped memory area
2
3 ma.reserve_count--.
4 if ((ma.reserve_count == 0) &&
5     (ma.enter_count == 0) &&
6     (ma.pin_count == 0))
7   ma.parent = null.
```

11.2.16 Physical Memory

Physical memory provides a means of allocating Java objects in specific areas of a system's physical address space. This is accomplished by creating a memory area that resides in the desired address range. The memory area can be any of the memory areas defined by this specification other than heap. A physical memory area is not type distinct from a normal memory area; it is just created by a different means.

1. Physical immortal memory—an immortal memory area that can be created by the application such that the associated allocation areas have specified physical and virtual memory characteristics. For example, the application could specify that the physical characteristics of the backing store should be Static RAM (SRAM) and that it should be mapped by the JVM into virtual memory that is never paged out to disk.
2. Physical scoped memory—a scoped memory area, that can be created by the application such that the associated backing store has specified physical and virtual memory characteristics.

This physical memory model is based on two constraints.

1. Java objects can only be allocated in a memory area when the physical allocation area supports the Java Memory Model (JMM) without the JVM having to perform any operation additional to those that it performs when accessing the main RAM for the host machine.
   (a) No extra compiler or JVM interactions shall be required. Hence memory regions (such as EEPROM) that potentially require special hardware instructions to perform write operations cannot be used as the backing store for physical memory areas.
   (b) Similarly, nonvolatile memory cannot be used, as object lifetimes in such an area may be longer than the lifetime of the VM.

   Although memory having such characteristics incompatible with the JMM are prohibited from being used as backing stores for object allocation, they can contain objects of primitive Java types and be accessed via the `RTSJ` Raw Memory facilities (see Section 13.2.1).
2. Any API must delegate detailed knowledge of the memory architecture to the programmer/integrator of the specific embedded system to be implemented. The model assumes that the programmer is aware of the memory map, either

through some native operating system interface[4] or from some property file read at program initialization time.

The RTSJ defines a *physical memory factory*, which maintains a mapping between physical memory characteristics and the associated physical addresses of memory that support those characteristics. The physical memory factory has no knowledge of the meaning of the physical characteristics. It only provides a look-up service and keeps track of which physical memory has been associated with a physical memory range by the application. The physical memory factory does, however, have detailed knowledge of the types of virtual memory it can support. It advertises this knowledge to the application. For example, it knows if the VM can lock memory pages into memory to ensure that they are never swapped out to disk. The application can then request that the physical memory manager create an association between physical memory with certain characteristics and a virtual memory type (for example, SRAM that is permanently resident in memory).

11.2.17 Stacked Memory

A StackedMemory area represents both a *memory area* providing ScopedMemory semantics and an explicit *backing store* from which its allocation area is drawn. The backing store may be further subdivided into additional allocation areas and backing stores. Such divisions behave as if new allocation areas are allocated contiguously from the bottom of the container, while new backing stores are allocated contiguously from the top, with allocation areas and backing stores meeting when the outer backing store is completely occupied.

11.2.17.1 Avoiding Backing Store Fragmentation

StackedMemory backing stores are explicitly created and sized, and have well-defined lifetimes similar to objects in a ScopedMemory area. A StackedMemory instance can be created as either a *host*, which has its own backing store, or a *leaf*, which uses all of its backing store for allocation and does not host any other instance of StackedMemory. A leaf can become a host by reducing the size of its allocation area, leaving the rest for hosting. A host or leaf created in another stacked memory is referred to as a *guest*. When a StackedMemory instance is created in an allocation context other than StackedMemory, it is called a *root* StackedMemory. In this case, its backing store is drawn from the global backing store or the physical backing store. Usually, a root backing store is also a host. A root StackedMemory's backing store will be freed under the same conditions as other host StackedMemory backing stores, but applications *should not* assume that the implementation provides any guarantees with respect to fragmentation, should this occurs. When a StackedMemory object is created in another StackedMemory's allocation context, it may be created as either a host or leaf, as illustrated in Figure 11.1. Either way, its backing store is drawn from its parent area's backing store, and its allocation area is created in the newly-divided

[4]For example, the *Advanced Configuration and Power Interface* (ACPI) specification is an open standard for device configuration and power management by the operating system. The ACPI defines platform-independent interfaces for hardware discovery, configuration, power management and monitoring. See http://www.acpi.info/

backing store. When it is created as a leaf, all of its backing store is used for allocation.

Object lifetimes for objects allocated in `StackedMemory` allocation contexts are the same as those in `ScopedMemory` allocation contexts. When a `StackedMemory` object itself is finalized, its allocation area is returned to the backing store from which it was drawn, and in the case of host `StackedMemory` areas, the associated backing store is also returned to the parent's backing store. Additionally, the allocation area of a `StackedMemory` can be resized under certain conditions. These semantics allow the memory represented by a root `StackedMemory` backing store to be partitioned and repartitioned as the application requires without danger of fragmentation and without requiring memory allocation external to the container to track the partitioning.

In order to preserve the fragmentation-free nature of this contract, certain rules are enforced by the infrastructure. Those rules are as follows:

1. a guest `StackedMemory` area can only be entered by a schedulable when its allocation context is the same as the allocation context in which that `StackedMemory` area's object was created;
2. a guest `StackedMemory` object cannot be created from another `StackedMemory` instance unless that other instance has enough backing store reserved for allocating the guest's backing store;
3. a host cannot be finalized while any of its guests are occupied by a schedulable; and
4. a `StackedMemory` instance's allocation area cannot be resized when more than one task is active in the area.

11.2.17.2 Enforcing Encapsulation

Access to backing store memory for creation of memory areas can also be controlled in a fine-grained fashion by creating a `Schedulable` with a `StackedMemory` as its explicit initial scoped memory area. Such a `Schedulable` may allocate `StackedMemory` instances only from the backing store of its initial allocation area and its children in the scope stack. This means that a `Schedulable` thus configured

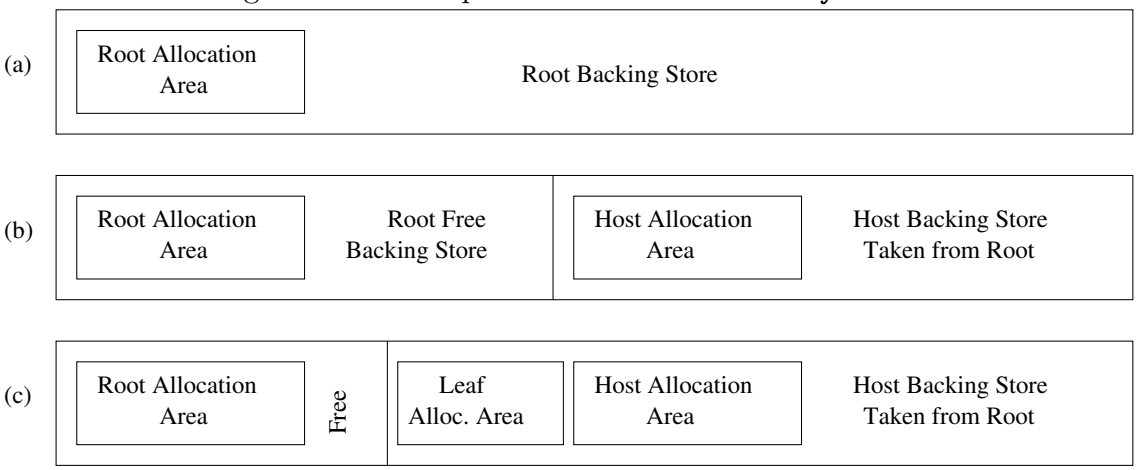
1. may not construct a root `StackedMemory`, and
2. may only construct a `StackedMemory` if its explicit initial scoped memory area is on its current scope stack.

Used in conjunction with the limits provided by `ScopedMemoryParameters`, this allows a `Schedulable`'s access to global memory resources to be tightly constrained.

11.2.17.3 Example

Figure 11.1 graphically depicts the behavior of `StackedMemory` backing stores and allocation areas for a root `StackedMemory` as well as one host and one guest child `StackedMemory` under that root. A code fragment that could create the stack topology in Figure 11.1 is as follows. Assume that this fragment executes in an allocation context other than a `StackedMemory`, and that zero overhead is required for memory area creation. An implementation may require a constant amount of overhead, drawn from the backing store, for each `StackedMemory` area created in the store.

Figure 11.1: Manipulation of `StackedMemory` Areas




```
1 // Create a StackedMemory with a 10 kB backing store and
2 // 2 kB allocation area
3 rootArea = new StackedMemory(2048, 10240); // (a)
4 rootArea.enter(new Runnable()
5 {
6   public void run()
7   {
8     // Create a host area with a 6 kB backing store and
9     // 2 kB allocation area
10    hostArea = new StackedMemory(2048, 6144); // (b)
11    // Create a guest area with a 2 kB allocation area
12    guestArea = new StackedMemory(1536); // (c)
13  }
14 });
```

Commented points (a), (b), and (c) correspond to their respective subfigures in Figure 11.1. At point (a), a root `StackedMemory` has been created with its 10 kB backing store drawn from the global store. It contains a 2 kB allocation area, which is then entered. With that allocation area as the current allocation context, a new host `StackedMemory` is created at (b), reserving 6 kB of the root `StackedMemory`'s backing store for its own use and creating a second 2 kB allocation area within that reservation. A new guest `StackedMemory` is then created at (c) in the root area (without entering the host child), occupying 1.5 kB of the remaining free 2 kB of the backing store in the root area. At this point, the root area's backing store is almost entirely occupied, with one 2 kB allocation area, one 1.5 kB store, and a 6 kB host area backing store reservation, and 512 B of free backing store in between. The host `StackedMemory` created at (b) has 4 kB of its backing store remaining unoccupied in its reservation, which could be allocated to additional host or guest `StackedMemory` areas beneath it in the stack.

11.2.18 Pinnable Memory

As with `LTMemory`, `PinnableMemory` class is a subset of `ScopedMemory`. The only difference between `PinnableMemory` and `LTMemory` is that `PinnableMemory` supports the concept of pinning. Pinning adds some additional requirements to reference counting, as described in Section 11.2.6. To minimize the chance for race conditions, when and from what context a `PinnableMemory` can be pinned and unpinned is restricted. Mor details are given in the documentation for `PinnableMemory.pin` and `PinnableMemory.unpin`.

11.2.19 Startup Considerations

Normally, a realtime Java program starts with a conventional Java thread with a normal thread group. The `RTSJ` now requires the initial thread group to be a realtime thread group. Optionally the thread group can be changed to a realtime thread at startup too. In addition, an Alternative Memory Module option provides a means of running without a heap. This requires changing the initial memory area as well.

A compilant implementation my provide a property called `javax.realtime.start.realtime` to control the starty thread type. By setting `true`, the Java main thread and all internal system threads are created as realtime threads, instead of conventional Java threads. Though a conventional Java thread may have a realtime priority, it may not enter a scoped memory. This property removes the need to create an extra thread for entering scoped memory.

Furthermore, a property called `javax.realtime.start.immortal` may also be provided by systems that support the `javax.realtime.memory` package. Setting this property to `true` configures the system to not use a heap at all. Instead, the initial memory area is the instance of `ImmortalMemory`. An implementation that cannot run without a heap should not start up when this property is set; where possible, the process should return a documented nonzero error code.

The default value for each of these properties is `false`. Setting `javax.realtime.start.immortal` to `true` without setting `javax.realtime.start.realtime` as well is an error condition. Where possible, the process should return another documented nonzero error code for this error.

11.3 javax.realtime

11.3.1 Enumerations

11.3.1.1 EnclosedType

---

public enum EnclosedType

Inheritance

java.lang.Object
  java.lang.Enum<EnclosedType>
    EnclosedType

Description

Represents type size classes for deciding how large a lambda is. This size is dependent on what variables the lambda expression contains in its closure, i.e., it encloses. It is used by the `reserveLambda` methods in `SizeEstimator`.

Since RTSJ 2.0

11.3.1.1.1 Enumeration Constants

BOOLEAN

```
public static final EnclosedType BOOLEAN
```

Description

Represents a Java boolean.

BYTE

```
public static final EnclosedType BYTE
```

Description

Represents a Java byte.

CHAR

```
public static final EnclosedType CHAR
```

Description

Represents a Java char.

SHORT

```
public static final EnclosedType SHORT
```

Description

Represents a Java short.

INT
```
public static final EnclosedType INT
```
Description

Represents a Java int.

FLOAT
```
public static final EnclosedType FLOAT
```
Description

Represents a Java float.

LONG
```
public static final EnclosedType LONG
```
Description

Represents a Java long.

DOUBLE
```
public static final EnclosedType DOUBLE
```
Description

Represents a Java double.

REFERENCE
```
public static final EnclosedType REFERENCE
```
Description

Represents a reference to any object.

11.3.1.1.2 Methods

---

values
Signature
```
public static javax.realtime.EnclosedType[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.EnclosedType
valueOf(String name)
```

Description

11.3.2 Classes

11.3.2.1 HeapMemory

---

public class HeapMemory

Inheritance

java.lang.Object
  MemoryArea
    PerennialMemory
      HeapMemory

Description

The `HeapMemory` class is a singleton object that allows logic with a non-heap allocation context to allocate objects in the Java heap.

11.3.2.1.1 Methods

---

enter

Signature

```
public void
enter()
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the instance of `Runnable` given in the constructor. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Throws

`IllegalTaskStateException`—when the caller context in not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when the caller is a schedulable and a `null` value for `logic` was supplied when the memory area was constructed.

`MemoryAccessError`—when caller is a schedulable which may not use the heap.

enter(Runnable)

Signature

```
public void
enter(Runnable logic)
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the given `Runnable`. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Parameters

`logic`—The Runnable object whose `run()` method should be invoked.

Throws

`MemoryAccessError`—when caller is a schedulable which may not use the heap.

`IllegalTaskStateException`—when the caller context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when the caller is a schedulable and `logic` is `null`.

instance

Signature

```
public static javax.realtime.HeapMemory
instance()
```

Description

Returns a reference to the singleton instance of `HeapMemory` representing the Java heap. The singleton instance of this class shall be allocated in the `ImmortalMemory` area.

Returns

the singleton `HeapMemory` object.

executeInArea(Runnable)

Signature

```
public void
executeInArea(Runnable logic)
```

Description

Executes the run method from the `logic` parameter using heap as the current allocation context. For a schedulable, this saves the current scope stack and replaces it with one consisting only of the `HeapMemory` instance; restoring the original scope stack upon completion.

Parameters

`logic`—The runnable object whose `run()` method should be executed.

Throws

`StaticIllegalArgumentException`—when `logic` is `null`.

`MemoryAccessError`—when caller is a schedulable which may not use the heap.

newArray(Class, int)

Signature

```
public java.lang.Object
newArray(java.lang.Class<?> type,
         int number)
```

Description

Allocates an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of the elements of the new array. To create an array of a primitive type use a `type` such as `Integer.TYPE` (which would call for an array of the primitive int type.)

`number`—The number of elements in the new array.

Throws

`MemoryAccessError`—when caller is a schedulable which may not use the heap.

`StaticIllegalArgumentException`—when `number` is less than zero, `type` is `null`, or `type` is `java.lang.Void.TYPE`.

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

Returns

a new array of class type, of number elements.

newInstance(Class)

Signature

```
public T
newInstance(java.lang.Class<T> type)
throws IllegalAccessException,
       InstantiationException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of which to create a new instance.

Throws

`MemoryAccessError`—when caller is a schedulable which may not use the heap.

`IllegalAccessException`—The class or initializer is inaccessible.

StaticIllegalArgumentException—when `type` is `null`.

ExceptionInInitializerError—when an unexpected exception has occurred in a static initializer.

StaticOutOfMemoryError—when space in the memory area is exhausted.

InstantiationException—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, or it is an array.

Returns

a new instance of class `type`.

newInstance(Constructor, Object)

Signature

```
public T
newInstance(java.lang.reflect.Constructor<T> c,
            java.lang.Object[] args)
throws IllegalAccessException,
       InstantiationException,
       InvocationTargetException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`c`—The constructor for the new instance.

`args`—An array of arguments to pass to the constructor.

Throws

MemoryAccessError—when caller is a schedulable which may not use the heap.

IllegalAccessException—when the class or initializer is inaccessible under Java access control.

InstantiationException—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

StaticOutOfMemoryError—when space in the memory area is exhausted.

StaticIllegalArgumentException—when `c` is `null`, or the `args` array does not contain the number of arguments required by `c`. A `null` value of `args` is treated like an array of length 0.

InvocationTargetException—when the underlying constructor throws an exception.

Returns

a new instance of the object constructed by `c`.

11.3.2.2 ImmortalMemory

public class ImmortalMemory

Inheritance

java.lang.Object
MemoryArea
PerennialMemory
ImmortalMemory

Description

`ImmortalMemory` is a memory resource that is unexceptionally available to all schedulables and Java threads for use and allocation.

An immortal object may not contain references to any form of scoped memory, e.g., `javax.realtime.memory.LTMemory`, `javax.realtime.memory.StackedMemory`, or `javax.realtime.memory.PinnableMemory`.

Objects in immortal memory have the same states with respect to finalization as objects in the standard Java heap, but there is no assurance that immortal objects will be finalized even when the JVM is terminated.

Methods from `ImmortalMemory` should be overridden only by methods that use `super`.

11.3.2.2.1 Methods

---

instance

Signature

```
public static javax.realtime.ImmortalMemory
instance()
```

Description

Returns a pointer to the singleton `ImmortalMemory` object.

Returns

The singleton `ImmortalMemory` object.

executeInArea(Runnable)

Signature

```
public void
executeInArea(Runnable logic)
```

Description

Executes the run method from the `logic` parameter using this memory area as the current allocation context. For a schedulable, this saves the current scope stack and replaces it with one consisting only of the `ImmortalMemory` instance; restoring the original scope stack upon completion.

Parameters

`logic`—The runnable object whose `run()` method should be executed.

Throws

`StaticIllegalArgumentException`—when `logic` is `null`.

11.3.2.3 MemoryArea

---

public abstract class MemoryArea

Inheritance

java.lang.Object
  MemoryArea

Description

`MemoryArea` is the abstract base class of all classes dealing with the representations of allocatable memory areas, including the immortal memory area, physical memory and scoped memory areas. This is an abstract class, but no method in this class is abstract. An application should not subclass `MemoryArea` without complete knowledge of its implementation details.

11.3.2.3.1 Constructors

MemoryArea(long, Runnable)

Signature

```
protected
MemoryArea(long size,
           Runnable logic)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError,
       IllegalAssignmentError
```

Description

Creates an instance of `MemoryArea`.

Parameters

`size`—The size of `MemoryArea` to allocate, in bytes.

`logic`—A runnable, whose `run()` method will be called whenever `enter()` is called. When `logic` is `null`, this constructor is equivalent to `MemoryArea(long size)`.

Throws

`StaticIllegalArgumentException`—when the `size` parameter is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `MemoryArea` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

MemoryArea(SizeEstimator, Runnable)

Signature

```
protected
MemoryArea(SizeEstimator size,
           Runnable logic)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError,
       IllegalAssignmentError
```

Description

Equivalent to `MemoryArea(long, Runnable)` with the argument list `(size.getEstimate(), logic)`.

Parameters

`size`—A `SizeEstimator` object which indicates the amount of memory required by this `MemoryArea`.

`logic`—A runnable, whose `run()` method will be called whenever `enter()` is called. When `logic` is `null`, this constructor is equivalent to `MemoryArea(SizeEstimator size)`.

Throws

`StaticIllegalArgumentException`—when `size` is `null` or `size.getEstimate()` is negative.

`StaticOutOfMemoryError`—when there is insufficient memory for the `MemoryArea` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

MemoryArea(long)

Signature

```
protected
MemoryArea(long size)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError
```

Description

Equivalent to `MemoryArea(long, Runnable)` with the argument list `(size, null)`.

Parameters

`size`—The size of `MemoryArea` to allocate, in bytes.

Throws

`StaticIllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `MemoryArea` object or for its allocation area in its backing store.

MemoryArea(SizeEstimator)

Signature

```
protected
MemoryArea(SizeEstimator size)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError
```

Description

Equivalent to `MemoryArea(long, Runnable)` with the argument list `(size.getEstimate(), null)`.

Parameters

`size`—A `SizeEstimator` object which indicates the amount of memory required by this `MemoryArea`.

Throws

`StaticIllegalArgumentException`—when the `size` parameter is `null`, or `size.getEstimate()` is negative.

`StaticOutOfMemoryError`—when there is insufficient memory for the `MemoryArea` object or for its allocation area in its backing store.

11.3.2.3.2 Methods

---

enter

Signature

```
public void
enter()
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       ThrowBoundaryError,
       MemoryAccessError
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the instance of `Runnable` given in the constructor. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Throws

`IllegalTaskStateException`—when the caller context is not an instance of `Schedulable`.

`StaticIllegalArgumentException`—when the caller is a schedulable and a `null` value for `logic` was supplied when the memory area was constructed.

ThrowBoundaryError—Thrown when the JVM needs to propagate an exception allocated in this scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an IllegalAssignmentError, so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError instance is preallocated by the VM to avoid cascading creation of ThrowBoundaryError.

MemoryAccessError—when caller is a schedulable that may not use the heap and this memory area's logic value is allocated in heap memory.

enter(Runnable)

Signature

```
public void
enter(Runnable logic)
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the run() method of the given Runnable. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using enter, or executeInArea) or the enter method exits.

Parameters

logic—The Runnable object whose run() method should be invoked.

Throws

IllegalTaskStateException—when the caller context is not an instance of Schedulable.

StaticIllegalArgumentException—when the caller is a schedulable and logic is null.

ThrowBoundaryError—Thrown when the JVM needs to propagate an exception allocated in this scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an IllegalAssignmentError, so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError instance is preallocated by the VM to avoid cascading creation of ThrowBoundaryError.

enter(Supplier)

Signature

```
public T
enter(java.util.function.Supplier<T> logic)
```

Description

Same as enter(Runnable) except that the executed method is called get and an object is returned. The Supplier.get() method must ensure that the returned object is allocated outside the area, when the area is not a PerennialMemory.

Parameters
`logic`—The object whose get method will be executed.
Throws
`IllegalAssignmentError`—when the return value allocated in area and area is not a `PerennialMemory`.

Returns
a result from the computation.

Since RTSJ 2.0

enter(BooleanSupplier)

Signature

```
public boolean
enter(BooleanSupplier logic)
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

enter(IntSupplier)

Signature

```
public int
enter(IntSupplier logic)
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

enter(LongSupplier)

Signature

```
public long
enter(LongSupplier logic)
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

enter(DoubleSupplier)

Signature

```
public double
enter(DoubleSupplier logic)
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

getMemoryArea(Object)

Signature

```
public static javax.realtime.MemoryArea
getMemoryArea(Object object)
```

Description

Gets the `MemoryArea` in which the given object is located.

Throws
`StaticIllegalArgumentException`—when the value of `object` is `null`.

Returns
the instance of `MemoryArea` from which `object` was allocated.

memoryConsumed

Signature

```
public long
memoryConsumed()
```

Description

For memory areas where memory is freed under program control this returns an exact count, in bytes, of the memory currently used by the system for the allocated objects. For memory areas (such as heap) where the definition of "used" is imprecise, this returns the best value it can generate in constant time.

Returns
the amount of memory consumed in bytes.

memoryRemaining

Signature

```
public long
memoryRemaining()
```

Description

An approximation of the total amount of memory currently available for future allocated objects, measured in bytes.

Returns
the amount of remaining memory in bytes.

newArray(Class, int)

Signature

```
public java.lang.Object
newArray(java.lang.Class<?> type,
         int number)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError,
       StaticSecurityException
```

Description

Allocates an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters
`type`—The class of the elements of the new array. To create an array of a primitive type use a `type` such as `Integer.TYPE` (which would call for an array of the primitive int type.)

`number`—The number of elements in the new array.

Throws
`StaticIllegalArgumentException`—when `number` is less than zero, `type` is `null`, or `type` is `java.lang.Void.TYPE`.

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

`StaticSecurityException`—when the caller does not have permission to create a new instance.

Returns
a new array of class type, of number elements.

newArrayInArea(Object, Class, int)

Signature

```
public static java.lang.Object
newArrayInArea(Object object,
               java.lang.Class<?> type,
               int size)
```

Description

A helper method to create an array of type `type` in the memory area containing `object`.

Parameters

`object`—is the reference for determining the area in which to allocate the array.

`type`—is the type of the array element for the returned array.

`size`—is the size of the array to return.

Returns

a new array of element `type` with `size` elements.

Since RTSJ 2.0

newInstance(Class)

Signature

```
public T
newInstance(java.lang.Class<T> type)
throws IllegalAccessException,
       StaticIllegalArgumentException,
       InstantiationException,
       StaticOutOfMemoryError,
       ExceptionInInitializerError,
       StaticSecurityException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of which to create a new instance.

Throws

`IllegalAccessException`—The class or initializer is inaccessible.

`StaticIllegalArgumentException`—when `type` is `null`.

`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, or it is an array.

`ConstructorCheckedException`—a checked exception was thrown by the constructor.

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

`ExceptionInInitializerError`—when an unexpected exception has occurred in a static initializer.

`StaticSecurityException`—when the caller does not have permission to create a new instance.

Returns

a new instance of class `type`.

newInstance(Constructor, Object)

Signature

```
public T
newInstance(java.lang.reflect.Constructor<T> c,
            java.lang.Object[] args)
throws ExceptionInInitializerError,
       IllegalAccessException,
       StaticIllegalArgumentException,
       InstantiationException,
       InvocationTargetException,
       StaticOutOfMemoryError,
       StaticSecurityException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`c`—The constructor for the new instance.

`args`—An array of arguments to pass to the constructor.

Throws

`ExceptionInInitializerError`—when an unexpected exception has occurred in a static initializer

`IllegalAccessException`—when the class or initializer is inaccessible under Java access control.

`StaticIllegalArgumentException`—when `c` is `null`, or the `args` array does not contain the number of arguments required by `c`. A `null` value of `args` is treated like an array of length 0.

`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

`InvocationTargetException`—when the underlying constructor throws an exception.

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

`StaticSecurityException`—when the caller does not have permission to create a new instance.

Returns

a new instance of the object constructed by `c`.

size

Signature

```
public long
size()
```

Description

Queries the size of the memory area. The returned value is the current size. Current size may be larger than initial size for those areas that are allowed to grow.

Returns

the size of the memory area in bytes.

executeInArea(Runnable)

Signature

```
public void
executeInArea(Runnable logic)
throws StaticIllegalArgumentException
```

Description

Executes the `run()` method from the `logic` parameter using this memory area as the current allocation context. The effect of `executeInArea` on the scope stack is specified in the subclasses of `MemoryArea`.

Parameters

`logic`—The runnable object whose `run()` method should be executed.

Throws

`StaticIllegalArgumentException`—when `logic` is `null`.

executeInArea(Supplier)

Signature

```
public T
executeInArea(java.util.function.Supplier<T> logic)
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and an object is returned. For a memory are that is not a `PerennialMemory`, care must be taken that the returned value is assignable to an object allocated in the current area.

Parameters

`logic`—The object whose get method will be executed.

Throws

`IllegalAssignmentError`—when the return value is not assignable to an object allocated in the current area.

Returns

a result from the computation.

Since RTSJ 2.0

executeInArea(BooleanSupplier)

Signature

```
public boolean
executeInArea(BooleanSupplier logic)
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

executeInArea(IntSupplier)

Signature

```
public int
executeInArea(IntSupplier logic)
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

executeInArea(LongSupplier)

Signature

```
public long
executeInArea(LongSupplier logic)
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

executeInArea(DoubleSupplier)

Signature

```
public double
executeInArea(DoubleSupplier logic)
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

mayHoldReferenceTo

Signature

```
public boolean
mayHoldReferenceTo()
```

Description

Determines whether an object `A` allocated in the memory area represented by `this` can hold a reference to an object `B` allocated in the current memory area.

Returns

`true` when `B` can be assigned to a field of `A`, otherwise `false`.

Since RTSJ 2.0

mayHoldReferenceTo(Object)

Signature

```
public boolean
mayHoldReferenceTo(Object value)
```

Description

Determines whether an object `A` allocated in the memory area represented by `this` can hold a reference to the object `value`.

Parameters

`value`—The object to test.

Returns

`true` when `value` can be assigned to a field of `A`, otherwise `false`.

Since RTSJ 2.0

11.3.2.4 MemoryParameters

public class MemoryParameters

Inheritance

java.lang.Object
  MemoryParameters

Interfaces

`Cloneable`
`Serializable`

Description

Memory parameters can be given on the constructor of any `Schedulable`. They provide limits on allocation. For garbage-collected objects, they provide the rate of allocation, and for Immortal, the overall amount of allocation.

The limits in a `MemoryParameters` instance are enforced when a schedulable creates a new object, e.g., uses the `new` operation. When a schedulable exceeds its allocation or allocation rate limit, the error is handled as if the allocation failed because of insufficient memory. The failed object allocation throws an `OutOfMemoryError`.

A `MemoryParameters` object may be bound to more than one schedulable, but that does not cause the memory budgets reflected by the parameter to be shared among the schedulables that are associated with the parameter object.

As of RTSJ 2.0, instances of `MemoryParameters` are immutable.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level.

11.3.2.4.1 Fields

UNLIMITED

`public static final long UNLIMITED`

Description

Specifies no maximum limit.

Since RTSJ 2.0

11.3.2.4.2 Constructors

MemoryParameters(long, long, long)

Signature

```
public
MemoryParameters(long maxInitialArea,
                 long maxImmortal,
                 long allocationRate)
throws StaticIllegalArgumentException
```

Description

Creates a `MemoryParameters` object with the given values.

Parameters

`maxInitialArea`—A limit on the amount of memory the schedulable may allocate in its initial scoped memory area. Units are in bytes. When zero, no allocation is allowed in the memory area. When the initial memory area is not a `ScopedMemory`, this parameter has no effect. To specify no limit, use `UNLIMITED`.

`maxImmortal`—A limit on the amount of memory the schedulable may allocate in the immortal area. Units are in bytes. When zero, no allocation is allowed in immortal. To specify no limit, use `UNLIMITED`.

`allocationRate`—A limit on the rate of allocation in the heap. Units are in bytes per second of wall clock time. When `allocationRate` is zero, no allocation is allowed in the heap. To specify no limit, use `UNLIMITED`. Measurement starts when the schedulable is first released for execution; not when it is constructed. Enforcement of the allocation rate is an implementation option. When the implementation does not enforce allocation rate limits, it treats all positive allocation rate limits as `UNLIMITED`.

Throws

`StaticIllegalArgumentException`—when any value less than zero is passed as the value of `maxInitialArea`, `maxImmortal`, or `allocationRate`.

MemoryParameters(long, long)

Signature

```
public
MemoryParameters(long maxInitialArea,
                 long maxImmortal)
```

Description

Creates a `MemoryParameters` object with the given values and `allocationRate` set to `UNLIMITED`. It has the same effect as `MemoryParameters(maxInitialArea, maxImmortal, UNLIMITED)`

MemoryParameters(long)

Signature

```
public
MemoryParameters(long allocationRate)
```

Description

Creates a `MemoryParameters` object with the given values and `allocationRate` set to `allocationRate`. It has the same effect as `MemoryParameters(UNLIMITED, UNLIMITED, allocationRate)`

Since RTSJ 2.0

11.3.2.4.3 Methods

---

clone

Signature

```
public java.lang.Object
clone()
```

Description

Returns a clone of `this`. This method should behave effectively as if it constructed a new object with the visible values of `this`.

- The new object is in the current allocation context.
- `clone` does not copy any associations from `this` and it does not implicitly bind the new object to a SO.

Since RTSJ 1.0.1

getAllocationRate

Signature

```
public long
getAllocationRate()
```

Description

Determines the limit on the rate of allocation in the heap. Units are in bytes per second.

Returns

the allocation rate in bytes per second. When zero, no allocation is allowed in the heap. When the returned value is `UNLIMITED` then the allocation rate on the heap is uncontrolled. Enforcement of allocation rates between zero and `UNLIMITED` is implementation dependent.

getMaxImmortal

Signature

```
public long
getMaxImmortal()
```

Description

Gets the limit on the amount of memory the schedulable may allocate in the immortal area. Units are in bytes.

Returns

the limit on immortal memory allocation. When zero, no allocation is allowed in immortal memory. When the returned value is `UNLIMITED` then there is no limit for allocation in immortal memory.

getMaxInitialArea

Signature

```
public long
getMaxInitialArea()
```

Description

Gets the limit on the amount of memory the schedulable may allocate in its initial memory area, when initial is a scoped memory. Units are in bytes.

Returns

the allocation limit in the schedulable's initial memory area. When zero, no allocation is allowed in the initial memory area. When the returned value is `UNLIMITED` then there is no limit for allocation in the initial memory area.

Since RTSJ 2.0

11.3.2.5 PerennialMemory

---

public abstract class PerennialMemory

Inheritance

java.lang.Object
  MemoryArea
    PerennialMemory

Description

A base class for all memory areas whose contents can be unexceptionally referenced. In other words, any memory area can store a reference to an object stored in one of these areas. This includes all concrete memory areas in the core package. Only memory areas of this type can be a root for a scoped memory.

Since RTSJ 2.0

11.3.2.6 SizeEstimator

---

public class SizeEstimator

Inheritance

java.lang.Object
  SizeEstimator

Description

This class maintains an estimate of the amount of memory required to store a set of objects.

`SizeEstimator` is a floor on the amount of memory that should be allocated. Many objects allocate other objects when they are constructed. `SizeEstimator` only estimates the memory requirement of the object itself, it does not include memory required for any objects allocated at construction time. When the instance itself is allocated in several parts (when for instance the object and its monitor are separate), the size estimate shall include the sum of the sizes of all the parts that are allocated from the same memory area as the instance. Alignment considerations, and possibly other order-dependent issues may cause the allocator to leave a small amount of unusable space, consequently the size estimate cannot be seen as more than a close estimate.

See Section MemoryArea.MemoryArea(SizeEstimator)

11.3.2.6.1 Constructors

SizeEstimator

Signature

```
public
SizeEstimator()
```

Description

Create an empty size estimator.

11.3.2.6.2 Methods

---

reserve(Class, int)

Signature

```
public void
reserve(java.lang.Class<?> c,
        int number)
```

Description

Takes into account additional `number` instances of Class `c` when estimating the size of the `MemoryArea`.

Parameters

`c`—The class to take into account.

`number`—The number of instances of `c` to estimate.

Throws

`StaticIllegalArgumentException`—when `c` is `null` or `number` is negative.

Since RTSJ 2.0 throws `StaticIllegalArgumentException` also when `number` is less than zero.

reserve(SizeEstimator, int)

Signature

```
public void
reserve(SizeEstimator estimator,
        int number)
```

Description

Takes into account additional `number` of the estimations from instances of SizeEstimator `size` when estimating the size of the `MemoryArea`.

Parameters

`estimator`—The given instance of `SizeEstimator`.

`number`—The number of times to reserve the size denoted by `estimator`.

Throws

`StaticIllegalArgumentException`—when `estimator` is `null` or `number` is less than zero.

Since RTSJ 2.0 throws `StaticIllegalArgumentException` also when `number` is less than zero.

reserve(SizeEstimator)

Signature

```
public void
reserve(SizeEstimator size)
```

Description

Takes into account an additional estimation from the instance of SizeEstimator `size` when estimating the size of the `MemoryArea`.

Parameters

`size`—The given instance of `SizeEstimator`.

Throws

`StaticIllegalArgumentException`—when `size` is `null`.

reserveArray(int)

Signature

```
public void
reserveArray(int length)
```

Description

Takes into account an additional instance of an array of `length` reference values when estimating the size of the `MemoryArea`.

Parameters

`length`—The number of entries in the array.

Throws

`StaticIllegalArgumentException`—when `length` is negative.

Since RTSJ 1.0.1

reserveArray(int, Class)

Signature

```
public void
reserveArray(int length,
             java.lang.Class<?> type)
```

Description

Takes into account an additional instance of an array of `length` primitive values when estimating the size of the `MemoryArea`.

Class values for the primitive types are available from the corresponding class types; e.g., Byte.TYPE, Integer.TYPE, and Short.TYPE.

Parameters

`length`—The number of entries in the array.

`type`—The class representing a primitive type. The reservation will leave room for an array of `length` of the primitive type corresponding to `type`.

Throws

`StaticIllegalArgumentException`—when `length` is negative, or `type` does not represent a primitive type.

Since RTSJ 1.0.1

reserveLambda(EnclosedType, EnclosedType, EnclosedType)

Signature

```
public void
reserveLambda(EnclosedType first,
              EnclosedType second,
              EnclosedType[] others)
```

Description

Determines the size of a lambda with more than two variables in its closure and add it to this size estimator.

Parameters
`first`—Type of first variable in closure.
`second`—Type of second variable in closure.
`others`—Types of additional variables in closure.
Since RTSJ 2.0

reserveLambda(EnclosedType, EnclosedType)

Signature

```
public void
reserveLambda(EnclosedType first,
              EnclosedType second)
```

Description

Determines the size of a lambda with two variables in its closure and add it to this size estimator.

Parameters
`first`—Type of first variable in closure.
`second`—Type of second variable in closure.
Since RTSJ 2.0

reserveLambda(EnclosedType)

Signature

```
public void
reserveLambda(EnclosedType first)
```

Description

Determines the size of a lambda with one variable in its closure and add it to this size estimator.

Parameters
`first`—Type of first variable in closure.
Since RTSJ 2.0

reserveLambda

Signature

```
public void
reserveLambda()
```

Description

Determines the size of a lambda with no closure and add it to this size estimator.

Since RTSJ 2.0

getEstimate

Signature

```
public long
getEstimate()
```

Description

Gets an estimate of the number of bytes needed to store all the objects reserved.

Returns

the estimated size in bytes.

clear

Signature

```
public void
clear()
```

Description

Restores the estimate value to zero for reuse.

Since rtsj 2.0

11.4 javax.realtime.memory

11.4.1 Annotations

11.4.1.1 ClassAllocation

---

public abstract class ClassAllocation

Interfaces
java.lang.annotation.Annotation

Description

An annotation to mark the memory area to use for class allocation and initialization for a package.

11.4.2 Interfaces

11.4.2.1 PhysicalMemoryCharacteristic

---

public interface PhysicalMemoryCharacteristic

Description

A tagging interface used to identify physical memory characteristics. Applications can give names to regions of memory that are described by `PhysicalMemoryRegion`. The names are defined by creating instances of this interface. For example, final static PhysicalMemoryCharacteristic STATIC_RAM = ...;

Since RTSJ 2.0

11.4.3 Enumerations

11.4.3.1 MemoryAreaType

---

public enum MemoryAreaType

Inheritance
java.lang.Object
  java.lang.Enum<MemoryAreaType>
    MemoryAreaType

11.4.3.1.1 Enumeration Constants

NONE
```
public static final MemoryAreaType NONE
```

HEAP
```
public static final MemoryAreaType HEAP
```

IMMORTAL
```
public static final MemoryAreaType IMMORTAL
```

PERENNIAL
```
public static final MemoryAreaType PERENNIAL
```

SCOPED
```
public static final MemoryAreaType SCOPED
```

ANY
```
public static final MemoryAreaType ANY
```

11.4.3.1.2 Methods

---

values

Signature

```
public static javax.realtime.memory.MemoryAreaType[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.memory.MemoryAreaType
valueOf(String name)
```

Description

get(int)

Signature

```
public javax.realtime.memory.MemoryAreaType
get(int key)
```

11.4.3.2 PhysicalMemorySelector.CachingBehavior

---

public enum PhysicalMemorySelector.CachingBehavior

Inheritance

java.lang.Object
  java.lang.Enum<PhysicalMemorySelector.CachingBehavior>
    PhysicalMemorySelector.CachingBehavior

Description

Marker for standard caching behaviors. Not all need be supported. For example, a VM running in Kernel mode might only support DISABLED.

11.4.3.2.1 Enumeration Constants

DISABLED

```
public static final PhysicalMemorySelector.CachingBehavior DISABLED
```

Description

Represents direct mapping, i.e., caching disabled or not present.

WRITE_THROUGH

```
public static final PhysicalMemorySelector.CachingBehavior
    WRITE_THROUGH
```

Description

Represents caching where writes are immediately written to cache and memory.

WRITE_BACK

```
public static final PhysicalMemorySelector.CachingBehavior
    WRITE_BACK
```

Description

Represents caching where writes are immediately written to cache, but the write to memory is delayed, such as until the cache line is flushed.

11.4.3.2.2 Methods

values

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.CachingBehavior[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.CachingBehavior
valueOf(String name)
```

Description

11.4.3.3 PhysicalMemorySelector.PagingBehavior

public enum PhysicalMemorySelector.PagingBehavior

Inheritance

java.lang.Object
  java.lang.Enum<PhysicalMemorySelector.PagingBehavior>
    PhysicalMemorySelector.PagingBehavior

Description

Marker for standard paging behaviors. Not all need be supported. For example, a VM running in Kernel mode might only support `DIRECT`.

11.4.3.3.1 Enumeration Constants

DIRECT

```
public static final PhysicalMemorySelector.PagingBehavior DIRECT
```

Description

Represents when the page is always mapped with the same virtual address as its physical address.

FIXED

```
public static final PhysicalMemorySelector.PagingBehavior FIXED
```

Description

Represents when the page stays resident in memory, so the mapping does not change.

SWAPPABLE

```
public static final PhysicalMemorySelector.PagingBehavior SWAPPABLE
```

Description

Represents when the page may be swapped to disk; hence the mapping may change and encounter delay when accessed while swapped out.

11.4.3.3.2 Methods

values

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.PagingBehavior[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.PagingBehavior
valueOf(String name)
```

Description

11.4.4 Classes

11.4.4.1 LTMemory

public class LTMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea

ScopedMemory
LTMemory

Description

`LTMemory` represents a memory area guaranteed by the system to have linear time allocation when memory consumption from the memory area is less than the memory area's *size*.

The memory area described by a `LTMemory` instance does not exist in the Java heap, and is not subject to garbage collection. Thus, it is safe to use a `LTMemory` object as the initial memory area for a `javax.realtime.Schedulable` instance which may not use the `javax.realtime.HeapMemory` or to enter the memory area using the `ScopedMemory.enter` method within such an instance.

Enough memory must be committed by the completion of the constructor to satisfy the memory requirement given in the constructor. Committed means that this memory must always be available for allocation. The memory allocation must behave, with respect to successful allocation, as if it were contiguous; i.e., a correct implementation must guarantee that any sequence of object allocations that could ever succeed without exceeding a specified initial memory size will always succeed without exceeding that initial memory size and succeed for any instance of `LTMemory` with that initial memory size.

Creation of an `LTMemory` shall fail with a `javax.realtime.StaticOutOfMemoryError` when the current `javax.realtime.Schedulable` has been configured with a `ScopedMemoryParameters.getMaxGlobalBackingStore` that would be exceeded by said creation.

Methods from `LTMemory` should be overridden only by methods that use `super`.

See Section javax.realtime.MemoryArea
See Section ScopedMemory
See Section javax.realtime.Schedulable
Since RTSJ 2.0 moved to this package.

11.4.4.1.1 Constructors

LTMemory(long, Runnable)

Signature

```
public
LTMemory(long size,
         Runnable logic)
```

Description

Create a scoped memory of the given size and with the give logic to run upon entry when no other logic is given.

Since RTSJ 1.0.1
Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(long)`.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

`javax.realtime.IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(SizeEstimator, Runnable)

Signature

```
public
LTMemory(SizeEstimator size,
         Runnable logic)
```

Description

Equivalent to `LTMemory(long, Runnable)` with argument list `(size.getEstimate(), runnable)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `javax.realtime.SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(SizeEstimator)`.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is `null`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

`javax.realtime.IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(long)

Signature

```
public
LTMemory(long size)
```

Description

Equivalent to `LTMemory(long, Runnable)` with the argument list (`(size, null)`.

Since RTSJ 1.0.1

Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

LTMemory(SizeEstimator)

Signature

```
public
LTMemory(SizeEstimator size)
```

Description

Equivalent to `LTMemory(long, Runnable)` with argument list `(size.getEstimate(), null)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `javax.realtime.SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is `null`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object, or when the current `Schedulable` would exceed its configured allowance of global backing store.

11.4.4.2 PhysicalMemoryFactory

---

public class PhysicalMemoryFactory

Inheritance

java.lang.Object
PhysicalMemoryFactory

Description

A physical memory representation of memory ranges, in the form of `PhysicalMemoryRegion` instances with physical memory characteristics in the form of `PhysicalMemoryCharacteristic` instances for creating memory areas in those ranges.

Each physical memory module can have one or more physical memory characteristic. A physical memory characteristic can apply to many physical memory modules. The range of physical addresses of modules shall not overlap. A memory that spans more than one physical memory module may not be created.

The `PhysicalMemoryFactory` determines the physical addresses from the modules and keeps a relation between instances of `PhysicalMemoryRegion` and Physical Memory Addresses. The range of physical addresses of modules shall not overlap. A created memory area may not span more than one physical memory module. To find a memory range that supports PMC A and PMC B, it uses set intersection modules(A) ∩ modules(B)

Since RTSJ 2.0

11.4.4.2.1 Constructors

PhysicalMemoryFactory

Signature

```
public
PhysicalMemoryFactory()
```

Description

Creates an empty factory, but when only one factory is required, uses `getDefault` instead.

11.4.4.2.2 Methods

---

getDefault

Signature

```
public static javax.realtime.memory.PhysicalMemoryFactory
getDefault()
```

Description

Obtains the default physical memory factory.

Returns
the default factory.

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

```
public void
associate(PhysicalMemoryCharacteristic name,
          PhysicalMemoryRegion module)
throws StaticIllegalArgumentException,
       RangeOutOfBoundsException
```

Description

Associates a programmer-defined name with a physical address range.

Parameters
`name`—The physical memory characteristic. e.g STATIC_RAM.
`module`—The object representing a range of contiguous physical addresses.
Throws
`javax.realtime.StaticIllegalArgumentException`—when either name or module is null.
`RangeOutOfBoundsException`—when `module` overlaps a previously associated `PhysicalMemoryRegion` instance or cannot be mapped as Java object storage.

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

```
public void
associate(PhysicalMemoryCharacteristic[] names,
          PhysicalMemoryRegion module)
throws StaticIllegalArgumentException,
       RangeOutOfBoundsException
```

Description

Associates an array of programmer-defined names with a physical address range.

Parameters
`names`—The array of physical memory characteristics. e.g { STATIC_RAM }.
`module`—The object representing a range of contiguous physical addresses.
Throws
`javax.realtime.StaticIllegalArgumentException`—when either names or module is null.
`RangeOutOfBoundsException`—when `module` overlaps a previously associated `PhysicalMemoryRegion` instance or cannot be mapped as Java object storage.

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

```
public static void
associate(PhysicalMemoryCharacteristic name,
          PhysicalMemoryRegion[] modules)
throws StaticIllegalArgumentException,
       RangeOutOfBoundsException
```

Description

Associates a programmer-defined name with an array of physical address ranges.

Parameters

`name`—is the physical memory characteristic. e.g STATIC_RAM.

`modules`—is an array of objects each representing a range of contiguous physical addresses.

Throws

`javax.realtime.StaticIllegalArgumentException`—when either name or modules is null.

`RangeOutOfBoundsException`—when `module` overlaps a previously associated `PhysicalMemoryRegion` instance or cannot be mapped as Java object storage.

createImmortalMemory(PhysicalMemorySelector, long, Runnable)

Signature

```
public javax.realtime.ImmortalMemory
createImmortalMemory(PhysicalMemorySelector selector,
                     long size,
                     Runnable logic)
throws StaticSecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       StaticIllegalArgumentException
```

Description

Instantiates a `javax.realtime.ImmortalMemory` object in a `PhysicalMemoryRegion`, where the memory type matches the `PhysicalMemoryCharacteristic` instances in `selector` and the virtual memory parameters of `selector` are applied.

Parameters

`selector`—Used to choose the memory module and set the virtual mapping.

`size`—The size of memory to be taken out of the selected module.

`logic`—The default logic to execute on entry (may be `null`).

Throws

StaticSecurityException—when the application does not have permission to access physical memory or the given range of memory.

javax.realtime.SizeOutOfBoundsException—when the implementation detects that `size` extends beyond a physically addressable memory module.

javax.realtime.UnsupportedPhysicalMemoryException—when the underlying hardware does not support the given type, or when no matching PhysicalMemoryCharacteristic has been registered with this `PhysicalMemoryFactory`.

MemoryTypeConflictException—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

javax.realtime.StaticIllegalArgumentException—when `size` is less than zero.

Returns

the new memory area

createLTMemory(PhysicalMemorySelector, long, Runnable)

Signature

```
public javax.realtime.memory.PinnableMemory
createLTMemory(PhysicalMemorySelector selector,
               long size,
               Runnable logic)
throws StaticSecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       StaticIllegalArgumentException
```

Description

Instantiates a LTMemory object in a PhysicalMemoryRegion, matching the PhysicalMemoryCharacteristic in `selector` with virtual memory parameters of `selector` applied.

Parameters

`selector`—Used to choose the memory module and set the virtual mapping.

`size`—The size of memory to be taken out of the selected module.

`logic`—The default logic to execute on entry (may be `null`).

Throws

StaticSecurityException—when the application does not have permission to access physical memory or the given range of memory.

javax.realtime.SizeOutOfBoundsException—when the implementation detects that `size` extends beyond a physically addressable memory module.

javax.realtime.UnsupportedPhysicalMemoryException—when the underlying hardware does not support the given type, or when no matching PhysicalMemoryCharacteristic has been registered with this `PhysicalMemoryFactory`.

MemoryTypeConflictException—when the specified base does not point to memory that matches the requested type, or when type specifies incompatible memory attributes.

javax.realtime.StaticIllegalArgumentException—when size is less than zero.

Returns
the new memory area

createPinnableMemory(PhysicalMemorySelector, long, Runnable)

Signature

```
public javax.realtime.memory.PinnableMemory
createPinnableMemory(PhysicalMemorySelector selector,
                     long size,
                     Runnable logic)
throws StaticSecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       StaticIllegalArgumentException
```

Description

Instantiates a PinnableMemory object in a PhysicalMemoryRegion, matching the PhysicalMemoryCharacteristic in selector with virtual memory parameters of selector applied.

Parameters

selector—Used to choose the memory module and set the virtual mapping.

size—The size of memory to be taken out of the selected module.

logic—The default logic to execute on entry (may be null).

Throws

StaticSecurityException—when the application does not have permissions to access physical memory or the given range of memory.

javax.realtime.SizeOutOfBoundsException—when the implementation detects that size extends beyond a physically addressable memory module.

javax.realtime.UnsupportedPhysicalMemoryException—when the underlying hardware does not support the given type, or when no matching PhysicalMemoryCharacteristic has been registered with this PhysicalMemoryFactory.

MemoryTypeConflictException—when the specified base does not point to memory that matches the requested type, or when type specifies incompatible memory attributes.

javax.realtime.StaticIllegalArgumentException—when size is less than zero.

Returns

the new memory area

createStackedMemory(PhysicalMemorySelector, long, long, Runnable)

Signature

```
public javax.realtime.memory.StackedMemory
createStackedMemory(PhysicalMemorySelector selector,
                    long scopeSize,
                    long backingSize,
                    Runnable logic)
throws StaticSecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       StaticIllegalArgumentException
```

Description

Instantiates a `StackedMemory` object in a `PhysicalMemoryRegion`, matching the `PhysicalMemoryCharacteristic` in `selector` with virtual memory parameters of `selector` applied.

Parameters

`selector`—Used to choose the memory module and set the virtual mapping.

`scopeSize`—The size of the scope to be created.

`backingSize`—The size of the backing store to take out of the selected module.

`logic`—The default logic to execute on entry (may be `null`).

Throws

`StaticSecurityException`—when the application does not have permissions to access physical memory or the given range of memory.

`javax.realtime.SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond a physically addressable memory module.

`javax.realtime.UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryCharacteristic` has been registered with this `PhysicalMemoryFactory`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`javax.realtime.StaticIllegalArgumentException`—when `scopeSize` or `backingSize` is less than zero.

Returns

the new memory area

11.4.4.3 PhysicalMemoryRegion

public class PhysicalMemoryRegion

Inheritance
java.lang.Object
PhysicalMemoryRegion

Description

Enables an application to define a range of physical memory addresses.

Since RTSJ 2.0

11.4.4.3.1 Constructors

PhysicalMemoryRegion(long, long)

Signature

```
public
PhysicalMemoryRegion(long base,
                     long length)
```

Description

Creates an instance representing a range of contiguous physical memory.

Parameters
`base`—A physical address.
`length`—The size of contiguous memory from that base.
Throws
`javax.realtime.StaticIllegalArgumentException`—when length is less than or equal to zero, or when base is less than zero or when this module overlaps with another memory module.
`javax.realtime.SizeOutOfBoundsException`—when base + length is greater than the physical address range of the processor.

11.4.4.3.2 Methods

getBase

Signature

```
public long
getBase()
```

Description

Gets the base address of the contiguous memory represented by this.

Returns
the base address

getLength

Signature

```
public long
getLength()
```

Description

Gets the length of the contiguous memory represented by this.

Returns
the length

11.4.4.4 PhysicalMemorySelector

---

public class PhysicalMemorySelector

Inheritance
java.lang.Object
PhysicalMemorySelector

Description

Provides characteristics both for physical memory, used to select a memory range from a memory module, and for virtual memory to be used for setting the characteristics of the mapped pages.

Since RTSJ 2.0

11.4.4.4.1 Constructors

PhysicalMemorySelector(PhysicalMemoryCharacteristic, PhysicalMemoryCharacteristic, CachingBehavior, PagingBehavior)

Signature

```
public
PhysicalMemorySelector(PhysicalMemoryCharacteristic[] request,
                       PhysicalMemoryCharacteristic[] reject,
                       PhysicalMemorySelector.CachingBehavior caching,
                       PhysicalMemorySelector.PagingBehavior paging)
```

Description

Creates a selector object for obtaining physical memory objects. The arguments are used to select the desired memory type.

Parameters

`request`—characteristics that are required

`reject`—characteristics that should apply to the object

`caching`—the required caching behavior

`paging`—the required paging behavior

11.4.4.4.2 Methods

---

getSupportedCachingBehavior

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.CachingBehavior[]
getSupportedCachingBehavior()
```

Description

Gets the caching behaviors that are supported by this JVM

Returns

an array of the supported caching behaviors.

getSupportedPagingBehavior

Signature

```
public static javax.realtime.memory.PhysicalMemorySelector.PagingBehavior[]
getSupportedPagingBehavior()
```

Description

Gets the paging behaviors that are supported by this JVM

Returns

an array of the supported paging behaviors.

getRequestSet

Signature

```
public javax.realtime.memory.PhysicalMemoryCharacteristic[]
getRequestSet()
```

Description

A getter for the `PhysicalMemoryCharacteristic` list to be requested

Returns

the `PhysicalMemoryCharacteristic` list

getRejectSet

Signature

```
public javax.realtime.memory.PhysicalMemoryCharacteristic[]
getRejectSet()
```

Description

A getter for the `PhysicalMemoryCharacteristic` list to be excluded

Returns

the `PysicalMemoryCharacteristic` list

getCachingBehavior

Signature

```
public javax.realtime.memory.PhysicalMemorySelector.CachingBehavior
getCachingBehavior()
```

Description

A getter for the `CachingBehavior` to be requested

Returns

the `CachingBehavior`

getPagingBehavior

Signature

```
public javax.realtime.memory.PhysicalMemorySelector.PagingBehavior
getPagingBehavior()
```

Description

A getter for the `PagingBehavior` to be requested

Returns

the `PagingBehavior`

11.4.4.5 PinnableMemory

---

public class PinnableMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    ScopedMemory
      PinnableMemory

Description

This class is for passing information between different threads as in the producer consumer pattern. One thread can enter an empty `PinnableMemory`, allocate some data structure, put a reference in the portal, pin the scope, exit it, and then pass it to another thread for further processing or consumption. Once the last thread is done, the memory can be unpinned, causing its contents to be freed.

Creation of a `PinnableMemory` shall fail with a `javax.realtime.StaticOutOfMemoryError` when the current `javax.realtime.Schedulable` has been configured with a `ScopedMemoryParameters.getMaxGlobalBackingStore` that would be exceeded by said creation.

Since RTSJ 2.0

11.4.4.5.1 Constructors

PinnableMemory(long)

Signature

```
public
PinnableMemory(long size)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError
```

Description

Creates a scoped memory of fixed size that can be held open when no `javax.realtime.Schedulable` has it on its scoped memory stack.

Parameters

`size`—The number of bytes in the memory area.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `PinnalbeMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

PinnableMemory(long, Runnable)

Signature

```
public
PinnableMemory(long size,
               Runnable logic)
```

Description

Creates a scoped memory of fixed size that can be held open when no `javax.realtime.Schedulable` has it on its scoped memory stack.

Parameters

`size`—The number of bytes in the memory area.

`logic`—The logic to execute when none is provide at enter.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `PinnalbeMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

PinnableMemory(SizeEstimator)

Signature

```
public
PinnableMemory(SizeEstimator size)
throws StaticIllegalArgumentException,
       StaticOutOfMemoryError
```

Description

Equivalent to `PinnableMemory(long)` with `size.getEstimate()` as its argument.

Parameters

`size`—An estimator for determining the number of bytes in the memory area.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `size` is `null`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory for the `PinnalbeMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

PinnableMemory(SizeEstimator, Runnable)

Signature

```
public
PinnableMemory(SizeEstimator size,
               Runnable logic)
```

Description

Equivalent to `PinnableMemory(long, Runnable)` with `size.getEstimate()` as its first argument.

Parameters

`size`—An estimator for determining the number of bytes in the memory area.

`logic`—The logic to execute when none is provide at enter.

Throws

javax.realtime.StaticIllegalArgumentException—when `size` is `null`.

javax.realtime.StaticOutOfMemoryError—when there is insufficient memory for the `PinnalbeMemory` object or for its allocation area in its backing store, or when the current `Schedulable` would exceed its configured allowance of global backing store.

11.4.4.5.2 Methods

---

pin

Signature

```
public void
pin()
throws StaticIllegalStateException
```

Description

Prevents the contents from being freed.

Throws

StaticIllegalStateException—when the current allocation context is not `this` allocation context.

unpin

Signature

```
public void
unpin()
throws StaticIllegalStateException
```

Description

Allows the contents to be freed once no javax.realtime.Schedulable is active within the scope. The `unpin` method must be called as many times as pin to take effect. If there is no task in the area when the call takes affect, then the object in the area are reclaimed immediately, in the caller's context.

Throws

javax.realtime.StaticIllegalStateException—when schedulable does not have `this` memory area as its current memory area.

isPinned

Signature

```
public boolean
isPinned()
```

Description

Determines whether the scope may be cleared on last exit.

Returns
true when yes, otherwise false.

getPinCount

Signature

```
public int
getPinCount()
```

Description

Finds out how many times the scope has been pinned, but not unpinned.

Returns
the number of outstanding pins.

joinPinned

Signature

```
public void
joinPinned()
throws InterruptedException
```

Description

Same as `ScopedMemory.join()` except that the area may be pinned so the memory may not have been cleared.

Throws
`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

joinPinned(HighResolutionTime)

Signature

```
public void
joinPinned(javax.realtime.HighResolutionTime<?> limit)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `ScopedMemory.join(HighResolutionTime)` except that the area may be pinned so the memory may not have been cleared.

Parameters
`limit`—The maximum time to wait.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

joinAndEnterPinned

Signature

```
public void
joinAndEnterPinned()
throws InterruptedException,
       ScopedCycleException,
       IllegalTaskStateException,
       MemoryAccessError
```

Description

Same as `ScopedMemory.joinAndEnter()` except that the area may be pinned so the memory may not have been cleared.

Throws

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the instance of `Schedulable` that triggered finalization. This would include the scope containing the instance of `Schedulable`, and the scope (if any) containing the scope containing the instance of `Schedulable`.

`MemoryAccessError`—when calling schedulable may not use the heap and this memory area's `logic` value is allocated in heap memory.

joinAndEnterPinned(Runnable)

Signature

```
public void
joinAndEnterPinned(Runnable logic)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `ScopedMemory.joinAndEnter(Runnable)` except that the area may be pinned so the memory may not have been cleared.

Parameters

`logic`—the code to be executed in this memory area.

Throws

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`StaticIllegalArgumentException`—when `logic` is `null`.

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the instance of `Schedulable` that triggered finalization. This would include the scope containing the instance of `Schedulable`, and the scope (if any) containing the scope containing the instance of `Schedulable`.

`MemoryAccessError`—when calling schedulable may not use the heap and this memory area's `logic` value is allocated in heap memory.

joinAndEnterPinned(Supplier)

Signature

```
public T
joinAndEnterPinned(java.util.function.Supplier<T> logic)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable)` except that the executed method is called `get` and an object is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(BooleanSupplier)

Signature

```
public boolean
joinAndEnterPinned(BooleanSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(IntSupplier)

Signature

```
public int
joinAndEnterPinned(IntSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(LongSupplier)

Signature

```
public long
joinAndEnterPinned(LongSupplier logic)
```

```
    throws InterruptedException,
           IllegalTaskStateException,
           StaticIllegalArgumentException,
           StaticUnsupportedOperationException,
           ScopedCycleException,
           MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnterPinned(DoubleSupplier)

Signature

```
public double
joinAndEnterPinned(DoubleSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(HighResolutionTime)

Signature

```
public void
joinAndEnterPinned(javax.realtime.HighResolutionTime<?> limit)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
```

```
        MemoryAccessError
```

Description

Same as `ScopedMemory.joinAndEnter(HighResolutionTime)` except that pinning is ignored so the memory may not have been cleared.

Parameters

`limit`—The maximum time to wait.

Throws

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the instance of `Schedulable` that triggered finalization. This would include the scope containing the instance of `Schedulable`, and the scope (if any) containing the scope containing the instance of `Schedulable`.

`javax.realtime.StaticIllegalArgumentException`—when the caller is a schedulable, and `time` is `null` or no non-null `logic` value was supplied to the memory area's constructor.

`MemoryAccessError`—when calling schedulable may not use the heap and this memory area's `logic` value is allocated in heap memory.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

joinAndEnterPinned(Runnable, HighResolutionTime)

Signature

```
public void
joinAndEnterPinned(Runnable logic,
                   javax.realtime.HighResolutionTime<?> limit)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `ScopedMemory.joinAndEnter(Runnable, HighResolutionTime)` except that pinning is ignored so the memory may not have been cleared.

Parameters

`logic`—The logic to execute upon entry.

`limit`—The maximum time to wait.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`IllegalTaskStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the instance of `Schedulable` that triggered finalization. This would include the scope containing the instance of `Schedulable`, and the scope (if any) containing the scope containing the instance of `Schedulable`.

`javax.realtime.StaticIllegalArgumentException`—when the caller is a schedulable, and `time` is `null` or no non-null `logic` value was supplied to the memory area's constructor.

`MemoryAccessError`—when calling schedulable may not use the heap and this memory area's `logic` value is allocated in heap memory.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

joinAndEnterPinned(Supplier, HighResolutionTime)

Signature

```
public P
joinAndEnterPinned(java.util.function.Supplier<P> logic,
                   javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable, HighResolutionTime)` except that the executed method is called `get` and an object is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(BooleanSupplier, HighResolutionTime)

Signature

```
public boolean
joinAndEnterPinned(BooleanSupplier logic,
                   javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `boolean` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(IntSupplier, HighResolutionTime)

Signature

```
public int
joinAndEnterPinned(IntSupplier logic,
                   javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable, HighResolutionTime)` except that the executed method is called `get` and an `int` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(LongSupplier, HighResolutionTime)

Signature

```
public long
joinAndEnterPinned(LongSupplier logic,
                   javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `long` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

joinAndEnterPinned(DoubleSupplier, HighResolutionTime)

Signature

```
public double
joinAndEnterPinned(DoubleSupplier logic,
                   javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       ScopedCycleException,
       MemoryAccessError
```

Description

Same as `joinAndEnterPinned(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

11.4.4.6 ScopedConfigurationParameters

public class ScopedConfigurationParameters

Inheritance

java.lang.Object
javax.realtime.ConfigurationParameters
ScopedConfigurationParameters

Description

This is the same as `javax.realtime.ConfigurationParameters` except an instance of `javax.realtime.BoundSchedulable` that uses this parameters object may not access the heap and one that uses the super type may.

11.4.4.6.1 Constructors

ScopedConfigurationParameters(int, int, int, int, int, long)

Signature

```
public
ScopedConfigurationParameters(int messageLength,
                              int stackTraceDepth,
                              int classNameLength,
                              int methodNameLength,
                              int fileNameLength,
                              long[] sizes)
throws StaticIllegalStateException
```

Description

Similar to `javax.realtime.ConfigurationParameters.ConfigurationParameters(int, int, int, int, int, long[])`, except the receiver may not use the heap.

Throws

`StaticIllegalStateException`—when the current memory context is a heap memory.

11.4.4.6.2 Methods

setDefault(ScopedConfigurationParameters)

Signature

```
public static synchronized void
setDefault(ScopedConfigurationParameters config)
```

Description

Set the parameters object to be used when none is provided for an instance of `javax.realtime.Schedulable`. Setting to `null` restores the default values.

Parameters

`config`—the new default parameter object.

Throws

`StaticIllegalArgumentException`—when `config` is not allocated in immortal memory or its configuration parameters are not `ScopedConfigurationParameters`.

getDefault

Signature

```
public static synchronized javax.realtime.memory.ScopedConfigurationParameters
getDefault()
```

Description

Set the parameters object to be used when none is provided for an instance of `javax.realtime.Schedulable`.

Returns

the default parameter object.

setDefaultRunner(ReleaseRunner)

Signature

```
public static synchronized void
setDefaultRunner(ReleaseRunner runner)
throws StaticIllegalArgumentException
```

Description

Sets the system default release runner.

Parameters

`runner`—The runner to be used when none is set. When `null`, the default release runner is set to the original system default.

Throws

`StaticIllegalArgumentException`—when `runner` is not allocated in immortal memory or its configuration parameters are not `ScopedConfigurationParameters`.

getDefaultRunner

Signature

```
public synchronized javax.realtime.ReleaseRunner
getDefaultRunner()
```

Description

Gets the system default release runner.

Returns

a general runner to be used when none is set.

mayUseHeap

Signature

```
public boolean
mayUseHeap()
```

Description

Returns

`true` only when this configuration may allocate on the heap and may enter the `Heap`.

11.4.4.7 ScopedMemory

---

public abstract class ScopedMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    ScopedMemory

Description

`ScopedMemory` is the abstract base class of all classes dealing with representations of memory spaces which have a limited lifetime. In general, objects allocated in scoped memory are freed when, and only when, no schedulable has access to the objects in the scoped memory.

A `ScopedMemory` area is a connection to a particular region of memory and reflects the current status of that memory. The object does not necessarily contain direct references to the region of memory. That is implementation dependent.

When a `ScopedMemory` area is instantiated, the object itself is allocated from the current memory allocation context, but the memory space that object represents (its backing store) is allocated from memory that is not otherwise directly visible to Java code; e.g., it might be allocated with the C `malloc` function. This backing store behaves effectively as if it were allocated when the

associated scoped memory object is constructed and freed at that scoped memory object's finalization.

The `ScopedMemory.enter` method of `ScopedMemory` is one mechanism used to make a memory area the current allocation context. The other mechanism for activating a memory area is making it the initial memory area for a realtime thread or async event handler. Entry into the scope is accomplished, for example, by calling the method:

```
public void enter(Runnable logic)
```

where `logic` is an instance of `Runnable` whose `run()` method represents the entry point of the code that will run in the new scope. Exit from the scope occurs between the time the `runnable.run()` method completes and the time control returns from the `enter` method. By default, allocations of objects within `runnable.run()` are taken from the backing store of the `ScopedMemory`.

`ScopedMemory` is an abstract class, but all specified methods include implementations. The responsibilities of `MemoryArea, ScopedMemory` and the classes that extend `ScopedMemory` are not specified. Application code should not extend `ScopedMemory` without detailed knowledge of its implementation. since RTSJ 2.0, moved from `javax.realtime`.

11.4.4.7.1 Methods

---

globalBackingStoreSize

Signature

```
public static long
globalBackingStoreSize()
```

Description

Determines the total amount of memory in the global backing store.

Returns

the total amount of global backing store in bytes.

Since RTSJ 2.0

globalBackingStoreRemaining

Signature

```
public static long
globalBackingStoreRemaining()
```

Description

Determines the amount of memory remaining for allocation to new scoped memories in the backing store of this scoped memory.

Returns
the amount of global backing store remaing in bytes.

Since RTSJ 2.0

globalBackingStoreConsumed

Signature

```
public static long
globalBackingStoreConsumed()
```

Description

Determines the amount of memory consumed by exisiting scoped memories from the global backing store.

Returns
the amount of backing store available in bytes.

Since RTSJ 2.0

visitScopeRoots(Consumer)

Signature

```
public static void
visitScopeRoots(java.util.function.Consumer<ScopedMemory> visitor)
throws StaticIllegalArgumentException,
       ForEachTerminationException
```

Description

A means of accessing all live scoped memories whose parent is a primodial memory area, even those to which no reference exists, such a `javax.realtime.memory.PinnableMemory` that is pinned or another `javax.realtime.memory.ScopedMemory` that contains a `Schedulable`. The set may be concurrently modified by other tasks, but the view seen by the visitor may not be updated to reflect those changes. The following is guaranteed even when the set is disturbed by other tasks:

- the visitor shall visit no member more than once,
- it shall visit only scopes that were a member of the set at some time during the enumeration of the set, and
- it shall visit all the scopes that are not deleted during the execution of the visitor.

The visitor's `accept` method is called on all live roots scopes, so long as the `visitor` does not throw `javax.realtime.ForEachTerminationException`. When that is thrown, the visit terminates. A closure could be used to capture the last element visited.

When execution of the visitor's `accept` method is terminated abruptly by throwing an exception, then execution of visitScopedChildren also terminates abruptly by throwing the same exception.

Parameters

`visitor`—Determines the action to be performed on each of the children scopes.

Throws

`javax.realtime.StaticIllegalArgumentException`—when visitor is `null`.

`ForEachTerminationException`—when the traversal ends prematurely.

`javax.realtime.StaticSecurityException`—when the application does not have permissions to access visit root scopes.

Since RTSJ 2.0

enter

Signature

```
public void
enter()
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException,
       MemoryAccessError
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the instance of `Runnable` given in the constructor. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Throws

`ScopedCycleException`—when this invocation would break the single parent rule.

`ThrowBoundaryError`—Thrown when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the execution context that triggered finalization. This would include the scope containing the execution context, and the scope (if any) containing the scope containing execution context.

`javax.realtime.StaticIllegalArgumentException`—null

MemoryAccessError—when caller is a schedulable that may not use the heap and this memory area's logic value is allocated in heap memory.

enter(Runnable)

Signature

```
public void
enter(Runnable logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the given `Runnable`. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Parameters

`logic`—The Runnable object whose `run()` method should be invoked.

Throws

`ScopedCycleException`—when this invocation would break the single parent rule.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing task.

`javax.realtime.StaticIllegalArgumentException`—null

enter(Supplier)

Signature

```
public T
enter(java.util.function.Supplier<T> logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and an object is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

enter(BooleanSupplier)

Signature

```
public boolean
enter(BooleanSupplier logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters
`logic`—the object whose get method will be executed.
Returns
a result from the computation.

enter(IntSupplier)

Signature

```
public int
enter(IntSupplier logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters
`logic`—the object whose get method will be executed.
Returns
a result from the computation.

enter(LongSupplier)

Signature

```
public long
enter(LongSupplier logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns

a result from the computation.

enter(DoubleSupplier)

Signature

```
public double
enter(DoubleSupplier logic)
throws ScopedCycleException,
       ThrowBoundaryError,
       IllegalTaskStateException,
       StaticIllegalArgumentException
```

Description

Same as `enter(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns

a result from the computation.

executeInArea(Runnable)

Signature

```
public void
executeInArea(Runnable logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Executes the run method from the `logic` parameter using this memory area as the current allocation context. This method behaves as if it moves the allocation context down the scope stack to the occurrence of `this`.

Parameters

`logic`—The runnable object whose `run()` method should be executed.

Throws

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is an instance of `javax.realtime.Schedulable` schedulable and `logic` is `null`.

executeInArea(Supplier)

Signature

```
public T
executeInArea(java.util.function.Supplier<T> logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and an object is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns

a result from the computation.

executeInArea(BooleanSupplier)

Signature

```
public boolean
executeInArea(BooleanSupplier logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns
a result from the computation.

executeInArea(IntSupplier)

Signature

```
public int
executeInArea(IntSupplier logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters
`logic`—the object whose get method will be executed.
Returns
a result from the computation.

executeInArea(LongSupplier)

Signature

```
public long
executeInArea(LongSupplier logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters
`logic`—the object whose get method will be executed.
Returns
a result from the computation.

executeInArea(DoubleSupplier)

Signature

```
public double
executeInArea(DoubleSupplier logic)
throws IllegalTaskStateException,
       StaticIllegalArgumentException,
       InaccessibleAreaException
```

Description

Same as `executeInArea(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—the object whose get method will be executed.

Returns

a result from the computation.

getPortal

Signature

```
public java.lang.Object
getPortal()
throws IllegalAssignmentError,
       IllegalTaskStateException
```

Description

Returns a reference to the portal object in this instance of `ScopedMemory`.

Assignment rules are enforced on the value returned by `getPortal` as if the return value were first stored in an object allocated in the current allocation context, then moved to its final destination.

Throws

`javax.realtime.IllegalAssignmentError`—when a reference to the portal object cannot be stored in the caller's allocation context; that is, when the object is allocated in a more deeply nested scoped memory than the current allocation context or not on the caller's scope stack.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

Returns

a reference to the portal object or `null` when there is no portal object. The portal value is always set to `null` when the contents of the memory are deleted.

getReferenceCount

Signature

```
public int
getReferenceCount()
```

Description

Returns the reference count of this `ScopedMemory`.

Note that a reference count of zero reliably means that the scope is not referenced, but other reference counts are subject to artifacts of lazy/eager maintenance by the implementation.

Returns

the reference count of this `ScopedMemory`.

join

Signature

```
public void
join()
throws InterruptedException
```

Description

Waits until the reference count of this `ScopedMemory` goes down to zero. Returns immediately when the memory is unreferenced.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

join(HighResolutionTime)

Signature

```
public void
join(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException
```

Description

Waits at most until the time designated by the `time` parameter for the reference count of this `ScopedMemory` to drop to zero. Returns immediately when the memory area is unreferenced.

Since the time is expressed as a `javax.realtime.HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then the delay is the amount of time given by `time`, and measured by its associated clock. When absolute, then the delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `join` returns immediately.

Parameters

`time`—When this time is an absolute time, the wait is bounded by that point in time. When the time is a relative time (or a member of the `RationalTime` subclass of `RelativeTime`) the wait is bounded by a the specified interval from some time between the time `join` is called and the time it starts waiting for the reference count to reach zero.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and `time` is `null`.

`StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

joinAndEnter

Signature

```
public void
joinAndEnter()
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       MemoryAccessError
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, then enters the `ScopedMemory` and executes the `run` method from `logic` passed in the constructor. When no instance of `Runnable` was passed to the memory area's constructor, the method throws `StaticIllegalArgumentException` immediately.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that although `joinAndEnter` guarantees that the reference count is zero when the schedulable is released for entry, it does not guarantee that the reference count will remain one for any length of time. A subsequent `enter` could raise the reference count to two.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area

would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`javax.realtime.ScopedCycleException`—when this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and no non-null `logic` value was supplied to the memory area's constructor.

`MemoryAccessError`—when caller is a non-heap schedulable and this memory area's logic value is allocated in heap memory.

joinAndEnter(HighResolutionTime)

Signature

```
public void
joinAndEnter(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, or for the current time to reach the designated time, then enter the `ScopedMemory` and execute the `run` method from `Runnable` object passed to the constructor. When no instance of `Runnable` was passed to the memory area's constructor, the method throws `StaticIllegalArgumentException` immediately.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Since the time is expressed as a `javax.realtime.HighResolutionTime`, this method has an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then

the calling thread is blocked for at most the amount of time given by `time`, and measured by its associated clock. When absolute, then the time delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `joinAndEnter` behaves effectively like `enter`.

Note that expiration of `time` may cause control to enter the memory area before its reference count has gone to zero.

Parameters

`time`—The time that bounds the wait.

Throws

`javax.realtime.ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`javax.realtime.IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`javax.realtime.ScopedCycleException`—when the execution context is a schedulable and this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable, and `time` is `null` or no non-null `logic` value was supplied to the memory area's constructor.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

`javax.realtime.MemoryAccessError`—when calling schedulable may not use the heap and this memory area's logic value is allocated in heap memory.

joinAndEnter(Runnable)

Signature

```
public void
joinAndEnter(Runnable logic)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
```

```
ScopedCycleException,
StaticIllegalArgumentException,
MemoryAccessError
```

Description

In the error-free case, `joinAndEnter` combines `join();` and `enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, then enter the `ScopedMemory` and execute the `run` method from `logic`

When `logic` is `null`, the method throws `StaticIllegalArgumentException` immediately.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that although `joinAndEnter` guarantees that the reference count is zero when the schedulable is released for entry, it does not guarantee that the reference count will remain one for any length of time. A subsequent `enter` could raise the reference count to two.

Parameters

`logic`—The `Runnable` object which contains the code to execute.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—thrown when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`javax.realtime.ScopedCycleException`—when this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and `logic` is `null`.

joinAndEnter(Supplier)

Signature

```
public T
joinAndEnter(java.util.function.Supplier<T> logic)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable)` except that the executed method is called `get` and an object is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnter(BooleanSupplier)

Signature

```
public boolean
joinAndEnter(BooleanSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable)` except that the executed method is called `get` and a `boolean` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnter(IntSupplier)

Signature

```
public int
joinAndEnter(IntSupplier logic)
```

```
    throws InterruptedException,
           IllegalTaskStateException,
           ThrowBoundaryError,
           ScopedCycleException,
           StaticIllegalArgumentException,
           MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable)` except that the executed method is called `get` and an `int` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnter(LongSupplier)

Signature

```
public long
joinAndEnter(LongSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable)` except that the executed method is called `get` and a `long` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnter(DoubleSupplier)

Signature

```
public double
joinAndEnter(DoubleSupplier logic)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
```

```
        StaticIllegalArgumentException,
        MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

joinAndEnter(Runnable, HighResolutionTime)

Signature

```
public void
joinAndEnter(Runnable logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, or for the current time to reach the designated time, then enter the `ScopedMemory` and execute the `run` method from `logic`.

Since the time is expressed as a `javax.realtime.HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then the delay is the amount of time given by `time`, and measured by its associated clock. When absolute, then the delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `joinAndEnter` behaves effectively like `enter(Runnable)`.

The method throws `StaticIllegalArgumentException` immediately when `logic` is `null`.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that expiration of `time` may cause control to enter the memory area before its reference count has gone to zero.

Parameters

`logic`—The `Runnable` object which contains the code to execute.

`time`—The time that bounds the wait.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause a `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is preallocated and saves information about the exception it replaces.

`javax.realtime.ScopedCycleException`—when the execution context is a schedulable and this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and `time` or `logic` is `null`.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

joinAndEnter(Supplier, HighResolutionTime)

Signature

```
public P
joinAndEnter(java.util.function.Supplier<P> logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable, HighResolutionTime)` except that the executed method is called `get` and an object is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

joinAndEnter(BooleanSupplier, HighResolutionTime)

Signature

```
public boolean
joinAndEnter(BooleanSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `boolean` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

joinAndEnter(IntSupplier, HighResolutionTime)

Signature

```
public int
joinAndEnter(IntSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable, HighResolutionTime)` except that the executed method is called `get` and an `int` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

joinAndEnter(LongSupplier, HighResolutionTime)

Signature

```
public long
joinAndEnter(LongSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `long` is returned.

Parameters
`logic`—The object whose get method will be executed.
Returns
a result from the computation.

Since RTSJ 2.0

joinAndEnter(DoubleSupplier, HighResolutionTime)

Signature

```
public double
joinAndEnter(DoubleSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       IllegalTaskStateException,
       ThrowBoundaryError,
       ScopedCycleException,
       StaticIllegalArgumentException,
       StaticUnsupportedOperationException,
       MemoryAccessError
```

Description

Same as `joinAndEnter(Runnable, HighResolutionTime)` except that the executed method is called `get` and a `double` is returned.

Parameters

`logic`—The object whose get method will be executed.

Returns

a result from the computation.

Since RTSJ 2.0

getParent

Signature

```
public javax.realtime.MemoryArea
getParent()
```

Description

Returns a reference to this scope's parent scope (e.g., its parent in the single-parent-rule tree).

Returns

a reference to the next outer scoped memory region on the caller's scope stack.

- When there is no outer scoped memory and the primordial parent is heap memory, returns a reference to `this`.
- When there is no outer scoped memory and the primordial parent is immortal, or when `this` is unreferenced and unpinned, returns `null`

Problem. The single-parent tree is RTT-independent except for the primordial scope. The type of the primordial scope is RTT-dependent. What should we do about that? When called from a RTT that has entered ***`this`****, the above rules make some sense, but what if the caller has not even entered the scope, should we throw an exception? Or just return* ***`null`****? I think the right solution is to return* ***`this`*** *whatever the type of the primordial scope. The app can then know that* ***`null`*** *means the scope is not pinned and not referenced, and* ***`this`*** *means the parent is either heap or immortal. At that point, the app can learn what it wants to know by just finding what memory area contains the scope object.*

Since RTSJ 2.0

visitNestedScopes(Consumer)

Signature

```
public void
visitNestedScopes(java.util.function.Consumer<ScopedMemory> visitor)
throws StaticIllegalArgumentException,
       ForEachTerminationException
```

Description

A means of accessing all live nested scoped memories parented in this scoped memory, even those to which no reference exists, such a `javax.realtime.memory.PinnableMemory` that is pinned or another `javax.realtime.memory.ScopedMemory` that contains a `Schedulable`. It has the same semantics as the method `visitScopeRoots(Consumer)`, except for the following:

- what scoped memories are visited,
- the memory area must be reachable from the current scope stack, and
- there is not security manager check.

Parameters

`visitor`—Determines the action to be performed on each of the children scopes.

Throws

`javax.realtime.StaticIllegalArgumentException`—when visitor is `null`.

`ForEachTerminationException`—when the traversal ends prematurely.

Since RTSJ 2.0

newArray(Class, int)

Signature

```
public java.lang.Object
newArray(java.lang.Class<?> type,
         int number)
```

Description

Allocates an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of the elements of the new array. To create an array of a primitive type use a `type` such as `Integer.TYPE` (which would call for an array of the primitive int type.)

`number`—The number of elements in the new array.

Throws

`javax.realtime.StaticIllegalArgumentException`—null

`javax.realtime.StaticOutOfMemoryError`—null

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns

a new array of class type, of number elements.

newInstance(Class)

Signature

```
public T
newInstance(java.lang.Class<T> type)
```

```
    throws IllegalAccessException,
           StaticIllegalArgumentException,
           ExceptionInInitializerError,
           StaticOutOfMemoryError,
           InstantiationException,
           IllegalTaskStateException,
           InaccessibleAreaException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of which to create a new instance.

Throws

`IllegalAccessException`—The class or initializer is inaccessible.

`javax.realtime.StaticIllegalArgumentException`—null

`ExceptionInInitializerError`—when an unexpected exception has occurred in a static initializer.

`javax.realtime.StaticOutOfMemoryError`—null

`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, or it is an array.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns

a new instance of class `type`.

newInstance(Constructor, Object)

Signature

```
    public T
    newInstance(java.lang.reflect.Constructor<T> c,
                java.lang.Object[] args)
    throws IllegalAccessException,
           InstantiationException,
           InvocationTargetException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`c`—T The constructor for the new instance.

`args`—An array of arguments to pass to the constructor.

Throws

`IllegalAccessException`—when the class or initializer is inaccessible under Java access control.

`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

`javax.realtime.StaticOutOfMemoryError`—null

`javax.realtime.StaticIllegalArgumentException`—null

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`InvocationTargetException`—when the underlying constructor throws an exception.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns

a new instance of the object constructed by `c`.

setPortal(Object)

Signature

```
public void
setPortal(Object object)
throws IllegalTaskStateException,
       IllegalAssignmentError,
       InaccessibleAreaException
```

Description

Sets the *portal* object of the memory area represented by this instance of `ScopedMemory` to the given object. The object must have been allocated in this `ScopedMemory` instance.

Parameters

`object`—The object which will become the portal for this. When `null` the previous portal object remains the portal object for this or when there was no previous portal object then there is still no portal object for `this`.

Throws

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable`.

`IllegalAssignmentError`—when the execution context is an instance of `javax.realtime.Schedulable`, and `object` is not allocated in this scoped memory instance and not `null`.

`InaccessibleAreaException`—when the execution context is a schedulable, `this` memory area is not in the caller's scope stack and `object` is not `null`.

toString

Signature

```
public java.lang.String
toString()
```

Description

Returns a user-friendly representation of this `ScopedMemory` of the form `<class-name>@<num>` where `<class-name>` is the name of the class, e.g. `javax.realtime.memory.ScopedMemory`, and `<num>` is a number that uniquely identifies this scoped memory area.

Returns

the string representation

11.4.4.8 ScopedMemoryParameters

---

public class ScopedMemoryParameters

Inheritance

java.lang.Object
  javax.realtime.MemoryParameters
    ScopedMemoryParameters

Description

Extends memory parameters to provide limits for scoped memory.

See Section javax.realtime.MemoryParameters
Since RTSJ 2.0

11.4.4.8.1 Constructors

ScopedMemoryParameters(long, long, long, long, long, long)

Signature

```
public
ScopedMemoryParameters(long maxInitialArea,
                       long maxImmortal,
                       long allocationRate,
                       long maxContainingArea,
                       long maxInitialBackingStore,
                       long maxGlobalBackingStore)
throws StaticIllegalArgumentException
```

Description

Creates a `ScopedMemoryParameters` instance with the given values that can allow access to any `ScopedMemory`

Parameters

`maxInitialArea`—A limit on the amount of memory the schedulable may allocate in its initial scoped memory area. Units are in bytes. When zero, no allocation is allowed in the memory area. When the initial memory area is not a `ScopedMemory`, this parameter has no effect. To specify no limit, use `UNLIMITED`.

`maxImmortal`—A limit on the amount of memory the schedulable may allocate in the immortal area. Units are in bytes. When zero, no allocation allowed in immortal. To specify no limit, use `UNLIMITED`.

`allocationRate`—A limit on the rate of allocation in the heap. Units are in bytes per second of wall clock time. When `allocationRate` is zero, no allocation is allowed in the heap. To specify no limit, use `UNLIMITED`. Measurement starts when the schedulable is first released for execution; not when it is constructed. Enforcement of the allocation rate is an implementation option. When the implementation does not enforce allocation rate limits, it treats all positive allocation rate limits as `UNLIMITED`.

`maxContainingArea`—A limit on the amount of memory the schedulable may allocate in memory area where it was created. Units are in bytes. When zero, no allocation is allowed in the memory area. When the containing memory area is not a `ScopedMemory`, this parameter has no effect. To specify no limit, use `UNLIMITED`.

`maxInitialBackingStore`—A limit on the amount of backing store the schedulable may allocate from backing store of its initial memory area when that memory area is an instance of `StackedMemory`, in bytes. When zero, no allocation is allowed in that backing store. Backing store that is returned to the area backing store is subtracted from the limit. To specify no limit, use `UNLIMITED`.

`maxGlobalBackingStore`—A limit on the amount of backing store the schedulable may allocate from the global backing store to scoped memory areas in bytes. When zero, no allocation is allowed in the memory area. To specify no limit, use `UNLIMITED`.

Throws

`javax.realtime.StaticIllegalArgumentException`—when any value other less than zero is passed as the value of `maxInitialArea`, `maxImmortal`, `allocationRate`, `maxBackingStore`, or `maxContainingArea`.

ScopedMemoryParameters(long, long, long, long)

Signature

```
public
ScopedMemoryParameters(long maxInitialArea,
                       long maxImmortal,
                       long maxContainingArea,
                       long maxInitialBackingStore)
```

```
throws StaticIllegalArgumentException
```

Description

Same as `ScopedMemoryParameters(maxInitialArea, maxImmortal, 0, maxContainingArea, maxInitialBackingStore, 0)`. This constructor disallows root `StackedMemory`, `LTMemory`, and `Heap` allocation.

ScopedMemoryParameters(long, long, long)

Signature

```
public
ScopedMemoryParameters(long maxInitialArea,
                       long maxImmortal,
                       long maxContainingArea)
throws StaticIllegalArgumentException
```

Description

Same as `ScopedMemoryParameters(maxInitialArea, maxImmortal, MemoryParameters.UNLIMITED, maxGlobalBackingStore, 0, 0)`. This constructor disallows host `StackedMemory` and `LTMemory` allocation.

11.4.4.8.2 Methods

---

getMaxGlobalBackingStore

Signature

```
public long
getMaxGlobalBackingStore()
```

Description

Determines the limit on backing store for this task from the global pool.

Returns

the limit on backing store.

getMaxInitialBackingStore

Signature

```
public long
getMaxInitialBackingStore()
```

Description

Determines the limit on backing store for this task from its parent `StackedMemory`.

Returns

the limit on backing store.

getMaxContainingArea

Signature

```
public long
getMaxContainingArea()
```

Description

Determines the limit on allocation in the area where the task was created.

Returns

the limit on allocation in the area where the task was created.

11.4.4.9 StackedMemory

---

public class StackedMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    ScopedMemory
      StackedMemory

Description

`StackedMemory` implements a scoped memory allocation area and backing store management system. It is designed to allow for safe, fragmentation-free management of scoped allocation with certain strong guarantees provided by the virtual machine and runtime libraries.

Each `StackedMemory` instance represents a single object allocation area and additional memory associated with it in the form of a *backing store*. The backing store associated with a `StackedMemory` is a fixed-size memory area allocated at or before instantiation of the `StackedMemory`. The object allocation area is taken from the associated backing store, and the backing store may be further subdivided into additional `StackedMemory` allocation areas or backing stores by instantiating additional `StackedMemory` objects.

When a `StackedMemory` is created with a backing store, the backing store may be taken from a notional global backing store, in which case it is effectively immortal, or it may be taken from the enclosing `StackedMemory`'s backing store when the scope in which it is created is also a `StackedMemory`. In this case it is returned to its enclosing scope's backing store when the object is finalized. Implementations should return the space occupied by backing stores taken from the global backing store when their associated `StackedMemory` object is finalized.

These backing store semantics divide instances of `StackedMemory` into two categories:

- *host* — this denotes a `StackedMemory` with an object allocation area created in a new backing store, allocated either from the global store or from a parent `StackedMemory`'s backing store, and

- *guest* — this in turn indicates a `StackedMemory` with an object allocation area taken directly from a parent `StackedMemory`'s backing store without creating a sub-store.

In addition, there is one distinguished status for `StackedMemory` object: *root*. A root `StackedMemory` is a host `StackedMemory` created with a backing store drawn directly from the global backing store, created in an allocation context of some type other than `StackedMemory`.

Creation of a `StackedMemory` shall fail with a `javax.realtime.StaticOutOfMemoryError` when the current `javax.realtime.Schedulable` is configured with a limit on `ScopedMemoryParameters.maxGlobalBackingStore` and creation of the root `StackedMemory` would exceed that limit.

Creation of a `StackedMemory` is subject to additional restrictions when the current `Schedulable` is configured with an explicit initial memory area of type `StackedMemory`. In this case, the following rules apply.

- Construction of a root `StackedMemory` will fail and throw a `StaticOutOfMemoryError` *regardless* of the value of the `Schedulable`'s `ScopedMemoryParameters.maxGlobalBackingStore`.
- Construction of a `StackedMemory` from a current allocation context that is not the `Schedulable`'s explicit initial memory area or one of its descendants in the scope stack will fail and throw `StaticOutOfMemoryError`.
- A maximum of `ScopedMemoryParameters.maxInitialBackingStore` bytes may be allocated directly from the backing store of the `Schedulable`'s explicit initial memory area over the lifetime of the `Schedulable`. Any operation that would exceed this limit (whether by resizing the allocation area of the explicit initial memory area or a guest area in the same backing store, or by allocating a new `StackedMemory` with the explicit initial memory area as the current allocation context) will fail and throw a `StaticOutOfMemoryError`.

Allocations from a `StackedMemory` object allocation area are guaranteed to run in time linear in the size of the allocation. All memory for the backing store must be reserved at object construction time.

`StackedMemory` memory areas have two additional stacking constraints in addition to the single parent rule, designed to enable fragmentation-free manipulation:

- a `StackedMemory` that is created when another `StackedMemory` is the current allocation context can only be entered from the same allocation context in which it was created, and
- a guest `StackedMemory` may not be created from a `StackedMemory` that currently has another child area that is also a guest `StackedMemory`, i.e., a `StackedMemory` can have at most one direct child that is a guest `StackedMemory`.

The `StackedMemory` constructor semantics also enforce the property that a `StackedMemory` may not be created from another `StackedMemory` allocation context unless it is allocated from that context's backing store as either a host or guest area.

The backing store of a `StackedMemory` behaves as if any `StackedMemory`

object allocation areas are at the "bottom" of the backing store, while the backing stores for enclosed `StackedMemory` areas are taken from the "top" of the backing store.

There may be an implementation-specific memory overhead for creating a backing store of a given size. This means that creating a `StackedMemory` with a backing store of exactly the remaining available backing store of the current `StackedMemory` may fail with an `javax.realtime.StaticOutOfMemoryError`. This overhead must be bounded by a constant.

Since RTSJ 2.0

11.4.4.9.1 Constructors

StackedMemory(long, long, Runnable)

Signature

```
public
StackedMemory(long scopeSize,
              long backingSize,
              Runnable logic)
```

Description

Creates a host `StackedMemory` with an object allocation area and backing store of the specified sizes, bound to the specified `Runnable`. The backing store is allocated from the currently active memory area when it is also a `StackedMemory`, and the global backing store otherwise. The object allocation area is allocated from the backing store.

Parameters

`scopeSize`—Size of the allocation area within the backing store.

`backingSize`—Size of the total backing store.

`logic`—`Runnable` to be entered using `this` as its current memory area when `enter()` is called.

Throws

`javax.realtime.StaticIllegalArgumentException`—when either `scopeSize` or `backingSize` is less than zero, or when `scopeSize` is too large to be allocated from a backing store of size `backingSize`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available to reserve the requested backing store.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(SizeEstimator, SizeEstimator, Runnable)

Signature

```
public
StackedMemory(SizeEstimator scopeSize,
              SizeEstimator backingSize,
              Runnable logic)
```

Description

Equivalent to `StackedMemory(long, long, Runnable)` with argument list `(scopeSize.getEstimate(), backingSize.getEstimate(), runnable)`.

Parameters

`scopeSize`—`SizeEstimator` indicating the size of the object allocation area within the backing store.

`backingSize`—`SizeEstimator` indicating the size of the total backing store.

`logic`—`Runnable` to be entered using `this` as its current memory area when `enter()` is called.

Throws

`javax.realtime.StaticIllegalArgumentException`—when either `scopeSize` or `backingSize` is `null`, or when `scopeSize.getEstimate()` is too large to be allocated from a backing store of size `backingSize.getEstimate()`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available to reserve the requested backing store.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(long, long)

Signature

```
public
StackedMemory(long scopeSize,
              long backingSize)
```

Description

Equivalent to `StackedMemory(long, long, Runnable)` with argument list `(scopeSize, backingSize, null)`.

Parameters

`scopeSize`—Size of the allocation area within the backing store.

`backingSize`—Size of the total backing store.

Throws

`javax.realtime.StaticIllegalArgumentException`—when either `scopeSize` or `backingSize` is less than zero, or when `scopeSize` is too large to be allocated from a backing store of size `backingSize`.

javax.realtime.StaticOutOfMemoryError—when there is insufficient memory available to reserve the requested backing store.

javax.realtime.IllegalTaskStateException—when the current Schedulable has a StackedMemory as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(SizeEstimator, SizeEstimator)

Signature

```
public
StackedMemory(SizeEstimator scopeSize,
              SizeEstimator backingSize)
```

Description

Equivalent to StackedMemory(long, long, Runnable) with argument list (scopeSize.getEstimate(), backingSize.getEstimate(), null).

Parameters

scopeSize—SizeEstimator indicating the size of the object allocation area within the backing store.

backingSize—SizeEstimator indicating the size of the total backing store.

Throws

javax.realtime.StaticIllegalArgumentException—when either scopeSize or backingSize is null, or when scopeSize.getEstimate() is too large to be allocated from a backing store of size backingSize.getEstimate().

javax.realtime.StaticOutOfMemoryError—when there is insufficient memory available to reserve the requested backing store.

javax.realtime.IllegalTaskStateException—when the current Schedulable has a StackedMemory as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(long, Runnable)

Signature

```
public
StackedMemory(long scopeSize,
              Runnable logic)
```

Description

Create a guest StackedMemory with an object allocation area of the specified size, bound to the specified Runnable. The object allocation area is drawn from the same backing store as the parent scope's object allocation area. The parent scope must be a StackedMemory.

Parameters

scopeSize—Size of the allocation area within the backing store.

`logic`—`Runnable` to be entered using `this` as its current memory area when `enter()` is called.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the parent memory area is not a `StackedMemory`.

`javax.realtime.MemoryInUseException`—when the parent `StackedMemory` already has a child that is also a guest `StackedMemory`.

`javax.realtime.StaticIllegalArgumentException`—when `scopeSize` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available in the backing store of the parent `StackedMemory`'s object allocation area to reserve the requested object allocation area.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(SizeEstimator, Runnable)

Signature

```
public
StackedMemory(SizeEstimator scopeSize,
              Runnable logic)
```

Description

Equivalent to `StackedMemory(long, Runnable)` with argument list `(scopeSize.getEstimate(), runnable)`.

Parameters

`scopeSize`—`SizeEstimator` indicating the size of the object allocation area within the backing store.

`logic`—`Runnable` to be entered using `this` as its current memory area when `enter()` is called.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the parent memory area is not a `StackedMemory`.

`javax.realtime.MemoryInUseException`—when the parent `StackedMemory` already has a child that is also a guest `StackedMemory`.

`javax.realtime.StaticIllegalArgumentException`—when `scopeSize` is `null`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available in the backing store of the parent `StackedMemory`'s object allocation area to reserve the requested object allocation area.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(long)

Signature

```
public
StackedMemory(long scopeSize)
```

Description

Equivalent to `StackedMemory(long, Runnable)` with argument list `(scopeSize, null)`.

Parameters

`scopeSize`—Size of the allocation area within the backing store.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the parent memory area is not a `StackedMemory`.

`javax.realtime.MemoryInUseException`—when the parent `StackedMemory` already has a child that is also a guest `StackedMemory`.

`javax.realtime.StaticIllegalArgumentException`—when `scopeSize` is less than zero.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available in the backing store of the parent `StackedMemory`'s object allocation area to reserve the requested object allocation area.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

StackedMemory(SizeEstimator)

Signature

```
public
StackedMemory(SizeEstimator scopeSize)
```

Description

Equivalent to `StackedMemory(long, Runnable)` with argument list `(scopeSize.getEstimate(), null)`.

Parameters

`scopeSize`—`SizeEstimator` indicating the size of the object allocation area within the backing store.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the parent memory area is not a `StackedMemory`.

`javax.realtime.MemoryInUseException`—when the parent `StackedMemory` already has a child that is also a guest `StackedMemory`.

`javax.realtime.StaticIllegalArgumentException`—when `scopeSize` is `null`.

`javax.realtime.StaticOutOfMemoryError`—when there is insufficient memory available in the backing store of the parent `StackedMemory`'s object allocation area to reserve the requested object allocation area.

`javax.realtime.IllegalTaskStateException`—when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

11.4.4.9.2 Methods

---

resize(long)

Signature

```
public void
resize(long scopeSize)
```

Description

Changes the size of the object allocation area for this scope. This method may be used to either grow or shrink the allocation area when there are no objects allocated in the scope and no `Schedulable` object has this area as its current allocation context. It may be used to grow the allocation area, or to shrink the allocation area no smaller than the size of its current usage, when the calling `Schedulable` object is the only object that has this area on its scope stack and there are no guest `StackedMemory` object allocation areas created after this area in the same backing store but not yet finalized.

Parameters

`scopeSize`—The new allocation area size for this scope.

Throws

`javax.realtime.StaticSecurityException`—when the caller is not permitted to perform the requested adjustment.

`javax.realtime.StaticIllegalArgumentException`—there are additional guest `StackedMemory` allocation areas after this one in the backing store.

`javax.realtime.StaticOutOfMemoryError`—when the remaining backing store is insufficient for the requested adjustment, or when the current `Schedulable` has a `StackedMemory` as its explicit initial scoped memory area and that area is not on the scope stack.

getMaximumSize

Signature

```
public long
getMaximumSize()
```

Description

Gets the maximum size this memory area can attain. The value returned by this function is the maximum size that can currently be passed to `resize(long)` without triggering an `StaticOutOfMemoryError`.

Returns
the maximum size attainable.

hostBackingStoreSize

Signature

```
public long
hostBackingStoreSize()
```

Description

Determines the total amount of memory in the backing store of this stacked memory. For a guest stacked memory, this is always zero.

Returns
the total amount of backing store in bytes.

hostBackingStoreRemaining

Signature

```
public long
hostBackingStoreRemaining()
```

Description

Determines the amount of memory remaining for allocation to new stacked memories in the backing store of this stacked memory. For a guest stacked memory, this is always zero.

Returns
the amount of backing store remaining in bytes.

hostBackingStoreConsumed

Signature

```
public long
hostBackingStoreConsumed()
```

Description

Determines the amount of memory consumed by exisiting stacked memories from the backing store of this stacked memory. For a guest stacked memory, this is always zero.

Returns
the amount of backing store consumed in bytes.

enter

Signature

```
public void
enter()
```

Description

Associates this memory area with the current `Schedulable` object for the duration of the `run()` method of the instance of `Runnable` given in this object's constructor. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected.

This method may only be called from the memory area in which this scope was created.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the currently active memory area is a `StackedMemory` and is not the area in which this scope was created, or the current memory area is not a `StackedMemory` and this `StackedMemory` is not a root area.

`ThrowBoundaryError`—Thrown when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the execution context that triggered finalization. This would include the scope containing the execution context, and the scope (if any) containing the scope containing execution context.

`MemoryAccessError`—when caller is a schedulable that may not use the heap and this memory area's logic value is allocated in heap memory.

See Section ScopedMemory.enter()

enter(Runnable)

Signature

```
public void
enter(Runnable logic)
```

Description

Associates this memory area with the current `Schedulable` object for the duration of the `run()` method of the given `Runnable`. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected.

This method may only be called from the memory area in which this scope was created.

Throws

javax.realtime.StaticIllegalArgumentException—when the currently active memory area is a `StackedMemory` and is not the area in which this scope was created, or the current memory area is not a `StackedMemory` and this `StackedMemory` is not a root area.

javax.realtime.ThrowBoundaryError—null

javax.realtime.IllegalTaskStateException—null

javax.realtime.MemoryAccessError—null

See Section ScopedMemory.enter(Runnable)

joinAndEnter

Signature

```
public void
joinAndEnter()
throws InterruptedException
```

Description

Throws

java.lang.InterruptedException—when this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt() or javax.realtime.control.AsynchronouslyInterruptedException.fire() while waiting for the reference count to go to zero.

IllegalTaskStateException—when the execution context is not an instance of javax.realtime.Schedulable or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

ThrowBoundaryError—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an javax.realtime.IllegalAssignmentError, so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError is allocated in the current allocation context and contains information about the exception it replaces.

javax.realtime.ScopedCycleException—when this invocation would break the single parent rule.

javax.realtime.StaticIllegalArgumentException—when the execution context is a schedulable and no non-null `logic` value was supplied to the memory area's constructor.

`MemoryAccessError`—when caller is a non-heap schedulable and this memory area's logic value is allocated in heap memory.

joinAndEnter(HighResolutionTime)

Signature

```
public void
joinAndEnter(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException
```

Description

Parameters

`time`—The time that bounds the wait.

Throws

`javax.realtime.ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`javax.realtime.IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`javax.realtime.ScopedCycleException`—when the execution context is a schedulable and this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable, and `time` is `null` or no non-null `logic` value was supplied to the memory area's constructor.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

`javax.realtime.MemoryAccessError`—when calling schedulable may not use the heap and this memory area's logic value is allocated in heap memory.

joinAndEnter(Runnable)

Signature

```
public void
joinAndEnter(Runnable logic)
throws InterruptedException
```

Description

Parameters

`logic`—The `Runnable` object which contains the code to execute.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—thrown when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`javax.realtime.ScopedCycleException`—when this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and `logic` is `null`.

joinAndEnter(Runnable, HighResolutionTime)

Signature

```
public void
joinAndEnter(Runnable logic,
             javax.realtime.HighResolutionTime<?> time)
throws InterruptedException
```

Description

Parameters

`logic`—The `Runnable` object which contains the code to execute.

`time`—The time that bounds the wait.

Throws

`java.lang.InterruptedException`—when this schedulable is interrupted by `javax.realtime.RealtimeThread.interrupt()` or `javax.realtime.control.AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalTaskStateException`—when the execution context is not an instance of `javax.realtime.Schedulable` or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause a `javax.realtime.IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `javax.realtime.ThrowBoundaryError` is preallocated and saves information about the exception it replaces.

`javax.realtime.ScopedCycleException`—when the execution context is a schedulable and this invocation would break the single parent rule.

`javax.realtime.StaticIllegalArgumentException`—when the execution context is a schedulable and `time` or `logic` is `null`.

`javax.realtime.StaticUnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

11.5 The Rationale

The memory area support has three main areas of change: package separation, extensions for safer off-heap memory management, and factory based, type compatible physical memory areas. Each of these changes was driven by its own set of requirements. Still they where designed to produce a coherent set of features for the new specification.

11.5.1 Package Separation

`RTSJ` 2.0 has been reorganized to support a core group of classes and three subgroups. To do this, some facilities that where in the main `javax.realtime` package have had to be moved to other packages. Though not strictly necessary to support Java 8, these changes make it possible to define Java 9 modules for each of these groups of classes. For alternate memory management, the corresponding classes have been moved to `javax.realtime.memory` and could be in a module with the same name. This separation has been used as a means of separating the attributes used to raw memory from physical memory as well, since raw memory is in the `javax.realtime.device` package.

11.5.2 Class Allocation and Initialization

RTSJ 1.0.x was very prescriptive about class initialization, since most garbage collectors at the time could not provide any latency guarentees. This has changed, so it is reasonable to use garbage collection even for very time critical code, so much so that scoped memory is no longer a required RTSJ feature. This also mean more flexibility is required for class allocation and initialization. Hence, the user and implementor need more flexibility in where and under what circumstances classes objects are allocated an initialized.

11.5.3 The Scoped Memory Model

Languages that employ automatic reclamation of blocks of memory allocated in what is conventionally called the heap by program logic also typically use an algorithm called a garbage collector. Garbage collection algorithms and implementations vary in the amount of indeterminacy they add to the execution of program logic. Rather than require a garbage collector, and require it to meet realtime constraints that would necessarily be a compromise, this specification constructs alternative systems for "safe" management of memory. The scoped and immortal memory areas allow program logic to allocate objects in a Java-like style, ignore the reclamation of those objects, and not incur the latency of the implemented garbage collection algorithm.

The term *scope stack* might mislead a reader to infer that it contains only scoped memory areas. This is incorrect. Although the scope stack may contain scoped memory references, it may also contain heap and immortal memory areas. Also, although the scope stack's behavior is specified as a stack, an implementation is free to use any data structure that preserves the stack semantics.

This specification does not specifically address the lifetime of objects allocated in immortal memory areas. If they were reclaimed while they were still referenced, the referential integrity of the JVM would be compromised which is not permissible. Recovering immortal objects only at the termination of the application, or never recovering them under any circumstances is consistent with this specification.

When a scoped memory area is used by both heap and extraheap tasks, there could be cases where a finalizer executed in extraheap context could attempt to use a heap reference left by a heap-using task. The code in the finalizer would throw a memory access error. If that exception is not caught in the finalizer, it will be handled by the implementation so finalization will continue undisturbed, but the problem in finalizer that caused the illegal memory access could be hard to locate. So, catch clauses in finalizers for objects allocated in scoped memory are even more useful than they are for normal finalizers.

Support for explicit initial scoped memory areas (EISMAs) for schedulables has repercussions.

1. The EISMA's parent is set when its realtime thread is constructed or its ASEH becomes firable, but its reference count is not incremented until the thread is started or the asynchronous event handler is released. This lets a scope with a zero reference count have a parent. This may cause unexpected scoped cycle exceptions. The most surprising are from the `joinAndEnter` family of methods.

2. Any action that makes an event handler not firable must block until all the resulting finalization completes.
3. Any action that makes an event handler firable must block until any ongoing finalization of its EISMA completes.

Since an EISMA is only entered upon release and exited at the completion of release, the handler of the release can generally run finalization. A thread collecting the event that triggers the handler will not have any effect on EISMA finalization. Only another execution context can prevent finalization by the handler at release end.

11.5.4 Reservation Management

The reservation management semantics in `RTSJ` 2.0 were created to maintain the maximum semantic compatibility with `RTSJ` 1.0, while providing the default EISMA behavior more commonly desired (that is, that every release is begun in an empty memory area). Since a memory area that is the EISMA of a task but is not otherwise in use is not on any scope stack, without reservation management it or one of the scopes in the scope stack below it could be erroneously placed at a location in the tree of memory areas different from that where it will be entered on the task's release. This would cause an exception to be thrown at release, due to a violation of the single parent rule. By reserving its location in the tree at the time that it is configured, this exception (which cannot be conveniently caught by any application context) is avoided.

11.5.5 Backing Store Management

Management of backing store memory for memory areas was overhauled substantially for `RTSJ` 2.0. In this edition, access to the global and physical backing stores is limited on a per-`Schedulable` basis, and the ability to use and reuse allocations from these backing stores in a fragmentation-free manner is provided by `StackedMemory`. The rules for access to the global and physical backing stores and the creation of `StackedMemory` objects for `Schedulable`s with an explicit initial scoped memory area of type `StackedMemory` are strict, but necessary to achieve full control of backing store resources. In particular, It seems impractical to enforce that a `Schedulable` is incapable of examining the `MemoryArea`s that lie on its own scope stack, whether directly (e.g., via a visitor) or indirectly (e.g., by requesting the `MemoryArea` from which objects it can reach are allocated). Therefore, an implementation must enforce specific rules on *a)* the global and physical backing stores, and *b)* the `StackedMemory` hierarchy in which a *Schedulable* operates. These rules are designed to constrain the backing store allocations of a `Schedulable` regardless of the `MemoryArea`s with which it may come in contact.

11.5.6 The Physical Memory Model

Embedded systems may have many different types of directly addressable memory available to them. Each type has its own characteristics [2] that determine whether it is

1. volatile – whether it maintains its state when the power is turned off,
2. writable – whether it can be written at all, written once or written many times and whether writing is under program control,
3. synchronous or asynchronous – whether the memory is synchronized with the system bus,
4. erasable at the byte level – if the memory can be overwritten, whether this is done at the byte level or whether whole sectors of the memory need to be erased,
5. fast to access – both for reading and writing.

Examples include the following [2].

1. *Dynamic Random Access Memory* (DRAM) and *Static Random Access Memory* (SRAM) – these are volatile memory types that are usually writable at the byte level. There are no limits on the number of times the memory contents can be written. From the embedded systems designer's view point, the main differences between the two are their access times and their cost per byte. SRAM has faster access times and is more expensive. Both DRAM and SRAM are examples of asynchronous memory, SDRAM and SSRAM are their synchronized counterparts. Another important difference is that DRAM requires periodic refresh operations, which may interfere with execution time determinism.
2. Read-Only Memory (for example, *Erasable Programmable Read-Only Memory* (EPROM)) – these are nonvolatile memory types that once initialized with data can not be overwritten by the program (without recourse to some external effect, usually ultraviolet light as in EPROM). They are fast to access and cost less per byte than DRAM.
3. Hybrid Memory (for example, *Electrically Erasable Programmable Read-Only Memory* (EEPROM), and Flash) – these have some properties of both random access and read-only memory.
   (a) EEPROM – this is nonvolatile memory that is writable at the byte level. However, there are typically limits on how many time the same location can be overwritten. EEPROMs are expensive to manufacture, fast to read but slow to write.
   (b) FLASH memory – this is nonvolatile memory that is writable at the sector level. Like EEPROM there are limits on how many times the same location can be overwritten and they are fast to read but slow to write. Flash memory is cheaper to manufacture than EEPROM.

Some embedded systems may have multiple types of random-access memory, and multiple ways of accessing memory. For instance, there may be a small amount of very fast RAM on the processor chip, memory that is on the same board as the processor, memory that may be added and removed from the system dynamically, memory that is accessed across a bus, access to memory that is mediated by a cache, access where the cache is partially disabled so all stores are "write through", memory that is demand paged, and other types of memory and memory-access attributes only limited by physics and the imagination of electrical engineers. Some of these memory types will have no impact on the programmer, others will.

Individual computers are often targeted at a particular application domain. This domain will often dictate the cost and performance requirements, and therefore,

the memory type used. Some embedded systems are highly optimized and need to explore different options in memory to meet their performance requirements. Here are five example scenarios.

1. Ninety percent of performance-critical memory access is to a set of objects that could fit in a half the total memory.
2. The system enables the locking of a small amount of data in the cache, and a small number of pages in the translation look-aside buffer (TLB). A few very frequently accessed objects are to be locked in the cache and a larger number of objects that have jitter requirements can be TLB-locked to avoid TLB faults.
3. The boards accept added memory on daughter boards, but that memory is not accessible to DMA from the disk and network controllers and it cannot be used for video buffers. Better performance is obtained if one ensures that all data that might interact with disk, network, or video is not stored on the daughter board.
4. Improved video performance can be obtained by using an array as a video buffer. This will only be effective if a physically contiguous, unpagable, DMA-accessible block of RAM is used for the buffer and all stores forced to write through the cache. Of course, such an approach is dependent on the way the JVM lays out arrays in memory, and it breaks the JVM abstraction by depending on that layout.
5. The system has banks of SRAM and saves power by automatically putting them to "sleep" whenever they stay unused for 100ms or so. To exploit this, the objects used by each phase of this program can be collected in a separate bank of this special memory.

To be clear, few embedded systems are this aggressive in their hardware optimization. The majority of embedded systems have only ROM, RAM, and maybe flash memory. Configuration-controlled memory attributes (such as page locking, and TLB behavior) are more common.

As well as having different types of memory, many computers map input and output devices so that their registers can be accessed as if they were resident within the computer memory (see Section 13.2.1). Hence, some parts of the processor's address space map to real memory and other parts map to device registers. Logically, even a device's memory can be considered part of the memory hierarchy, even where the device's interface is accessed through special assembly instructions. Multiprocessor systems add a further dimension to the problem of memory access. Memory may be local to a CPU, tightly shared between CPUs, or remotely accessible from the CPU (but with a delay).

Traditionally, Java programmers are not concerned with these low-level issues; they program at a higher level of abstraction and assume the JVM makes judicious use of the underlying resources provided by the execution platform[5]. Embedded systems programmers cannot afford this luxury. Consequently, any Java environment that wishes to facilitate the programming of embedded systems must enable the programmer to exercise more control over memory.

[5]This is reflected by the OS support provided. For example, most POSIX systems only offer programs a choice of demand paged or page-locked memory.

11.5.6.1 The Original Physical Memory Framework

The RTSJ 1.0.x supported three ways to allocate objects that can be placed in particular types of memory.

1. `ImmortalPhysicalMemory` allocates immortal objects in memory with specified characteristics.
2. `LTPhysicalMemory` allocates scoped memory objects in a memory with specified characteristics using a linear time memory allocation algorithm.
3. `VTPhysicalMemory` allocates scoped memory objects in memory with specified characteristics using an algorithm that may be worse than linear time but could offer extra services (such as extensibility).

The only difference between the physical memory classes and the corresponding standard memory classes is that the ordinary memory classes give access to normal system RAM and the physical memory classes offer access to particular types of memory.

Originally, the RTSJ supported access to physical memory via a memory manager and one or more memory filters. The goal of the memory manager was to provide a single interface with which the programmer could interact to access memory with a particular characteristic. A memory filter provided access to a particular type of physical memory. Memory filters could be dynamically added and removed from the system, and there could only be a single filter for each memory type. The memory manager was unaware of the physical addresses of each type of memory. This was encapsulated by the filters. The filters also know the virtual memory characteristics that had been allocated to their memory type. For example, whether the memory is readable or writable.

In theory, any developer could create a new physical memory filter and register it with the Physical Memory Model (PMM). However, the programming of filters is difficult for the following reasons.

1. Physical memory type filters include a memory allocation function that must respond to allocation requests with whether a requested range of physical memory is free and, when it is not, the physical address of the next free physical memory of the requested type. This is complex because requests for compound types of physical memory must find a free segment that satisfies all attributes of the compound type.
2. The Java runtime must continue to behave correctly under the Java memory model when using physical memory. This is not a problem when a memory type behaves like the system's normal RAM with respect to the properties addressed by the memory model, or is more restricted than normal RAM. For instance, write-through cache is more restricted than copy-back cache. When a new memory type does not obey the memory model using the same instruction sequences as normal RAM, the memory filter must cooperate with the interpreter, the JIT, and any ahead-of-time compilation to modify those instruction sequences when accessing the new type of memory. That task is difficult for someone who can easily modify the Java runtime and nearly impossible for anyone else.
3. The physical memory filters where passed as type `Object` to physical memory type constructors, so no type checking supported proper usage.

Hence, the utility of the physical memory filter framework at Version 1.0.2 is questionable, and hence is replaced in 2.0 with a simpler, factory-based framework.

11.5.6.2 The RTSJ 2.0 Physical Memory Framework

The main problem with the 1.0.x framework is that it placed too great a burden on the JVM implementer. Even for embedded systems, the JVM implementer requires the VM to be portable between systems within the same processor family. Therefore, the JVM cannot have detailed knowledge of the underlying memory architecture. It is only concerned with the standard RAM provided to it by the host operating system.

The design of 2.0 model is based on two constraints.

1. Java objects can only be allocated in a memory area if the physical backing store supports the Java Memory Model without the JVM having to perform any operation in addition to those that it performs when accessing as the main RAM for the host machine. No extra compiler or JVM interactions shall be required. Hence memory types (such as EEPROM), which potentially require special hardware instructions to perform write operations, cannot be used as the backing store for physical memory areas. Similarly, nonvolatile memory could be used, but any objects stored therein may contain references to objects in volatile memory. Although these memory types are prohibited from being used as backing stores, they contain objects of primitive Java types and can be accessed via the RTSJ Raw Memory facilities (see Section 13.2.1).
2. Any API must delegate detailed knowledge of the memory architecture to the programmer of the specific embedded system to be implemented. There is less requirement for portability here, as embedded systems are usually optimized for their host environment. The model assumes that the programmer is aware of the memory map, either through some native operating system interface[6] or from some property file read at program initialization time.

When accessing physical memory, there are two main considerations:

1. the characteristics of the required physical memory, and
2. how that memory is to be mapped into the virtual memory of the application.

The program must identify (and inform the RTSJ's physical memory manager of) the physical memory characteristics and the range of physical addresses those characteristic apply to. For example, that there is SRAM between physical address range 0x100000000 and 0xA0000000.

The physical memory manager supports options for mapping physical memory into the virtual memory of the application. Examples include whether the range is to be permanently resident in memory and whether data is written to the cache and the main memory simultaneously, i.e., a write through caching. By default, memory is subject to paging or swapping.

Given the required physical memory characteristics, the programmer creates a PhysicalMemoryRegion for accessing this memory and registers it with a Physi-

[6]For example, the *Advanced Configuration and Power Interface* (ACPI) specification is an open standard for device configuration and power management by the operating system. The ACPI defines platform-independent interfaces for hardware discovery, configuration, power management and monitoring. See http://www.acpi.info/

calMemoryFactory. This factory can then be used with new constructors on the physical memory classes. For example,

```
1  PhysicalMemoryCharacteristic sram = new
       PhysicalMemoryCharacteristic(){};
2  PhysicalMemoryCharacteristic[] characteristics =
3    new PhysicalMemoryCharacteristic[]{ sram };
4  PhysicalMemorySelector selector =
5    new PhysicalMemorySelector(null, null, WRITE_THROUGH, FIXED);
6  MemoryArea memory = factory.createImmortalMemory(selectors,
       size, logic);
```

Use of this factory enables the programmer to specify the allocation of the backing store in a particular type of memory with particular memory characteristics. The selector is used to locate an area in physical memory with the required physical memory characteristics and to direct its mapping into the virtual address space.

Hence, once physical memory regions have been created and registered, physical memory areas can be created and objects can be allocated within those memory regions using the usual RTSJ mechanisms for changing the allocation context of the new operator.

11.5.6.3 An example

Consider an example of a system that has a SRAM physical memory module configured at a physical base address of 0x10000000 and of length 0x20000000. Another module (base address of 0xA0000000 and of length 0x10000000) also supports SRAM, but this module has been configured so that it saves power by sleeping when not in use. The following subsections illustrate how the embedded programmer informs the PMM about the structure during the program's initialization phase, and how the memory may be subsequently used after this. The example assumes that the PMM supports the virtual memory characteristics defined above.

11.5.6.3.1 Program Initialization

For simplicity, the example requires that the address of the memory modules are known, rather than being read from a property file. The program needs to have a class that implements the PhysicalMemoryCharacteristic. In this simple example, this is empty.

```
1 public class SRAMType implements PhysicalMemoryCharacteristic {}
```

The initialization method must now create instances of the PhysicalMemoryRegion class to represent the physical memory modules needed.

```
1 PhysicalMemoryRegion staticRam =
2   new PhysicalMemoryRegion(0x10000000L, 0x100000000L);
3 PhysicalMemoryRegion staticSleepableRam =
4   new PhysicalMemoryRegion(0xA0000000L, 0x100000000L);
```

It then creates names for the characteristics that the program wants to associate with each memory module.

```
1 PhysicalMemoryCharacteristic STATIC_RAM = new MyMemoryType();
2 PhysicalMemoryCharacteristic AUTO_SLEEPABLE = new MyMemoryType();
```

It then informs the PMM of the appropriate associations:

```
1 PhysicalMemoryFactory factory = PhysicalMemoryFactory.getDefault
      ();
2 factory.associate(STATIC_RAM, staticRam);
3 factory.associate(STATIC_RAM, staticSleepableRam);
4 factory.associate(AUTO_SLEEPABLE, staticSleepableRam);
```

Once this is done, the program can create a selector with the required properties. In this case, some SRAM must be auto sleepable.

```
1 PhysicalMemoryCharacteristic [] PMC =
2   new PhysicalMemoryCharacteristic[2];
3 PMC[0] = STATIC_RAM;
4 PMC[1] = AUTO_SLEEPABLE;
5
6 PhysicalMemorySelector selector =
7   new PhysicalMemorySelectory(PMC, null, DISABLED, FIXED);
```

If the program had just asked for SRAM then either of the memory modules could satisfy the request.

The initialization is now complete, and the programmer can use the memory for storing objects, as shown below.

11.5.6.3.2 Using Physical Memory

Once the programmer has configured the JVM so that it is aware of the physical memory modules, and the programmer names for characteristics of those memory modules, using the physical memory is straight forward. Here is an example.

```
1   ImmortalMemory IM = factory.createImmortalMemory(selector, 0
        x1000);
2   IM.enter(new Runnable()
3   {
4     public void run()
5     {
6       // The code executing here is running with its allocation
7       // context set to a physical immortal memory area that is
8       // mapped to RAM which is auto sleepable.
9       // Any objects created will be placed in that
10      // part of physical memory.
11    }
12  });
```

The physical memory factory keeps track of previously allocated memory and is able

to determine whether memory is available with the appropriate characteristics. Of course, the physical memory factory has no knowledge of what these names mean; it is merely providing a look-up service.

Chapter 12

Asynchronous Control Flow

An important aspects of this specification is its support for asynchronous control flow. The Control Module provides that support through a mechanism that

- enables asynchronous transfer of control and
- facilitates the asynchronous termination of realtime threads.

Two related mechanisms are provided: a general transfer mechanism called Asynchronous Transfer of Control (ATC), which provides a means of stopping some calculation prematurely and a task abort mechanism to safely terminate any task called Asynchronous Task Termination (ATT).

The `interrupt()` method in `java.lang.Thread` provides rudimentary asynchronous communication by setting a pollable and resettable flag in the target thread, and by throwing a synchronous exception when the target thread is blocked at an invocation of `wait()`, `sleep()`, `join()`, or an operation that throws `InterruptException`. This specification generalizes the notion of interrupt to all tasks, offering a more comprehensive asynchronous execution control facility without requiring polling. For RealtimeThreads, the effect of `Thread.interrupt()` must be extended by adding an overridden version in `RealtimeThread`.

This mechanism, called Asynchronous Transfer of Control (ATC), is based on throwing and propagating an exception that, though asynchronous, is deferred where necessary in order to avoid data structure corruption. The main elements of ATC are embodied in the class `AsynchronouslyInterruptedException`, its subclass `Timed`, the interface `Interruptible`, and in the semantics of the `interrupt` method in `Schedulable`.

A method indicates its eligibility for asynchronous interruption by including the checked exception `AsynchronouslyInterruptedException` in its `throws` clause. If a schedulable is asynchronously interrupted while executing such a method, then an AIE will be delivered as soon as the schedulable is outside of a section in which ATC is deferred. Several idioms are available for handling an AIE, giving the programmer the choice of using `catch` clauses and a low-level mechanism with specific control over propagation, or a higher-level facility that enables specifying the interruptible code, the handler, and the result retrieval as separate methods.

Whereas ATC provides a general transfer mechanism for code declared to be interruptible, ATT is designed to safely terminate code that is not explicitly programmed for being interrupted asynchronously. Thus ATC is recoverable and ATT

is not. Otherwise, the mechanisms are quite similar.

12.1 Definitions

Termination Pending — The attribute of a task which has been aborted before its begins the termination process.

Control Transfer Pending — The attribute of a task which has been interrupted and either has not reached an asynchronous transition point or is in an ATC deferred section.

Asynchronous Interrupt — A request for a transfer of control.

Abort — A request for a task to be terminated.

Terminating — The state of a task that is in the process of unwinding its execution stack following its being aborted.

Transferring Control — The state of a task that is in the process of unwinding its execution stack to the next point where the `AsynchronouslyInterruptException` is caught.

Safe Point — A point in the code, where the task is guaranteed not to mutate the heap.

Self-Suspending Operation — Any operation that causes the task to potentially self suspend. Self-suspend operations include

- an attempt to acquire a monitor lock,
- a call to `Object.wait()`,
- a call to `Thread.sleep()`,
- a call to `RealtimeThread.waitForNextRelease()`, and
- any IO operation

Asynchronous Transition Point — Any point in the execution of a task when that task must cease executing user code and begin any pending asynchronous control transfer.

Transition Deferred Section — A section of code during the execution of which a task may not transfer from a pending state to a Transferring or Terminating state, i.e., contains no Asynchronous Transition Points. Transition deferred section are the following:

- synchronized statements,
- static initializers, and
- the execution of finally clauses.

Asynchronously Interrupted Exception (AIE) — An instance of the `javax.realtime.AsynchronouslyInterruptedException` class (a subclass of `java.lang.InterruptedException`).

Asynchronously Interruptible Method (AI-Method) — A method or constructor that includes `AsynchronouslyInterruptedException` explicitly (that is, not a subclass of `AsynchronouslyInterruptedException`) in its throws clause.

Asynchronous Transfer of Control (ATC) — A nonlocal transfer of program control in a task, initiated from outside that task.

ATC Deferred Section — A superset of transition deferred sections with the inclusion of all methods that do not declare `AsynchronouslyInterrupted-`

`Exception` in its throws clause. As specified in the introduction to Chapter 8 in *Java Language Specification*, a synchronized method is equivalent to a non-synchronized method with the body of the method contained in a synchronized statement. Thus, a synchronized AI method behaves like an AI method containing only an ATC-deferred statement.

Interruptible Blocking Methods — The `RTSJ` and standard Java methods that are explicitly interruptible by an AsynchronouslyInterruptedException (AIE). The interruptible blocking methods comprise

- `HighResolutionTime.waitForObject()`,
- `Object.wait()`,
- `Thread.sleep()`,
- `RealtimeThread.sleep()`,
- `Thread.join()`,
- `ScopedMemory.join()`,
- `ScopedMemory.joinAndEnter()`,
- `RealtimeThread.waitForNextReleaseInterruptible()`,
- `WaitFreeWriteQueue.read()`,
- `WaitFreeReadQueue.waitForData()`,
- `WaitFreeReadQueue.write()`,
- `WaitFreeDequeue.blockingRead()`,
- `WaitFreeDequeue.blockingWrite()`

and their overloaded forms. Furthermore, the method `waitForNextRelease` in `RealtimeThread` is interruptible when the thread's release parameters `isRousable` method returns `true`. Similarly, instances of `AsyncBaseEventHandlers` are released early when their release parameters `isRousable` method returns `true`.

***Generation* of an asynchronous control change request** — this is the event in the underlying system that makes the AIE available to the program.

***Delivery* of the asynchronous control change request** — this is the action in the target thread that begins unwinding the stack to reach point where, in the case of ATC, control continues or where, in the case of ATT, the stack is empty and control in that task ceases.

12.2 Semantics

Both asynchronous transfer of control (ATC) and asynchronous task termination (ATT) provide a means of ending computation asynchronously. Since the programmer must declare in which code ATC can be taken, the programmer can ensure that it is safe to asynchronously pass control to another section of code. ATT enables ending computation more generally, but always results in task termination.

12.2.1 Asynchronous Transition Point

Whether it be an ATT or an ATC request, there are two steps to engage asynchronous control flow: generating and delivering the change of control flow request. The first is done by the task requesting the change, either ATC or ATT, and the second by

the task in which the change takes place. Delivery should take place as soon as possible, but the program must be in a well-defined state when this change of control happens. For this, the runtime must define points, called asynchronous transition points (ATP), where this control change may take place in the receiving task.

There are three requirements for asynchronous transition points.

1. An asynchronous transition point (ATP) should occur at each safe point and must be at regular intervals in the code.
2. There must be an ATP at least at the following points:
   - any self-suspending operation,
   - the release of a monitor lock,
   - any transition between a deferred and a nondeferred section (in either direction),
   - any call to `Thread.interrupt()`,
   - any call to `Thread.start()`, and
   - any call to `AsyncBaseEvent.attach()`
3. In general, all calls to methods (inlining excepted) should be asynchronous transition points.

Whether or not reaching an ATP results in delivery of a pending control change depends on whether or not the point is in a Deferred Section for the type of the pending control change.

As with throwing any instance of `Throwable`, delivering a pending control change request begins the unwinding of the stack. During this unwinding, all `finally` clauses are executed. Where the unwinding ends depends on the type of the control change request.

12.2.2 Asynchronous Transfer of Control

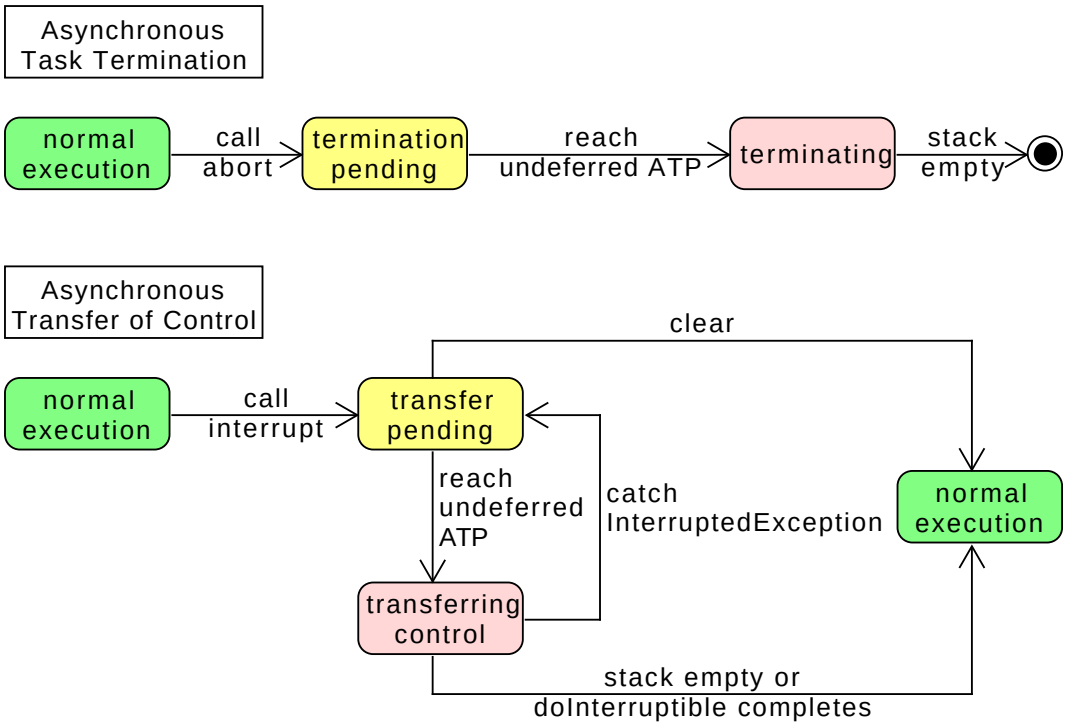
An ATC is generated by calling either the `fire()` method on an AIE where a task is in its `doInterruptible` method or the `Schedulable.interrupt()` method on a task. Between the generation of an AIE and its delivery, the exception is held *pending*. The AIE returns to pending after delivery was caught. It must be **cleared** by program logic, explicitly by using the `AsynchronouslyInterruptedException.clear()` method or implicitly when `AsynchronouslyInterruptedException.doInterruptible` completes, to proceed to the normal execution state at the new control flow point. Figure 12.1 illustrates the state transitions for ATC.

The following points define the semantics of ATC. Semantics that apply to particular classes, constructors, methods, and fields will be found in their detail sections, respectively.

1. An AIE is generated for a given task when
   - the `fire()` method is called on an AIE for which the task is executing within the `doInterruptible` method
   - or the `Schedulable.interrupt()` method is called.

   The latter is also effectively called when an AIE is generated by internal virtual machine mechanisms (such as an interrupted I/O operation) that are asynchronous to the execution of the program logic, which is the target of the AIE.

Figure 12.1: Control Flow Change State Diagrams



2. An AIE becomes pending upon generation and remains pending until explicitly cleared or replaced by another AIE.
3. An AIE is delivered to a schedulable when it is executing in a method declared to throw AIE, except in an ATC-deferred section as defined below.
   (a) The generation of an AIE through the `fire()` mechanism behaves as if it sets an asynchronously-interrupted status in the schedulable.
      i. When the schedulable is blocked within an interruptible blocking method or invokes an interruptible blocking method when this asynchronously-interrupted status is set, the invocation immediately completes by throwing the pending AIE and clearing the asynchronously-interrupted status.
      ii. When a pending AIE is explicitly cleared, the asynchronously-interrupted status is also cleared.
   (b) Blocking methods which are declared to throw `java.lang.IOException` but are not declared to throw `java.io.InterruptedException`, e.g., blocking methods in `java.io.*`, must be prevented from blocking indefinitely when invoked from a method with `AsynchronouslyInterruptedException` in its `throws` clause. When an AIE is generated and the target schedulable's control is blocked inside one of these methods with an AI-method on the call stack, the implementation may either unblock the blocked call, raise `java.lang.InterruptedIOException` on behalf of the call, or allow the call to complete normally if the implementation

determines that the call would unblock within a bounded period of time defined by the implementation.

(c) When an AI-method is attempting to acquire an object lock when an associated AIE is generated, the attempt to acquire the lock is abandoned.

(d) When control is in the lexical scope of an ATC-deferred section when an AIE (targeted at the executing schedulable) is generated, the AIE is not delivered until the first subsequent attempt to transfer control to code that is not ATC deferred. At that point, control is transferred to the `catch` or `finally` clause of the nearest dynamically-enclosing `try` statement that *i)* has a handler for the generated AIE (that is a handler naming the AIE's class or any of its superclasses, or a `finally` clause) and *ii)* is in an ATC-deferred section. Intervening handlers and `finally` clauses that are not in ATC-deferred sections are not executed, but object locks are released.

See Section 11.3 of *The Java Language Specification* second edition for an explanation of the terms: *dynamically enclosing* and *handler*. The `RTSJ` uses those JLS definitions unaltered. Note that if synchronized code is abandoned as a result of this control transfer, the associated locks are released.

4. A pending ATC becomes active at the next asynchronous transition point, not in an ATC deferred section.
5. Constructors are allowed to include `AsynchronouslyInterruptedException` in their `throws` clause and, if they do, will be asynchronously interruptible under the same conditions as AI methods.
6. Native methods that include `AsynchronouslyInterruptedException` in their `throws` clause have implementation-specific behavior.
7. An implementation must deliver the transfer of control in a schedulable that is subject to asynchronous interruption (in an AI-method but not in a synchronized block) within a bounded execution time of that schedulable. This worst-case response interval must be documented for some reference architecture.
8. Instances of the `Timed` class have a logically associated timer. When the timer fires, the schedulable executing the instance's `doInterruptible` method must have the AIE generated within a bounded execution time of the schedulable. This worst-case response interval must be documented for some reference architecture.
9. An AIE only has the semantics defined here when it originates with the `AsynchronouslyInterruptedException.fire()` method, the `Schedulable.interrupt()` method or from within the realtime VM. If an AIE is thrown from program logic using the Java throw statement, it uses the same semantics as throwing any other instance of a subclass of `Exception`, it is processed as a normal exception, and has no effect on the pending state of any AIE, and no effect on the firing of the AIE concerned.
10. The `Schedulable.interrupt()` method is a special case of ATC.

    (a) It causes the target task to throw the generic AIE and has the behaviors defined for `Thread.interrupt()`. This is the only interaction between

the ATC mechanism and the conventional `interrupt()` mechanism.

(b) An AEH that is waiting for a release and is rousable will release immediately as per Section 6.2.1.3.4 above with the generic AIE pending when it is interrupted.

(c) A RealtimeThread blocked in `waitForNextRelease` that is rousable will immediately return as per Section 6.2.1.3.2 with the generic AIE pending when it is interrupted.

11. The virtual machine must throw `AsynchronouslyInterruptedException` for interrupted `java.nio` methods as if RealtimeThread.interrupt() were called on the interrupted thread.

12.2.2.1 Extending Conventional Java Interrupts

The `RTSJ`'s approach to ATC is designed to follow the above principles. It is based on exceptions and is an extension of the current Java language rules for `java.lang.Thread.interrupt()`. In summary, ATC works as follows.

When `so` is an instance of a schedulable and the `interrupt()` method is called on the schedulable associated with that object, then the following holds.

1. When control is in an ATC-deferred section, then the AIE remains in a pending state. Execution continues normally until the first attempt to return to an AI method or invoke an AI method or exit a synchronized block within an AI method. Then ATC follows option 2 as appropriate.
2. When control is not in an ATC-deferred section, then control is transferred to the `catch` or `finally` clause of the nearest dynamically-enclosing `try` statement that is in an ATC-deferred section and has a handler for the generated AIE, i.e., is a handler naming the AIE's class or any of its superclasses, or a `finally` clause. Intervening handlers and `finally` clauses that are not in ATC-deferred sections are not executed, but objects locks are released. See section 11.3 of *The Java Language Specification* [5] for an explanation of the terms *dynamically enclosing* and *handlers*. The `RTSJ` uses those definitions unaltered.
3. When control is in an interruptible blocking method, the schedulable object is awakened and the generated AIE (which is a subclass of `InterruptedException)` is thrown with regular Java semantics (the AIE is still marked as pending). ATC then follows option 1 or 2 as appropriate.
4. When control is transferred from an ATC-deferred section to an AI method through the action of propagating an exception while an AIE is pending, when the transition to the AI-method occurs, the thrown exception is discarded and replaced by the pending AIE.

12.2.2.2 Nesting AsynchronouslyInterruptedExceptions

An AIE may be generated while another AIE is pending. Because AI code blocks are nested by method invocation (a stack-based nesting) there is a natural precedence among active instances of AIE. Let AIE_0 be the AIE raised when the `Schedulable.interrupt()` method is invoked and AIE_i ($i = 1, ..., n$, for n unique instances of AIE) be the AIE generated when AIE.`fire()` is invoked. In the following, the phrase "a frame deeper on the stack than this frame" refers to a stack frame further

from stack base. The phrase "a frame shallower on the stack than this frame" refers to a stack frame nearer to the stack base.

1. When the current AIE is an AIE_0 and the new AIE is an AIE_x associated with any frame on the stack, the new AIE (AIE_x) is discarded.
2. When the current AIE is an AIE_x and the new AIE is an AIE_0, the current AIE (AIE_x) is replaced by the new AIE (AIE_0).
3. When the current AIE is an AIE_x and the new AIE is an AIE_y from a frame deeper on the stack, the new AIE (AIE_y) is discarded.
4. When the current AIE is an AIE_x and the new AIE is an AIE_y from a frame shallower on the stack, the current AIE (AIE_x) is replaced by the new AIE (AIE_y).
5. When the current AIE is an AIE_0 and the new AIE is an AIE_0, or when the current AIE is an AIE_x and the new AIE is an AIE_x, the new AIE is discarded.

When `clear()` is called on a pending AIE or that AIE is superseded by another, the first AIE's pending state is cleared. Clearing a nonpending AIE (with the `clear()` method) has no effect.

12.2.3 Asynchronous Task Termination

Asynchronous task termination provides a best effort termination facility for tasks. It ensures that each task unwinds its stack in a well-defined way, so that it has a chance to release all resources it has taken. As illustrated in Figure 12.1, ATT has simpler state transitions than ATC. As with ATC, a generated ATT is first pending, but once it is delivered, it cannot return to the pending state.

The following rules govern ATT.

1. Any task, with the required security permissions, can abort any instance of `AsynchronousControlGroup` to which it has a reference.
2. A call to method `AsynchronousControlGroup.abort()` shall immediately mark the group and all tasks it contains as termination pending.
3. A task marked with termination pending shall enter its abort phase at its next asynchronous transition point not in an transition deferred section.
4. An asynchronous transition point for ATT is the same as for ATC except for what sections of code are deferred.
5. A task, on entering into its termination phase, shall behave as if an uncatchable `Error` has been thrown at the point in the code where the task moves from termination pending to terminating. When the task enters the terminating state, any uncaught exception handler set for the task shall be executed.
6. A task in the terminating phase shall be prohibited from execution any self-suspending operations except `close` and acquiring a lock.

In order for the abort mechanism to work, the system must prevent the application from doing any of the following.

1. All `finally` and catch `Throwable` clauses must terminate.
2. No `finally` or catch `Throwable` clause call may self suspend except for calls to close and taking a monitor.

These rules cannot be enforced completely at runtime. Static analysis and signing

the resultant code before loading is needed to ensure proper functioning of ATT.

12.3 javax.realtime.control

12.3.1 Interfaces

12.3.1.1 Interruptible

---

public interface Interruptible

Description

`Interruptible` is an interface implemented by classes that will be used as arguments on the methods`doInterruptible()` of `AsynchronouslyInterruptedException` and its subclasses. `doInterruptible()` invokes the implementations of the methods in this interface.

12.3.1.1.1 Methods

---

run(AsynchronouslyInterruptedException)

Signature

```
public void
run(AsynchronouslyInterruptedException exception)
throws AsynchronouslyInterruptedException
```

Description

The main piece of code that is executed when an implementation is given to `doInterruptible()`. When a class is created that implements this interface, for example through an anonymous inner class, it must include the `throws` clause to make the method interruptible.

Parameters

`exception`—The AIE object whose doInterruptible method is calling the `run` method. Used to invoke methods on `AsynchronouslyInterruptedException` from within the `run()` method.

interruptAction(AsynchronouslyInterruptedException)

Signature

```
public void
interruptAction(AsynchronouslyInterruptedException exception)
```

Description

This method is called by the system when the `run()` method is interrupted. By using this, the program logic can determine when the `run()` method completed normally or had its control asynchronously transferred to its caller.

Parameters

`exception`—The currently pending AIE. Used to invoke methods on `AsynchronouslyInterruptedException` from within the `interruptAction()` method.

12.3.2 Classes

12.3.2.1 AsynchronousControlGroup

---

public class AsynchronousControlGroup

Inheritance

java.lang.Object
  java.lang.ThreadGroup
    javax.realtime.RealtimeThreadGroup
      AsynchronousControlGroup

Description

An enhanced `RealtimeThreadGroup` in which asynchronous task termination can be performed. It defines a set of tasks, both instances of `javax.realtime.Schedulable` and `java.lang.Thread`, that can be terminated together. By combining this with a class loader, one can build a virtual process within a Java runtime environment.

12.3.2.1.1 Constructors

AsynchronousControlGroup(RealtimeThreadGroup, String)

Signature

```
public
AsynchronousControlGroup(RealtimeThreadGroup parent,
                         String name)
```

Description

Creates a new asynchronous control group with its scheduler type inherited from `parent`.

Parameters

`parent`—The parent group of the new group

`name`—The name of the new group

Throws

`StaticIllegalStateException`—when the parent `ThreadGroup` instance is not an instance of `RealtimeThreadGroup`.

`IllegalAssignmentError`—when the parent `ThreadGroup` instance is not assignable to this.

AsynchronousControlGroup(String)

Signature

```
public
AsynchronousControlGroup(String name)
throws StaticIllegalStateException,
       IllegalAssignmentError
```

Description

Creates a new group with the current `ThreadGroup` instance as its parent and that parent's scheduler type for its scheduler type. That parent must be an instance of `RealtimeThreadGroup`. The primordial realtime thread group has `Scheduler.class` as its scheduler type.

Parameters

`name`—The name of the new group

Throws

`StaticIllegalStateException`—when the parent `ThreadGroup` instance is not an instance of `RealtimeThreadGroup`.

`IllegalAssignmentError`—when the parent `ThreadGroup` instance is not assignable to this.

12.3.2.1.2 Methods

---

abort

Signature

```
public void
abort()
```

Description

Terminate all tasks running in this thread group.

12.3.2.2 AsynchronouslyInterruptedException

---

public class AsynchronouslyInterruptedException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.InterruptedException
        AsynchronouslyInterruptedException

Description

A special exception that is thrown in response to an attempt to asynchronously transfer the locus of control of a schedulable.

An instance of javax.realtime.Schedulable executing a method or constructor, which lists AsynchronouslyInterruptedException in its `throws` clause, can be asynchronously interrupted except when it is executing in the lexical scope of a synchronized statement within that method/constructor. As soon as the `Schedulable` object leaves the lexical scope of the method by calling another method/constructor it may be asynchronously interrupted when the called method/constructor is asynchronously interruptible. (See this chapter's introduction section for the detailed semantics).

The asynchronous interrupt is generated for a `Schedulable`, `s`, when the `s.interrupt()` method is called or the fire method is called of an AIE for which `s` has a `doInterruptible` method call in progress.

When an asynchronous interrupt is generated when the target `Schedulable` is executing within an ATC-deferred section, the asynchronous interrupt becomes pending. A pending asynchronous interrupt is delivered when the target `Schedulable` next attempts to enter asynchronously interruptible code.

Asynchronous transfers of control (ATCs) are intended to allow long-running computations to be terminated without the overhead or latency of polling with `java.lang.Thread.interrupted()`.

When javax.realtime.Schedulable.interrupt, or `AsynchronouslyInterruptedException.fire()` is called, the `AsynchronouslyInterruptedException` is compared against any currently pending `AsynchronouslyInterruptedException` on the `Schedulable`. When there is none, or when the depth of the `AsynchronouslyInterruptedException` is less than the currently pending `AsynchronouslyInterruptedException`; (i.e., it is targeted at a less deeply nested method call), the new `AsynchronouslyInterruptedException` becomes the currently pending `AsynchronouslyInterruptedException` and the previously pending `AsynchronouslyInterruptedException` is discarded. Otherwise, the new `AsynchronouslyInterruptedException` is discarded.

When an `AsynchronouslyInterruptedException` is caught, the catch clause may invoke the `clear()` method on the `AsynchronouslyInterruptedException` in which it is interested to see if the exception matches the pending `AsynchronouslyInterruptedException`. When so, the pending `AsynchronouslyInterruptedException` is cleared for the `Schedulable` and `clear` returns true. Otherwise, the current AIE remains pending and `clear` returns `false`.

`Schedulable.interrupt()` generates the generic `AsynchronouslyInterruptedException` which will always propagate outward through interruptible methods until the generic `AsynchronouslyInterruptedException` is identified and handled. The pending state of the generic AIE is per-instance of `Schedulable`.

Other sources (e.g., `AsynchronouslyInterruptedException.fire()` and Timed) will generate specific instances of `AsynchronouslyInterruptedException` which applications can identify and thus limit propagation.

12.3.2.2.1 Constructors

AsynchronouslyInterruptedException

Signature

```
public
AsynchronouslyInterruptedException()
```

Description

Creates an instance of `AsynchronouslyInterruptedException`.

AsynchronouslyInterruptedException(String)

Signature

```
public
AsynchronouslyInterruptedException(String message)
```

Description

Creates an instance of `AsynchronouslyInterruptedException`.

Parameters

`message`—A message to identify this instance.

12.3.2.2.2 Methods

getGeneric

Signature

```
public static javax.realtime.control.AsynchronouslyInterruptedException
getGeneric()
throws IllegalTaskStateException
```

Description

Gets the singleton system generic `AsynchronouslyInterruptedException` that is generated when `javax.realtime.Schedulable.interrupt()` is invoked.

Throws

`IllegalTaskStateException`—when the current thread context is not an instance of `javax.realtime.Schedulable`.

Returns

the generic `AsynchronouslyInterruptedException`.

enable

Signature

```
public boolean
enable()
```

Description

Enables the throwing of this exception. This method is valid only when the caller has a call to `doInterruptible` in progress. When invoked when no call to `doInterruptible` is in progress, `enable` returns `false` and does nothing.

Returns

`true`, when `this` was disabled before the method was called and the call was invoked whilst the associated `doInterruptible` was in progress, and `false` otherwise.

disable

Signature

```
public synchronized boolean
disable()
```

Description

Disables the throwing of this exception. When the `fire` method is called on `this` AIE whilst it is disabled, the fire is held pending and delivered as soon as the AIE is enabled and the interruptible code is within an AI-method. When an AIE is pending when the associated disable method is called, the AIE remains pending, and is delivered as soon as the AIE is enabled and the interruptible code is within an AI-method.

This method is valid only when the caller has a call to `doInterruptible` in progress. If invoked when no call to `doInterruptible` is in progress, `disable` returns `false` and does nothing.

Returns

`true`, when `this` was enabled before the method was called and the call was invoked with the associated `doInterruptible` in progress, and `false` otherwise.

isEnabled

Signature

```
public boolean
isEnabled()
```

Description

Queries the enabled status of this exception.

This method is valid only when the caller has a call to `doInterruptible` in progress. If invoked when no call to `doInterruptible` is in progress, `enable` returns `false` and does nothing.

Returns

`true`, when this is enabled and the method call was invoked in the context of the associated `doInterruptible`, and `false` otherwise.

fire

Signature

```
public boolean
fire()
```

Description

Generates this exception when its `doInterruptible` has been invoked and not completed. When `this` is the only outstanding AIE on the `schedulable` object that invoked this AIE's `doInterruptible(Interruptible)` method, this AIE becomes that `schedulable`'s current AIE. Otherwise, it only becomes the current AIE when it is at a less deep level of nesting compared with the current outstanding AIE.

Behaves as if `Thread.interrupt()` were called on the task currently operating within this exception's `doInterruptible`.

Returns

`true`, when `this` is not disabled and it has an invocation of a `doInterruptible` in progress and there is no outstanding fire request, and `false` otherwise.

doInterruptible(Interruptible)

Signature

```
public boolean
doInterruptible(Interruptible logic)
```

Description

Executes the `run()` method of the given `Interruptible`. This method may be on the stack in exactly one `javax.realtime.Schedulable` object. An attempt to invoke this method in a `schedulable` while it is on the stack of another or the same `schedulable` will cause an immediate return with a value of `false`.

The `run()` method of the given `Interruptible` is always entered with the exception in the enabled state, but that state can be modified with `enable()` and `disable()`, and the state can be observed with `isEnabled()`.

This AIE is cleared on return from `doInterruptible`.

Parameters

`logic`—An instance of an `Interruptible` whose `run()` method will be called.

Throws

`IllegalTaskStateException`—when called on the generic `AsynchronouslyInterruptedException`.

`StaticIllegalArgumentException`—when `logic` is `null`.

Returns

`true`, when the method call completed normally, and `false`, when another call to `doInterruptible` has not completed.

Since RTSJ 2.0 no longer throws an exception when called from a Java thread.

clear

Signature

```
public boolean
clear()
```

Description

Atomically checks whether or not `this` is pending on the currently executing `schedulable`, and when so, makes it non-pending.

This method may be called at any time, and in particular need not be called in a `try` or `catch` block.

Returns

`true`, when `this` was pending, and `false`, when `this` was not pending.

Since RTSJ 1.0.1
Since RTSJ 2.0 no longer throws an exception when called from a task that is not an instance of `javax.realtime.Schedulable`.

throwPending

Signature

```
public static void
throwPending()
throws AsynchronouslyInterruptedException
```

Description

Causes a pending `AsynchronouslyInterruptedException` to be thrown as a synchronous exception in an ATC-deferred region if one exists.

Throws

`AsynchronouslyInterruptedException`—if an AIE is pending.

Since RTSJ 2.0

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Does nothing, since no stacktrace is kept.

Returns

`this` instance.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

Does nothing, since no stacktrace is kept.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

No stacktrace is kept, so none can be returned.

Returns

an empty array.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

No stacktrace is kept, so a message to that effect is printed.

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

No stacktrace is kept, so a message to that effect is printed.

Parameters

`stream`—A `PrintStream` for printing

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

No stacktrace is kept, so a message to that effect is printed.

Parameters

`writer`—A `PrintWriter` for printing

12.3.2.3 Timed

---

public class Timed

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.InterruptedException
        AsynchronouslyInterruptedException
          Timed

Description

Creates a scope in a `javax.realtime.Schedulable` object which will be asynchronously interrupted at the expiration of a timer. This timer will begin measuring time at some point between the time `doInterruptible` is invoked and the time when the `run()` method of the `Interruptible` object is invoked. Each call of `doInterruptible` on an instance of `Timed` will restart the timer for the amount of time given in the constructor or the most recent invocation of `resetTime()`. The timer is cancelled when it has not expired before the `doInterruptible` method has finished.

All memory use of an instance of `Timed` occurs during construction or the first invocation of `doInterruptible`. Subsequent invocations of `doInterruptible` do not allocate memory.

When the timer fires, the resulting AIE will be generated for the schedulable within a bounded execution time of the targeted schedulable.

Typical usage: `new Timed(T).doInterruptible(interruptible);`

12.3.2.3.1 Constructors

Timed(HighResolutionTime)

Signature

```
public
Timed(javax.realtime.HighResolutionTime<?> time)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException
```

Description

Creates an instance of `Timed` with a timer set to `time`. When the `time` is in the past the `AsynchronouslyInterruptedException` mechanism is activated immediately after or when the `doInterruptible` method is called.

Parameters

`time`—When `time` is a `javax.realtime.RelativeTime` value, it is the interval of time between the invocation of `doInterruptible` and the time when the schedulable is asynchronously interrupted. When `time` is an `javax.realtime.AbsoluteTime` value, the timer asynchronously interrupts at this time (assuming the timer has not been cancelled).

Throws

`StaticIllegalArgumentException`—when `time` is `null`.

`StaticUnsupportedOperationException`—when `time` is not based on a `javax.realtime.Clock`.

12.3.2.3.2 Methods

---

doInterruptible(Interruptible)

Signature

```
public boolean
doInterruptible(Interruptible logic)
```

Description

Executes a timeout method by starting the timer and executing the `run()` method of the given `Interruptible` object.

Parameters

`logic`—An instance of an `Interruptible` whose `run()` method will be called.

Throws

`StaticIllegalArgumentException`—when `logic` is `null`.

`IllegalThreadStateException`—null

Returns

`true`, when the method call completed normally, and `false`, when another call to `doInterruptible` has not completed.

resetTime(HighResolutionTime)

Signature

```
public void
resetTime(javax.realtime.HighResolutionTime<?> time)
```

Description

Sets the timeout for the next invocation of `doInterruptible`.

Parameters

`time`—This can be an absolute time or a relative time. When `null` or not based on a `javax.realtime.Clock`, the timeout is not changed.

restart(HighResolutionTime)

Signature

```
public void
restart(javax.realtime.HighResolutionTime<?> time)
```

Description

Resets the timeout. When this `Timed` instance is executing, it adjusts the timeout to `time` and restarts the timer. When the instance is not executing, it adjusts the timeout for the next invocation.

Parameters

`time`—The new timeout.

Throws

`StaticIllegalArgumentException`—when `time` is `null` or a relative time less than zero.

`StaticUnsupportedOperationException`—when `time` is not based on a `javax.realtime.Clock`

Since RTSJ 2.0

12.4 Rationale

The ability to interrupt a task asynchronously is necessary in many kinds of applications, but such a facility must be designed carefully in order to minimize the risks of problems such as data structure corruption and deadlock. There is, invariably, a tension between the desire to cause an ATC to be immediate, and the desire to ensure that certain sections of code are executed to completion.

12.4.1 Asynchronous Transfer of Control

One basic decision was provide ATC, but only allow it in methods that explicitly permits it. The default of no ATC is reasonable, since most code is not written expecting ATC and asynchronously aborting the execution of such a method could lead to unpredictable results. Since the natural way to model ATC is with an exception (`AsynchronouslyInterruptedException`), the way that a method indicates

its susceptibility to ATC is by including `AsynchronouslyInterruptedException` in its `throws` clause. Causing this exception to be thrown in a schedule `s` as an effect of calling `s.interrupt()` was a natural extension of the semantics of interrupt as currently defined by `java.lang.Thread`.

One ATC-deferred section is `synchronized` code. This is a context that needs to be executed completely in order to ensure a program operates correctly. If `synchronized` code were aborted, a shared object could be left in an inconsistent state. Note that by making synchronized code ATC-deferred, this specification avoids the problems that caused `Thread.stop()` to be deprecated and that have made the use of `Thread.destroy()`, (now also deprecated in Java 1.5) prone to deadlock. If `synchronized` code calls an AI-method and an associated AIE is generated, then if no appropriate handler is present in the synchronized code, the AIE will propagate through the code.

Constructors and `finally` clauses are subject to interruption if the program indicates so. However, if a constructor is aborted, an object might be only partially initialized. If the execution of a `finally` clause in an AI-method is aborted, needed cleanup code might not be performed. Indeed, a `finally` clause in an aborted AI-method will not be executed at all if the abort occurs before its execution begins. It is the programmer's responsibility to ensure that executing these constructs either does not induce unwanted ATC latency (if ATCs are not allowed) or does not produce undesirable results (if ATCs are allowed).

A potential problem with using the exception mechanism to model ATC is that a method with a "catch-all" handler (for example a `catch` clause identifying `Exception` or even `Throwable` as the exception class) can inadvertently intercept an exception intended for a caller. This problem is avoided by having special semantics for catching an AIE. Even though a catch clause may catch an AIE, the exception will be propagated unless the handler invokes the `happened` method from AIE. Thus, if a schedulable is asynchronously interrupted while in a try block that has a handler such as

```
catch (Throwable e)  return;
```

the AIE will remain pending and will be thrown next time control enters or returns to an AI method.

This specification does not provide a special mechanism for terminating a realtime thread; ATC can be used to achieve this effect. This means that, by default, a realtime thread cannot be asynchronously terminated; to support asynchronous termination it needs to enter methods that are AI enabled at frequent intervals. Allowing termination as the default would have been questionable, bringing the same insecurities that are found in `Thread.stop()` and `Thread.destroy()`.

12.4.2 Asynchronous Task Termination

The trend towards microservices is just as applicable to realtime and embedded systems as to more conventional systems. It is often necessary to be able to terminate a single service in the system without affecting the rest of the system.

Though Java provides class loaders and thread groups to help insulate one service from another, there is no way of forcing a service to stop. ATT provides this, but

it can only provide limited safety, therefore it has been designed to take an entire group of threads down at once. Using it together with a class loader can minimize some of the problems associated with `Thread.stop()`.

In order to help preserve the state of the rest of the system, two decisions were made:

- all finally clauses are executed and
- only an entire realtime thread group can be aborted.

This means that malicious code could still prevent termination with faulty finalization code. For instance, the code sequence `while(true);`, can prevent termination. Therefore, some static analysis and signing should be used for code that one might want to terminate.

Chapter 13

Devices and Triggering

Interacting with the external environment in a timely manner is an important requirement for realtime, embedded systems. From an embedded system's perspective, all interactions with the physical world are performed by input and output devices. Hence, the problem is one of controlling and monitoring of devices. This is an area insufficiently addressed by other Java standards. A conventional Java Virtual Machine is not designed to support device access and interrupt handling. Programs that need this functionality must resort to code written in another language and called via the Java Native Interface (JNI). This specification addresses the problem by providing APIs for interrupt handling and direct memory access without resorting to JNI.

In contrast to earlier versions of this specification, version 2.0 has extended the goals of the device interfaces to be type safe and user extensible, so that the user can define new devices without changing the underlying virtual machine.

There are at least four execution (runtime) environments for the `RTSJ`:

1. on a realtime operating system where the Java application runs in user mode;
2. on a realtime operating system where the Java application runs in a context with a user space device driver;
3. as a "kernel module" incorporated into a realtime kernel where both kernel and application run in supervisor mode; and
4. as part of an embedded device where the Java application runs stand-alone on a hardware machine.

This specification should be implementable for all of these.

In execution environment 1, interaction with the embedded environment is usually via operating system calls using Java's connection-oriented APIs. The Java program will typically have no direct access to the I/O devices. Although some limited access to physical memory may be provided, it is unlikely that interrupts can be directly handled. However, asynchronous interaction with the environment is still possible, for example, via POSIX signals.

In the other execution environments, 2, 3, and 4, a Java program may be able to directly access devices and handle interrupts.

A device can be anything from a simple set of registers wired to sensors and actuators to a full processor performing some fixed task. The interface to a device is usually through a set of device registers. Depending on the I/O architecture of

the processor, the programmer can either access these registers via predetermined memory location (called *memory mapped I/O*) or via special assembler instructions (called *port-mapped I/O*).

A computer system with processing devices can be considered to be a collection of parallel threads. The device 'thread' can communicate and synchronize with the tasks executing inside the main processor either by having the main processor poll registers of the device or via a signal from the device. This signal is usually referred to as an interrupt. All high-level models of device programming must provide [3]

1. facilities for representing, addressing and manipulating device registers; and
2. a suitable representation of interrupts (if interrupts are to be handled).

Version 1.0 of the `RTSJ` went some way towards supporting this model through the notion of *happenings* and the *raw memory* access facilities. Unfortunately, happenings were under defined and the mechanisms for physical and raw memory were overly complex with no clear delineation of the separations of concerns between application developers and JVM implementors. Interrupt service routines were not considered at all.

Version 2.0 has significantly enhanced the support for happenings, and has provided a clearer separation between physical and raw memory. The interfaces for `Happening`, `Timer`, and `Signal`, as well as the new `RealtimeSignal`, are now unified under `ActiveEvent`. This means that `Happening`, `Signal`, and `RealtimeSignal`, like `Timer` are now subclasses of `AsyncBaseEvent`. As described in Chapter 8, `ActiveEvent` provides a common light-weight means of notifying that its event has occurred. Unlike `fire()`, where dispatching of the associated handlers is done in context of the caller, an `ActiveEvent` separates this notification that the event occurred, its triggering, from the dispatching by providing its own execution context for the dispatching. As with `Timer`, each class has its own `ActiveEventDispatcher`: `HappeningDispatcher`, `TimeDispatcher`, `SignalDispatcher`, and `RealtimeSignalDispatcher`. Finally, provisions for interrupt service routines have been made as well.

13.1 Definitions

Direct Memory Access (DMA) — A data transfer directly to memory without CPU intervention, as in DMA controller.

DMA Controller — A device that can move data in memory without using the CPU.

Happening — An event that takes place outside the Java runtime environment. The triggers for happenings depend on the external environment, but happenings might include signals and interrupts.

Interrupt Service Routine (ISR) — A special task that is executed when an interrupt happens. This code runs with execution eligibility higher than normal execution eligibities and can only be interrupted by another interrupt.

Raw Memory — A means of mapping memory locations, such as device registers, into Java objects for direct access from Java code without using JNI. The memory to map can be in an arbitrary address space.

Raw Memory Region — An address space for Raw Memory.

Stride — The distance between two memory locations. Adjacent memory locations have a stride of one. Stride is measured as units of the memory location size. For example, the stride between two bytes that are adjacent and two integers that are adjacent is both one, but the actual address offsets are one and four bytes respectively.

Open issue 13.1.1 (elb)

Check consistency with the JMM.

End of issue 13.1.1

13.2 Semantics

The classes in this Chapter are part of the Device Module introduced in Section 3.2.2.2 and are only required in implementations that include that module. There are several aspects of the API for supporting devices. Raw Memory provides the means of accessing the I/O register of a device. Direct Memory Access (DMA) support provide a means of transferring data using a DMA controller. Active events and dispatchers support releasing event handlers based on external events. Interrupt service routines and application-defined clocks are for linking external events to the internal active events.

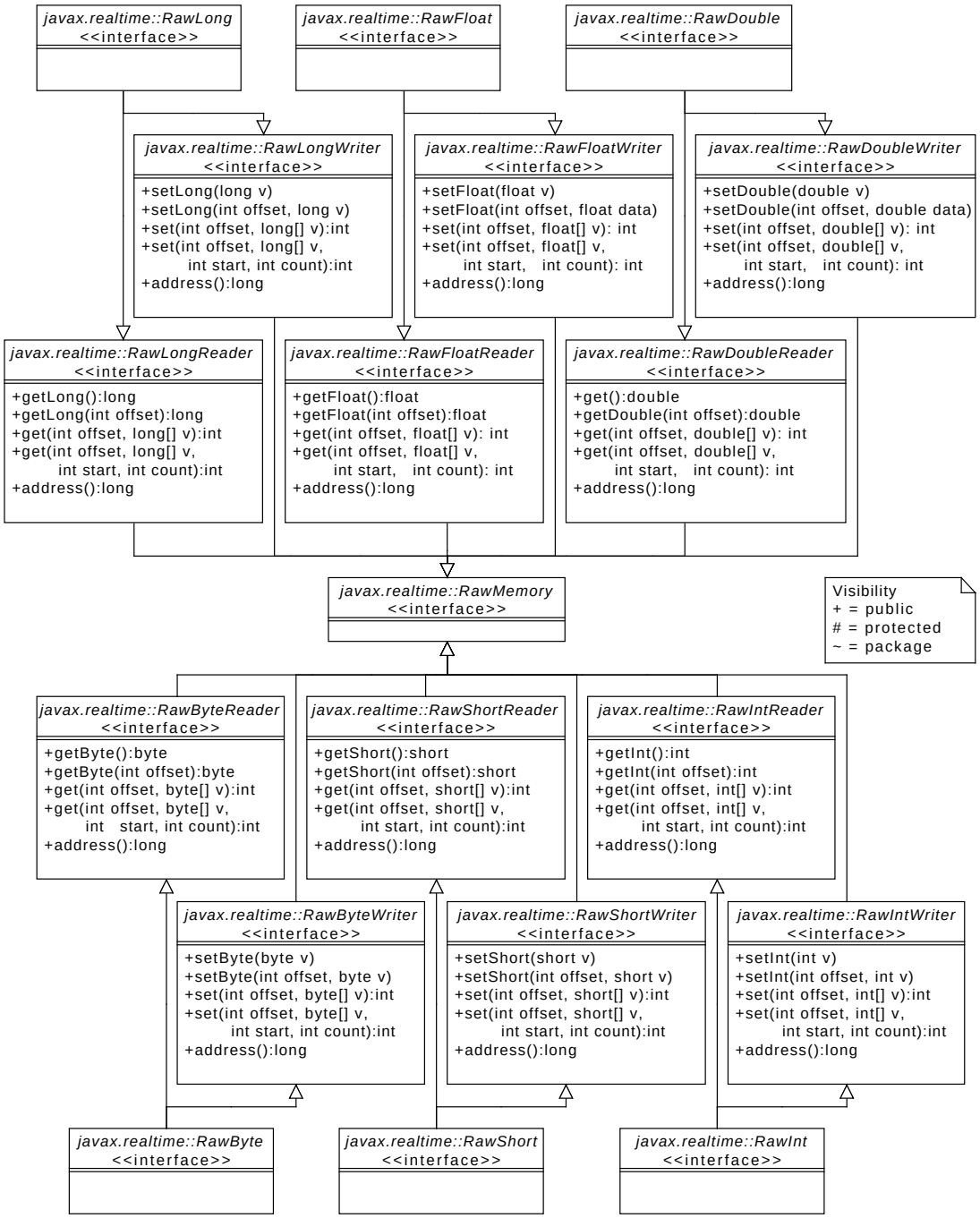
13.2.1 Raw Memory

Raw Memory provides means of accessing particular physical memory addresses as variables of Java's primitive data types, and thereby provides an application with direct access to physical memory, for example, for memory-mapped I/O.

Java objects or references therefore *cannot* be stored in raw memory. The following specifies the `RTSJ`'s facilities for raw memory access.

1. Each area of memory supporting raw memory access is identified by a subclass of `RawMemoryRegion`.
   (a) The raw memory region `RawMemoryFactory.MEMORY_MAPPED_REGION` facilitates access to memory locations that are outside the main memory used by the JVM. It is used to access input and output device registers when such registers are memory mapped.
   (b) The raw memory region `RawMemoryFactory.IO_PORT_MAPPED_REGION` facilitates access to locations that are outside the main memory used by the JVM. It is used to access input and output device registers when such registers are port-based and can only be accessed by special hardware instructions.
   (c) The application developer can define and register additional regions to support things like emulated access to devices or access to a bus over a bus controller.
2. Access to raw memory is controlled by implementation-defined objects, called *accessor objects*. These implement specification-defined interfaces (e.g., `RawByte`, `RawShort`, `RawInt`, etc.) and are created by implementation-defined factory objects. Each factory implements the `RawMemoryRegionFactory` interface, and is identified by its `RawMemoryRegion`.

Figure 13.1: Raw Memory Interface



3. The `RawMemoryFactory` class defines the application programmer's interface to the raw memory facilities.
4. The `RawMemoryRegionFactory` interface defines the interface that all factories must support for creating accessor objects.

13.2.1.1 Raw Memory Region

Raw memory is designed to support arbitrary I/O address spaces. The simplest of which is through the processor address space and is accessible via standard memory access instructions, such as `load` and `store`. This provides access to memory mapped I/O devices, but there are other address spaces as well. Each of these address spaces is referred to as a *Raw Memory Region*.

There are two raw memory regions that can be supported generically. Memory mapped I/O is one. The other is port mapped I/O. The most common instance is the I/O space provided by Intel x86 compatible processors through their **in** and **out** instructions. The memory mapped I/O raw memory region must be supported by all implementations, but the port mapped I/O raw memory region must only be supported on processors that have the necessary I/O instructions.

All other raw memory regions are optional and may be provided by a system integrator or an application developer. The API provides an interface, `RawMemoryRegionFactory`, that can be implemented to provide a means of creating accessor objects for that region. These additional regions can be anything from an I/O space provided by a memory mapped device, using memory mapped I/O to implement it, to a purely synthetic I/O space to emulate hardware that has not yet been built.

Each raw memory region is identified by its raw memory region object. These "types" are defined by instances of `RawMemoryRegion`: `RawMemoryFactory.MEMORY_MAPPED_REGION` for memory mapped devices and `RawMemoryFactory.IO_PORT_MAPPED_REGION` for port mapped devices for processors that have instructions for reading from and writing to an I/O bus directly. The instances are used to get accessors of a region instead of using a `RawMemoryRegionFactory` directly.

13.2.1.2 Raw Memory Factory

In order to support a variety of device address spaces efficiently, raw memory objects are created using the factory methods provided by `RawMemoryFactory`. This factory provides static methods to get accessors for a region via a region's type. Regions created during runtime can be provided by registering their factory with the main raw memory factory, so the application code only needs to have a reference to the object identifying the required region. For instance, one could create an I^2C raw memory region by implementing a factory for it using a memory mapped I^2C controller.

13.2.1.3 Stride

Since the word size of devices do not always match the word size of the memory or I/O bus, the interface provides for the notion of stride. Stride defines the distance between elements in a raw memory area. Normally elements of a memory area are mapped sequentially, without any space between the elements. This is a stride of

one. A stride of two, means that every other element in physical memory is mapped into the raw memory area.

For example, it is often easier to map a 16 bit device into a 32 bit system by mapping the 16 bit registers at 32 bit intervals. This enables 16 bit accesses to the device to be atomic on 32 bit addressed systems, even when the bus always does 32 bit transfers. One can create a `RawShort` area with a stride of two. Then the area can be accessed as if the registers where contiguous.

Since stride is designed to support mapping devices that have a smaller word size than the host machine, the implementation is allowed to assume that the padding between values is "do not care" data, and can be overwritten arbitrarily.

13.2.2 Direct Memory Access Support

Many embedded systems provide a means of moving data without direct involvement of the main processor. This is typically programmed with a special device called a DMA controller. DMA controllers are treated specially since they are central to bulk transfer in device drivers. The data to be transferred is not in device registers, but in normal RAM. Java already provides an API for managing this kind of memory in `java.nio`. The DMA API defined here provides a seamless means of integrating those features into a device driver for DMA.

There are various architectures for DMA controllers, each requiring its own programming paradigm, so only common low level support is provided by this specification. Raw memory can be used to program the DMA controller, but there needs to be a means of representing bulk data. The `java.nio.ByteBuffer` provides just such a representation. The only difference is that the restrictions on the memory behind byte buffer objects are different than for other `java.nio` mechanisms.

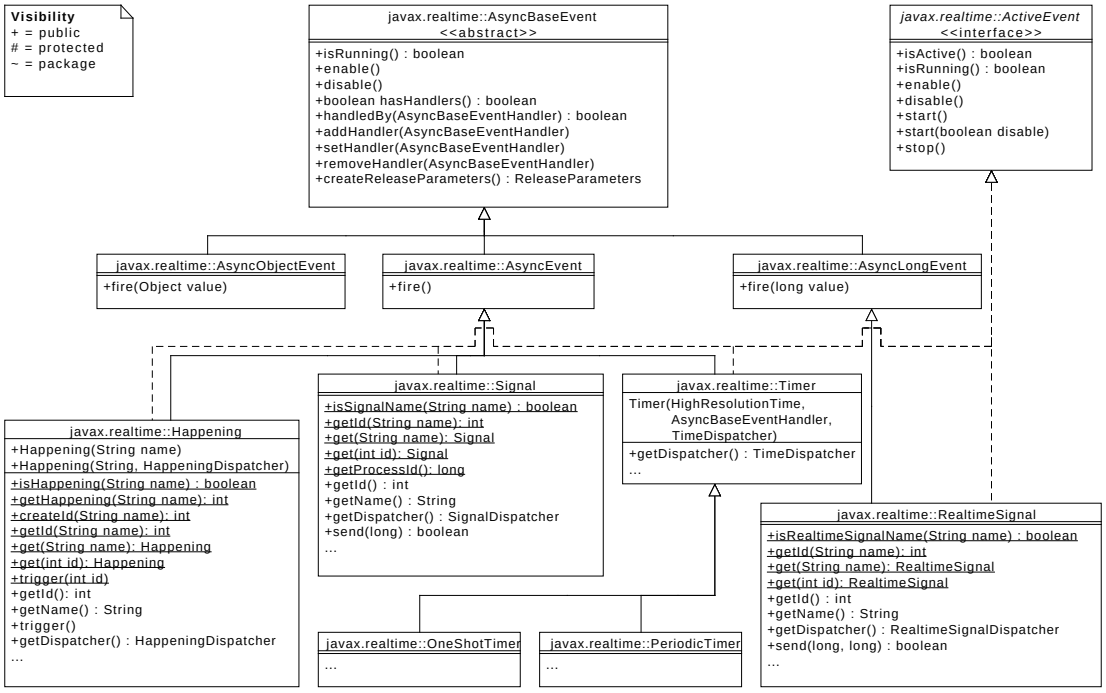
These differences are covered with a special byte buffer factory: `DirectMemoryBufferFactory`. An instance of this factory can produce direct byte buffers within a given memory range. This range can be chosen by the programmer to be within the range of a given DMA controller. The factory also provides methods for getting the start address of a buffer's memory and checking if a buffer's memory is within a given range. These addresses should be compatible with DMA controllers in the system, though for controllers with a smaller address space than the processor, the DMA address may have fixed offset from the processor physical address. The `DirectMemoryBufferFactory` class also provides static methods for ensuring that Java-generated changes to DMA-mapped memory buffers are visible to native code, and vice versa.

13.2.3 External Triggering

It is not enough to be able to read from and write to devices; many applications need a means of being interrupted when an event happens. This specification provides a two-level interrupt mechanism. For predefined interfaces, such as POSIX signals, the first level handling is provided by the virtual machine and asynchronous events provide the second level event handling. For external events and additional clocks, where the programmer needs to be able to define new instances and provide for their

triggering, additional classes are provided to manage both the first level and the second level handling. In all cases, the user can control the priority and affinity of the dispatching between the first level and second level handing.

Figure 13.2: Event Classes



13.2.3.1 Happenings

Whereas in previous versions of this specification, happenings were represented as a `String`, as of 2.0 they have become an object in their own right. This makes it easier to properly type methods that use them and for the user to define new happening for an application without the need to change the JVM. Furthermore, indirection is minimized by making the new `Happening` class a subclass of `AsyncEvent`.

Since a `Happening` needs to be triggerrable from an external event, such as an interrupt, the `Happening` class also implements `ActiveEvent` as depicted in Figure 13.2. As with other active events, `Happening` has its own dispatcher class: `HappeningDispatcher`. There is a default happening dispatcher that is used when none is provided at creation time, otherwise, the programmer can provide one to change the priority and affinity of dispatching.

Normally, happenings are triggered either from an `InterruptServiceRoutine` or from JNI code. For the later, the interface provides a means of linking a happening by name. This enables native code to get a handle for triggering a happening without having a direct reference. The given name must follow the Java naming conventions. A happening name defined outside of this specification should not begin with `java` or `javax`.

Figure 13.3: Happening State Transition Diagram

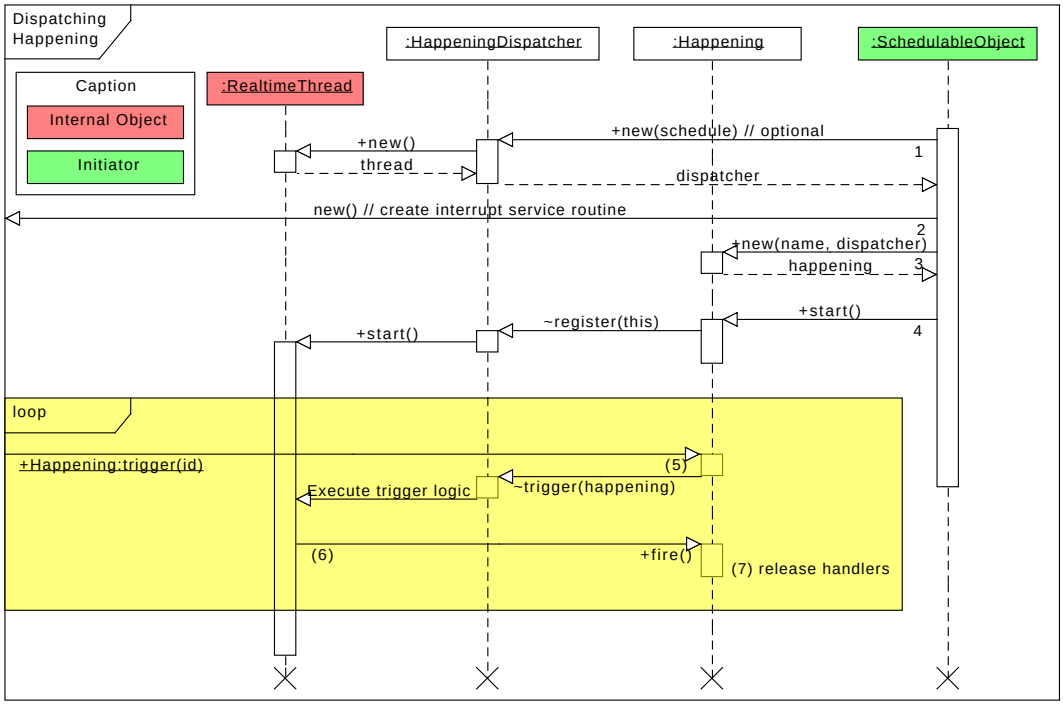
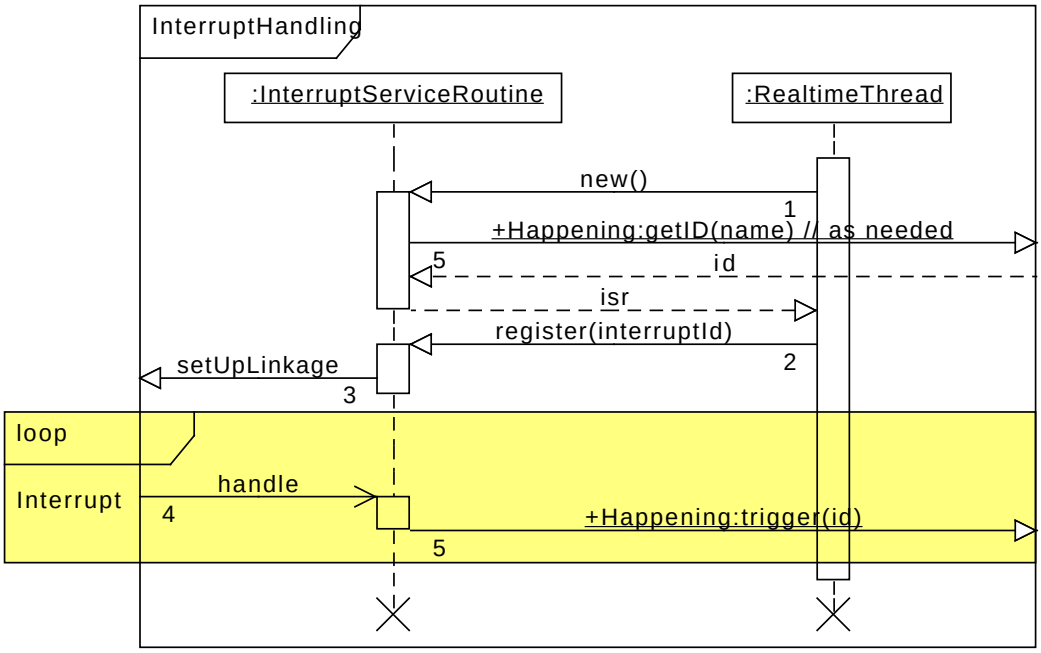


Figure 13.3 illustrates the sequence of actions necessary for defining and using a `Happening`. When using an application-defined dispatcher, it must be created first (1). When using an `InterruptServiceRoutine` to trigger the happening, it may be created before (2) or after the happening is create. After creating the happening (3), the happening must be started to be registered with its dispatcher to be triggered from native code. Of course, the JVM must have direct access to an interrupt, either by being directly bound in the kernel or by some other means, such as a system call, for setting up user-space device drivers. Only after both an `InterruptServiceRoutine` is registered and a `Happening` with the same name is started, can that happening be triggered (6–8).

There are three main differences between this mechanism and the string-based API.

1. The `Happening` class is now a first-class entity, rather than being buried in the implementation and identified only by a `String` object.
2. They include the `Happening.trigger(int)` method that enables a happening to be explicitly triggered by Java code, and at the implementation's option, also include a native code function that permits native application code to trigger the happening.
3. Finally, `Happening` is a subclass of `AsyncEvent`, just as `Timer`, instead of being attached to an `AsyncEvent`.

Figure 13.4: Interrupt servicing



13.2.4 Interrupt Service Routines

In Java-based systems, JNI is typically used to transfer control between an *interrupt service routine* (ISR) written in assembler or C and the program. `RTSJ` 2.0 supports the possibility of the ISR being written in Java code. This is clearly an area where it is difficult to maintain the portability goal of Java. Furthermore, not all `RTSJ` deployments can support `InterruptServiceRoutine`. A JVM that runs in user space does not generally have access to interrupts.

The JVM must either be standalone, running in a kernel module, or running in a special I/O partition on a partitioning OS where interrupts are passed through using some virtualization technique. Hence, JVM support for ISR is not required for `RTSJ` compliance.

Interrupt handling is necessarily machine dependent. However, the `RTSJ` provides an abstract model that can be implemented on top of all architectures. The following semantic model shall be supported by the `RTSJ`.

1. An *occurrence* of an interrupt consists of its *generation* and *delivery*.
2. Generation of the interrupt is the mechanism in the underlying hardware or system that makes the interrupt available to the Java program.
3. Delivery is the action that invokes an interrupt service routine (ISR) in response to the occurrence of the interrupt. This may be performed by the JVM or the application native code linked with the JVM, or directly by the hardware interrupt mechanism.
4. Between generation and delivery, the interrupt is *pending*.
5. Some or all interrupt occurrences may be inhibited. While an interrupt oc-

currence is inhibited, all occurrences of that interrupt shall be prevented from being delivered. Whether such occurrences remain pending or are lost is implementation defined, but it is expected that the implementation shall make a best effort to avoid losing pending interrupts.

6. Certain implementation-defined interrupts are *reserved*. Reserved interrupts are either interrupts for which application-defined ISRs are not supported, or those that already have ISRs by some other implementation-defined means. For example, a clock interrupt, which is used for internal time keeping by the JVM, is a reserved interrupt.
7. An application-defined ISR can be registered with one or more nonreserved interrupts. Registering an ISR for an interrupt shall implicitly deregister any already registered ISR for that interrupt. Any daisy-chaining of interrupt handlers shall be performed explicitly by the application interrupt handlers.
8. While an ISR is registered to an interrupt, the `handle` method shall be called *once* for each delivery of that interrupt. For locking out further interrupts during interrupt handling, the `handle`, the implementation must use the available interrupt masking facilities of the processor.
9. In order to safely share data between an interrupt service routine and other tasks, usually an Happening, a special monitor control policy is provided: `InterruptMasking`. When in use, it raises the eligibility of the entering task above all other task in the system and locks out the requisite interrupts. This synchronization is similar to priority ceiling emulation, as it always raises the eligibility of the entering task, but it also inhibits the interrupt for which it is configured, and potentially all less eligible interrupts.
10. The default allocation context of the `handle` method is the memory area passed during construction.
11. Any exception propagated from the `handle` method shall be caught by the JVM and ignored.
12. Code running in the context of an ISR may only attempt to acquire a lock that has a corresponding `InterruptMasking` as its monitor control policy. A `CeilingViolationException` is thrown, when an ISR attempts to acquire a lock with a different monitor control policy type.
13. An ISR object may be allocated in any memory area that does not move the handler. This includes immortal and scoped memory, but might not include heap memory on all systems.
14. As long as the ISR is registered, the memory area containing it is an execution context and thus may not be released.

The model assumes that

1. the processor has a (logical) interrupt controller that monitors a number of *interrupt lines*;
2. the interrupt controller may associate each interrupt line with a particular, but not necessarily unique, interrupt mask;
3. associated with the interrupt lines is a (logical) interrupt vector that contains the addresses of the ISRs;
4. the processor has instructions that enable interrupts from a particular line to be disabled or masked irrespective of the device attached or its type;

5. disabling interrupts from a specific line should disable the interrupts from lines having lower eligibility;
6. a device can be connected to an arbitrary interrupt line;
7. when an interrupt is signaled on an interrupt line by a device, the processor uses the identity of the interrupt line to index into the interrupt vector and jumps to the address of the ISR; the hardware automatically disables further interrupts (either of the same priority and lower or, possibly, all interrupts); and
8. on return from the ISR, interrupts are automatically re-enabled.

For interrupts, the `RTSJ` has an associated hardware priority that is more eligible that any task running on any scheduler. That priority can be used to set the eligibility of a task entering an object with a `InterruptMasking` monitor control policy. The `RTSJ` virtual machine may use this policy to disable the interrupts from the associated interrupt line and less eligible interrupts, as if the task was servicing the corresponding interrupt. On a multicore system, the situation is more complex, since there may be other cores available to handle other interrupts, even at lower eligibility, and some other locking mechanism may be necessary as well.

Though synchronization is not required in general, it is required to enforce visibility of changes made to any variables shared between some normal `Schedulable` and a `handle` method. For the `handle` method, this may be done automatically by the hardware interrupt handling mechanism or it may require added support from the realtime Java virtual machine. However, for clarity of the model, `RTSJ` recommends that the `handle` method should be defined as synchronized.

Support for interrupt handling is encapsulated in the `InterruptServiceRoutine` abstract class that has two main methods. The first is the final `register` method that will register an instance of the class with the system so that the appropriate interrupt vector can be initialized. The second is the abstract `handle` method that provides the code to be executed in response to the interrupt occurring. An individual realtime JVM may place restrictions on the code that can be written in this method. The process is illustrated in Figure 13.4, and is described below.

1. The ISR is instantiated by some application realtime thread for a given interrupt id.
2. The created ISR is registered with the JVM.
3. As part of the registration process, system dependent code sets up the underlying interrupt vectors linkage for calling the Java handler.
4. When the interrupt occurs, the handler is called.

In order to integrate further the interrupt handling with the Java application, the handle method may trigger a second level handler. The `InterruptServiceRoutine` mechanism is designed to work with `Happening`. In the simplest case, the `handle` method simply calls the `trigger` method on an instance of `Happening`. Though `handle` method could use `Object.notify` to wake a thread as an alternative, happenings are more flexible. In any case, using `Object.notifyAll` is not recommended and `Object.wait` should not be used at all.

13.2.4.1 Synchronization

Sometimes it is necessary to share data between happenings or between happenings and their associated interrupt service routines. Synchronization is the paradigm used in Java, but sharing data with handlers required not just eligibility inversion avoidance, but also interrupt masking. Since normal monitor control policies do not suffice for this, the device module provides additional monitor control policies for this: the abstract base type `InterruptMasking` along with its subtypes `InterruptInheritance` and `InterruptCeilingEmulation`.

13.2.4.2 Required Documentation

An implementation of the `RTSJ` that supports first-level interrupt handling will document the following items.

1. For each interrupt, its identifying integer value, the priority at which the interrupt occurs and whether it can be inhibited or not, and the effects of registering ISRs to noninhibitable interrupts (if this is permitted).
2. Which runtime stack the `handle` method uses when it executes.
3. Any implementation-specific or hardware-specific activity that happens before the `handle` method is invoked, e.g., reading device registers or acknowledging devices.
4. The state (inhibited/uninhibited) of the nonreserved interrupts when the program starts; if some interrupts are uninhibited, what the mechanism is that a program can use to protect itself before it can register the corresponding ISR.
5. The treatment of interrupt occurrences that are generated while the interrupt is inhibited, i.e., whether one or more occurrences are held for later delivery or all are lost.
6. Whether predefined or implementation-defined exceptions are raised as a result of the occurrence of any interrupt (for example, a hardware trap resulting from a segmentation error), and the mapping between the interrupt and the predefined exceptions.
7. On a multiprocessor, the rules governing the delivery of an interrupt occurrence to a particular processor. For example, whether execution of the `handle` method may spin if the lock of the associated object is held by another processor.

13.3 javax.realtime.device

13.3.1 Interfaces

13.3.1.1 DirectMemoryByteBuffer

---

public interface DirectMemoryByteBuffer

Description

An interface that can be implemented by a subclass of ByteBuffer for supporting DMA.

Since RTSJ 2.0

13.3.1.1.1 Methods

---

isReadOnly

Signature

```
public boolean
isReadOnly()
```

Description

Determines whether or not one can write to the buffer.

Returns

`true` when and only when the buffer is read only.

duplicate

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
duplicate()
```

Description

Creates a new memory buffer pointing to the same underlying memory. The content of the new buffer will remain the same. Changes to this buffer's content will be visible in the new buffer and vice versa. Initially the two buffers' position, limit, and mark values will be the same, but independent of one another. Changes to one will not be reflected in the other.

Returns

the new memory buffer

get

Signature

```
public byte
get()
```

Description

Obtains the byte at the current position and then increments the position.

Returns

the byte at the old position.

get(int)

Signature

```
public byte
get(int index)
throws IndexOutOfBoundsException
```

Description

Obtains the byte at `index`.

Parameters

`index`—The index the byte will be fetched

Throws

`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns

the byte at `index`.

getChar

Signature

```
public char
getChar()
```

Description

Obtains the char at the current position and then increments the position.

Returns

the char at the old position.

getChar(int)

Signature

```
public char
getChar(int index)
throws IndexOutOfBoundsException
```

Description

Obtains the char at `index`.

Parameters
`index`—The index where the char will be fetched
Throws
`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns
the char at `index`.

getDouble

Signature

```
public double
getDouble()
```

Description

Obtains the double at the current position and then increments the position.

Returns
the double at the old position.

getDouble(int)

Signature

```
public double
getDouble(int index)
```

Description

Obtains the double at `index`.

Parameters
`index`—The index where the double will be fetched
Throws
`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns
the double at `index`.

getFloat

Signature

```
public float
getFloat()
```

Description

Obtains the float at the current position and then increments the position.

Returns
the float at the old position.

getFloat(int)

Signature

```
public float
getFloat(int index)
```

Description
Obtains the float at `index`.

Parameters
`index`—The index where the float will be fetched
Throws
`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns
the float at `index`.

getInt

Signature

```
public int
getInt()
```

Description
Obtains the int at the current position and then increments the position.

Returns
the int at the old position.

getInt(int)

Signature

```
public int
getInt(int index)
```

Description
Obtains the int at `index`.

Parameters
`index`—The index where the int will be fetched
Throws
`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns
the int at `index`.

getLong

Signature

```
public long
getLong()
```

Description

Obtains the long at the current position and then increments the position.

Returns

the long at the old position.

getLong(int)

Signature

```
public long
getLong(int index)
```

Description

Obtains the long at `index`.

Parameters

`index`—The index where the long will be fetched

Throws

`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns

the long at `index`.

getShort

Signature

```
public short
getShort()
```

Description

Obtains the short at the current position and then increments the position.

Returns

the short at the old position.

getShort(int)

Signature

```
public short
getShort(int index)
```

Description

Obtains the short at `index`.

Parameters
`index`—The index where the short will be fetched
Throws
`IndexOutOfBoundsException`—when index is negative or not smaller than the buffer's limit.

Returns
the short at `index`.

put(byte)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
put(byte value)
throws BufferOverflowException,
       ReadOnlyBufferException
```

Description

Sets the byte at the current position to `value` and then increments the position by one.

Parameters
`value`—The value of the byte that will be set
Throws
`BufferOverflowException`—when the current position is not smaller than its limit.
`ReadOnlyBufferException`—when this buffer is read only.

Returns
`this`

put(int, byte)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
put(int index,
    byte value)
throws BufferOverflowException,
       ReadOnlyBufferException
```

Description

Sets the byte at the `index` to `value`.

Parameters
`index`—The index where the byte will be set
`value`—The value of the byte that will be set
Throws
`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putChar(char)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putChar(char value)
```

Description

Sets the char at the current position to `value` and then increments the position by one.

Parameters

`value`—The value of the char that will be set

Throws

`BufferOverflowException`—when the current position is not smaller than its limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putChar(int, char)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putChar(int index,
        char value)
```

Description

Sets the char at the `index` to `value`.

Parameters

`index`—The index where the char will be set

`value`—The value of the char that will be set

Throws

`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putDouble(double)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putDouble(double value)
```

Description

Sets the double at the current position to `value` and then increments the position by one.

Parameters

`value`—The value of the double that will be set

Throws

`BufferOverflowException`—when the current position is not smaller than its limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putDouble(int, double)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putDouble(int index,
          double value)
```

Description

Sets the double at the `index` to `value`.

Parameters

`index`—The index where the double will be set

`value`—The value of the double that will be set

Throws

`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putFloat(float)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putFloat(float value)
```

Description

Sets the float at the current position to `value` and then increments the position by one.

Parameters
`value`—The value of the float that will be set
Throws
`BufferOverflowException`—when the current position is not smaller than its limit.
`ReadOnlyBufferException`—when this buffer is read only.

Returns
`this`

putFloat(int, float)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putFloat(int index,
         float value)
```

Description

Sets the float at the `index` to `value`.

Parameters
`index`—The index where the float will be set
`value`—The value of the float that will be set
Throws
`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.
`ReadOnlyBufferException`—when this buffer is read only.

Returns
`this`

putInt(int)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putInt(int value)
```

Description

Sets the int at the current position to `value` and then increments the position by one.

Parameters
`value`—The value of the int that will be set
Throws
`BufferOverflowException`—when the current position is not smaller than its limit.
`ReadOnlyBufferException`—when this buffer is read only.

Returns
`this`

putInt(int, int)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putInt(int index,
       int value)
```

Description

Sets the int at the `index` to `value`.

Parameters

`index`—The index where the int will be set

`value`—The value of the int that will be set

Throws

`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putLong(long)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putLong(long value)
```

Description

Sets the long at the current position to `value` and then increments the position by one.

Parameters

`value`—The value of the long that will be set

Throws

`BufferOverflowException`—when the current position is not smaller than its limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putLong(int, long)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putLong(int index,
        long value)
```

Description

Sets the long at the `index` to `value`.

Parameters

`index`—The index where the long will be set

`value`—The value of the long that will be set

Throws

`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putShort(short)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putShort(short value)
```

Description

Sets the short at the current position to `value` and then increments the position by one.

Parameters

`value`—The value of the short that will be set

Throws

`BufferOverflowException`—when the current position is not smaller than its limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

putShort(int, short)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
putShort(int index,
         short value)
```

Description

Sets the short at the `index` to `value`.

Parameters

`index`—The index where the short will be set

`value`—The value of the short that will be set

Throws

`BufferOverflowException`—when `index` is negative or not smaller than the buffer's limit.

`ReadOnlyBufferException`—when this buffer is read only.

Returns

`this`

slice

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
slice()
```

Description

Creates a direct new byte buffer whose content is shared with a subsequence of this buffer's content. The content of the new buffer will start at the current value of this buffer's position. Changes to the content of the new buffer will be visible in this new buffer, and vice versa. The two buffers' position, limit, and mark values are independent or one another. The new buffer's position at start is zero, its capacity and its limit start at the number of bytes remaining in this buffer, and its mark is initially undefined.

Returns

The new buffer

position

Signature

```
public int
position()
```

Description

Determines the reference position of this buffer.

Returns

the current position

position(int)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
position(int position)
throws StaticIllegalArgumentException
```

Description

Sets the reference position for this buffer. When the mark is defined and is larger than the new position, the mark becomes undefined.

Parameters

`position`—The new current position, which must be a natural number no larger than the current limit.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the preconditions on `position` do not hold.

Returns

the buffer itself.

limit

Signature

```
public int
limit()
```

Description

Determines the buffers limit.

Returns

the limit.

limit(int)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
limit(int limit)
throws StaticIllegalArgumentException
```

Description

Sets this buffer's limit. When the position is larger than the new limit, position is set to the new limit. When the mark is defined and is larger than the new limit, the mark becomes undefined.

Parameters

`limit`—The new limit value which must be a natural number no larger than this buffer's capacity

Throws

`javax.realtime.StaticIllegalArgumentException`—when the preconditions on `limit` do not hold.

Returns

the buffer itself

mark

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
mark()
```

Description

Sets this buffer's mark to the current position.

Returns

the buffer itself.

reset

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
reset()
throws InvalidMarkException
```

Description

Resets this buffer's position to the previously marked position leaving the mark value unchanged.

Throws

`InvalidMarkException`—when the mark is undefined.

Returns

the buffer itself

flip

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
flip()
throws StaticIllegalArgumentException
```

Description

Flips this buffer, i.e., the limit is set to the current `position`, then the `position` is set to zero, and the mark becomes undefined. After a sequence of channel-read or put operations, invoke this method to prepare for a sequence of channel-write or relative get operations. Here is an example.

```
buf.put(magic);    // Prepend header
in.read(buf);      // Read data into rest of buffer
buf.flip();        // Flip buffer
out.write(buf);    // Write header + data to channel
```

This method is often used in conjunction with the compact method when transferring data from one place to another.

Returns

the buffer itself.

remaining

Signature

```
public int
remaining()
```

Description

Determines number of elements remaining in the buffer.

Returns

the number of elements between the current `position` and the `limit`.

hasRemaining

Signature

```
public boolean
hasRemaining()
```

Description

Determines whether or not there are any elements between the current `position` and the `limit`.

Returns

true when and only when there is at least one element between the current `position` and the `limit`.

13.3.1.2 RawByte

---

public interface RawByte

Interfaces

javax.realtime.device.RawByteReader
javax.realtime.device.RawByteWriter

Description

A marker for an object that can be used to access a single byte. Read and write access to that byte is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.3 RawByteReader

---

public interface RawByteReader

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a byte accessor object encapsulating the protocol for reading bytes from raw memory. A byte accessor can always access at least one byte. Each byte is transferred in a single atomic operation. Groups of bytes may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawByteReader` and `RawMemoryFactory.createRawByte`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.3.1 Methods

---

getByte

Signature

```
public byte
getByte()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns

the value at the *base address*.

getByte(int)

Signature

```
public byte
getByte(int offset)
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of byte in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, byte)

Signature

```
public int
get(int offset,
    byte[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the bytes in the intersection of the start and end of `values` and the *base address* and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first byte in the memory region to transfer.

`values`—The array to receive the bytes.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, byte, int, int)

Signature

```
public int
get(int offset,
    byte[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first byte in the memory region to transfer.

`values`—The array to receive the bytes.

`start`—The first index in array to fill.

`count`—The maximum number of bytes to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of bytes actually transferred.

13.3.1.4 RawByteWriter

---

public interface RawByteWriter

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a byte accessor object encapsulating the protocol for writing bytes to raw memory. A byte accessor can always access at least one byte. Each byte is transferred in a single atomic operation. Groups of bytes may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawByteWriter` and `RawMemoryFactory.createRawByte`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.4.1 Methods

---

setByte(byte)

Signature

```
public void
setByte(byte value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters

`value`—The new value for the element.

setByte(int, byte)

Signature

```
public void
setByte(int offset,
        byte value)
throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Byte*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of byte in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, byte)

Signature

```
public int
set(int offset,
    byte[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the bytes in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first byte in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, byte, int, int)

Signature

```
public int
set(int offset,
    byte[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first byte in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first byte in the memory region to set.

`values`—The array from which to retrieve the bytes.

`start`—The first index in array to copy.

`count`—The maximum number of bytes to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of bytes actually transferred.

13.3.1.5 RawDouble

---

public interface RawDouble

Interfaces

javax.realtime.device.RawDoubleReader
javax.realtime.device.RawDoubleWriter

Description

A marker for an object that can be used to access a single double. Read and write access to that double is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.6 RawDoubleReader

---

public interface RawDoubleReader

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a double accessor object encapsulating the protocol for reading doubles from raw memory. A double accessor can always access at least one double. Each double is transferred in a single atomic operation. Groups of doubles may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawDoubleReader` and `RawMemoryFactory.createRawDouble`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.6.1 Methods

---

getDouble

Signature

```
public double
getDouble()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns

the value at the *base address*.

getDouble(int)

Signature

```
public double
getDouble(int offset)
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of double in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, double)

Signature

```
public int
get(int offset,
    double[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the doubles in the intersection of the start and end of `values` and the *base address*

and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first double in the memory region to transfer.

`values`—The array to receive the doubles.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, double, int, int)

Signature

```
public int
get(int offset,
    double[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first double in the memory region to transfer.

`values`—The array to receive the doubles.

`start`—The first index in array to fill.

`count`—The maximum number of doubles to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of doubles actually transferred.

13.3.1.7 RawDoubleWriter

public interface RawDoubleWriter

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a double accessor object encapsulating the protocol for writing doubles to raw memory. A double accessor can always access at least one double. Each double is transferred in a single atomic operation. Groups of doubles may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawDoubleWriter` and `RawMemoryFactory.createRawDouble`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.7.1 Methods

setDouble(double)

Signature

```
public void
setDouble(double value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters

`value`—The new value for the element.

setDouble(int, double)

Signature

```
public void
setDouble(int offset,
          double value)
```

```
    throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Double*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of double in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, double)

Signature

```
public int
set(int offset,
    double[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the doubles in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first double in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, double, int, int)

Signature

```
public int
set(int offset,
    double[] values,
```

```
        int start,
        int count)
    throws OffsetOutOfBoundsException,
           ArrayIndexOutOfBoundsException,
           IllegalArgumentException,
           NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first double in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first double in the memory region to set.

`values`—The array from which to retrieve the doubles.

`start`—The first index in array to copy.

`count`—The maximum number of doubles to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of doubles actually transferred.

13.3.1.8 RawFloat

---

public interface RawFloat

Interfaces

javax.realtime.device.RawFloatReader
javax.realtime.device.RawFloatWriter

Description

A marker for an object that can be used to access a single float. Read and write access to that float is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.9 RawFloatReader

---

public interface RawFloatReader

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a float accessor object encapsulating the protocol for reading floats from raw memory. A float accessor can always access at least one float. Each float is transferred in a single atomic operation. Groups of floats may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawFloatReader` and `RawMemoryFactory.createRawFloat`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.9.1 Methods

---

getFloat

Signature

```
public float
getFloat()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns
the value at the *base address*.

getFloat(int)

Signature

```
public float
getFloat(int offset)
```

```
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of float in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, float)

Signature

```
public int
get(int offset,
    float[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the floats in the intersection of the start and end of `values` and the *base address* and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first float in the memory region to transfer.

`values`—The array to receive the floats.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, float, int, int)

Signature

```
public int
get(int offset,
    float[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first float in the memory region to transfer.

`values`—The array to receive the floats.

`start`—The first index in array to fill.

`count`—The maximum number of floats to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of floats actually transferred.

13.3.1.10 RawFloatWriter

---

public interface RawFloatWriter

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a float accessor object encapsulating the protocol for writing floats to raw memory. A float accessor can always access at least one float. Each float is transferred in a single atomic operation. Groups of floats may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawFloatWriter` and `RawMemoryFactory.createRawFloat`. Each object

references a range of elements in the RawMemoryRegion starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.10.1 Methods

---

setFloat(float)

Signature

```
public void
setFloat(float value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters

`value`—The new value for the element.

setFloat(int, float)

Signature

```
public void
setFloat(int offset,
         float value)
throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Float*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of float in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, float)

Signature

```
public int
set(int offset,
    float[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` $*$ `stride` $*$ *element size in bytes*. Only the floats in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first float in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, float, int, int)

Signature

```
public int
set(int offset,
    float[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first float in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first float in the memory region to set.

`values`—The array from which to retrieve the floats.

`start`—The first index in array to copy.

`count`—The maximum number of floats to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of floats actually transferred.

13.3.1.11 RawInt

---

public interface RawInt

Interfaces

javax.realtime.device.RawIntReader
javax.realtime.device.RawIntWriter

Description

A marker for an object that can be used to access a single int. Read and write access to that int is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.12 RawIntReader

---

public interface RawIntReader

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a int accessor object encapsulating the protocol for reading ints from raw memory. A int accessor can always access at least one int. Each int is transferred in a single atomic operation. Groups of ints may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawIntReader` and `RawMemoryFactory.createRawInt`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address*

provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.12.1 Methods

---

getInt

Signature

```
public int
getInt()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns

the value at the *base address*.

getInt(int)

Signature

```
public int
getInt(int offset)
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of int in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, int)

Signature

```
public int
get(int offset,
    int[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the ints in the intersection of the start and end of `values` and the *base address* and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first int in the memory region to transfer.

`values`—The array to receive the ints.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, int, int, int)

Signature

```
public int
get(int offset,
    int[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first int in the memory region to transfer.

`values`—The array to receive the ints.

`start`—The first index in array to fill.

`count`—The maximum number of ints to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of ints actually transferred.

13.3.1.13 RawIntWriter

---

public interface RawIntWriter

Interfaces

javax.realtime.device.RawMemory

Description

A marker for a int accessor object encapsulating the protocol for writing ints to raw memory. A int accessor can always access at least one int. Each int is transferred in a single atomic operation. Groups of ints may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawIntWriter` and `RawMemoryFactory.createRawInt`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.13.1 Methods

---

setInt(int)

Signature

```
public void
setInt(int value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters

`value`—The new value for the element.

setInt(int, int)

Signature

```
public void
setInt(int offset,
       int value)
throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Int*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of int in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, int)

Signature

```
public int
set(int offset,
    int[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the ints in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first int in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, int, int, int)

Signature

```
public int
set(int offset,
    int[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first int in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first int in the memory region to set.

`values`—The array from which to retrieve the ints.

`start`—The first index in array to copy.

`count`—The maximum number of ints to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of ints actually transferred.

13.3.1.14 RawLong

---

public interface RawLong

Interfaces
javax.realtime.device.RawLongReader
javax.realtime.device.RawLongWriter

Description

A marker for an object that can be used to access a single long. Read and write access to that long is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.15 RawLongReader

---

public interface RawLongReader

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a long accessor object encapsulating the protocol for reading longs from raw memory. A long accessor can always access at least one long. Each long is transferred in a single atomic operation. Groups of longs may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawLongReader` and `RawMemoryFactory.createRawLong`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.15.1 Methods

---

getLong

Signature

```
public long
getLong()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns

the value at the *base address*.

getLong(int)

Signature

```
public long
getLong(int offset)
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of long in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, long)

Signature

```
public int
get(int offset,
    long[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the longs in the intersection of the start and end of `values` and the *base address*

and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first long in the memory region to transfer.

`values`—The array to receive the longs.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, long, int, int)

Signature

```
public int
get(int offset,
    long[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first long in the memory region to transfer.

`values`—The array to receive the longs.

`start`—The first index in array to fill.

`count`—The maximum number of longs to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset` + `count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start` + `count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of longs actually transferred.

13.3.1.16 RawLongWriter

public interface RawLongWriter

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a long accessor object encapsulating the protocol for writing longs to raw memory. A long accessor can always access at least one long. Each long is transferred in a single atomic operation. Groups of longs may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawLongWriter` and `RawMemoryFactory.createRawLong`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.16.1 Methods

setLong(long)

Signature

```
public void
setLong(long value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters
`value`—The new value for the element.

setLong(int, long)

Signature

```
public void
setLong(int offset,
        long value)
```

```
throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Long*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of long in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, long)

Signature

```
public int
set(int offset,
    long[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the longs in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first long in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, long, int, int)

Signature

```
public int
set(int offset,
    long[] values,
```

```
        int start,
        int count)
    throws OffsetOutOfBoundsException,
           ArrayIndexOutOfBoundsException,
           IllegalArgumentException,
           NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first long in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first long in the memory region to set.

`values`—The array from which to retrieve the longs.

`start`—The first index in array to copy.

`count`—The maximum number of longs to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of longs actually transferred.

13.3.1.17 RawMemory

---

public interface RawMemory

Description

A marker for all raw memory accessor objects.

Since RTSJ 2.0

13.3.1.17.1 Methods

---

getAddress

Signature

```
public long
getAddress()
```

Description

Gets the base physical address of this object.

Returns

the first physical address this raw memory object can access.

getSize

Signature

```
public int
getSize()
```

Description

Gets the number of bytes that this object spans.

Returns

the size of this raw memory.

getStride

Signature

```
public int
getStride()
```

Description

Gets the distance between elements in multiples of element size.

Returns

the span between elements of this raw memory.

13.3.1.18 RawMemoryRegionFactory

---

public interface RawMemoryRegionFactory

Description

A means of giving an application the ability to provide support for a `RawMemoryRegion` that is not already provided by the standard. An instance of this interface can be registered with a `RawMemoryFactory` and provide the object that that factory should return for with a given `RawMemoryRegion`. It is responsible for checking all requests and throwing the proper exception when a request is invalid or the requester is not authorized to make the request.

Since RTSJ 2.0

13.3.1.18.1 Methods

getRegion

Signature

```
public javax.realtime.device.RawMemoryRegion
getRegion()
```

Description

Determines for what region this factory creates raw memory objects.

Returns

the region of this factory.

getName

Signature

```
public java.lang.String
getName()
```

Description

Determines the name of the region for which this factory creates raw memory objects.

Returns

the name of the region of this factory.

createRawByte(long, int, int)

Signature

```
public javax.realtime.device.RawByte
createRawByte(long base,
              int count,
              int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawByte` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByte* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawByte` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawByteReader(long, int, int)

Signature

```
public javax.realtime.device.RawByteReader
createRawByteReader(long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawByteReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByteReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawByteReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawByteWriter(long, int, int)

Signature

```
public javax.realtime.device.RawByteWriter
createRawByteWriter(long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawByteWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByteWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawByteWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawShort(long, int, int)

Signature

```
public javax.realtime.device.RawShort
createRawShort(long base,
               int count,
               int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawShort` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawShort* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawShort` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawShortReader(long, int, int)

Signature

```
public javax.realtime.device.RawShortReader
createRawShortReader(long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawShortReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawShortReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawShortReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawShortWriter(long, int, int)

Signature

```
public javax.realtime.device.RawShortWriter
createRawShortWriter(long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawShortWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawShortWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawShortWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawInt(long, int, int)

Signature

```
public javax.realtime.device.RawInt
createRawInt(long base,
             int count,
             int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawInt` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawInt* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawInt` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawIntReader(long, int, int)

Signature

```
public javax.realtime.device.RawIntReader
createRawIntReader(long base,
                   int count,
                   int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawIntReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawIntReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawIntReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawIntWriter(long, int, int)

Signature

```
public javax.realtime.device.RawIntWriter
createRawIntWriter(long base,
                   int count,
                   int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawIntWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawIntWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawIntWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawLong(long, int, int)

Signature

```
public javax.realtime.device.RawLong
createRawLong(long base,
              int count,
              int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
```

```
SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawLong` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawLong* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawLong` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawLongReader(long, int, int)

Signature

```
public javax.realtime.device.RawLongReader
createRawLongReader(long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawLongReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawLongReader* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawLongReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawLongWriter(long, int, int)

Signature

```
public javax.realtime.device.RawLongWriter
createRawLongWriter(long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawLongWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawLongWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawLongWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawFloat(long, int, int)

Signature

```
public javax.realtime.device.RawFloat
createRawFloat(long base,
               int count,
               int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawFloat` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawFloat* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawFloat` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawFloatReader(long, int, int)

Signature

```
public javax.realtime.device.RawFloatReader
createRawFloatReader(long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawFloatReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawFloatReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawFloatReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawFloatWriter(long, int, int)

Signature

```
public javax.realtime.device.RawFloatWriter
createRawFloatWriter(long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
```

```
SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawFloatWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawFloatWriter* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawFloatWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawDouble(long, int, int)

Signature

```
public javax.realtime.device.RawDouble
createRawDouble(long base,
                int count,
                int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawDouble` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawDouble* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawDouble` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawDoubleReader(long, int, int)

Signature

```
public javax.realtime.device.RawDoubleReader
createRawDoubleReader(long base,
                      int count,
                      int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawDoubleReader` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawDoubleReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawDoubleReader` and supports access to the specified range in the memory region.

Since RTSJ 2.0

createRawDoubleWriter(long, int, int)

Signature

```
public javax.realtime.device.RawDoubleWriter
createRawDoubleWriter(long base,
                      int count,
                      int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException
```

Description

Creates an instance of a class that implements `RawDoubleWriter` and accesses memory of `getRegion` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawDoubleWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element in mulitple of element count, where a value of `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is not greater than zero.

`OffsetOutOfBoundsException`—when `base` is invalid.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range of memory.

Returns

an object that implements `RawDoubleWriter` and supports access to the specified range in the memory region.

Since RTSJ 2.0

13.3.1.19 RawShort

---

public interface RawShort

Interfaces
javax.realtime.device.RawShortReader
javax.realtime.device.RawShortWriter

Description

A marker for an object that can be used to access a single short. Read and write access to that short is checked by the factory that creates the instance; therefore, no access checking is provided by this interface, only bounds checking.

Since RTSJ 2.0

13.3.1.20 RawShortReader

---

public interface RawShortReader

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a short accessor object encapsulating the protocol for reading shorts from raw memory. A short accessor can always access at least one short. Each short is transferred in a single atomic operation. Groups of shorts may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawShortReader` and `RawMemoryFactory.createRawShort`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of accessible elements.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.20.1 Methods

---

getShort

Signature

```
public short
getShort()
```

Description

Gets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Returns

the value at the *base address*.

getShort(int)

Signature

```
public short
getShort(int offset)
throws OffsetOutOfBoundsException
```

Description

Gets the value at the address represented by `offset` from the base of this instance: *base address* + (`offset` ∗ `stride` ∗ *element size in bytes*). When an exception is thrown, no data is transferred.

Parameters

`offset`—of short in the memory region starting from the address specified in the associated factory method.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

Returns

the value at the address specified.

get(int, short)

Signature

```
public int
get(int offset,
    short[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Fills `values` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the shorts in the intersection of the start and end of `values` and the *base address*

and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first short in the memory region to transfer.

`values`—The array to receive the shorts.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

get(int, short, int, int)

Signature

```
public int
get(int offset,
    short[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       IllegalArgumentException,
       NullPointerException
```

Description

Fills `values` from index `start` with elements from this instance, where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first short in the memory region to transfer.

`values`—The array to receive the shorts.

`start`—The first index in array to fill.

`count`—The maximum number of shorts to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset` + `count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start` + `count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null or `count` is negative.

Returns

the number of shorts actually transferred.

13.3.1.21 RawShortWriter

public interface RawShortWriter

Interfaces
javax.realtime.device.RawMemory

Description

A marker for a short accessor object encapsulating the protocol for writing shorts to raw memory. A short accessor can always access at least one short. Each short is transferred in a single atomic operation. Groups of shorts may be transferred together; however, this is not required.

Objects of this type are created with the method `RawMemoryFactory.createRawShortWriter` and `RawMemoryFactory.createRawShort`. Each object references a range of elements in the `RawMemoryRegion` starting at the *base address* provided to the factory method. The size provided to the factory method determines the number of elements accessible.

Caching of the memory access is controlled by the factory that created this object. If the memory is not cached, this method guarantees serialized access. In other words, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.

Since RTSJ 2.0

13.3.1.21.1 Methods

setShort(short)

Signature

```
public void
setShort(short value)
```

Description

Sets the value at the first position referenced by this instance, i.e., the value at its start address. This operation must be atomic with respect to all other raw memory accesses to the address.

Parameters

`value`—The new value for the element.

setShort(int, short)

Signature

```
public void
setShort(int offset,
         short value)
```

```
throws OffsetOutOfBoundsException
```

Description

Sets the value of the n^{th} element referenced by this instance, where `n` is `offset` and the address is *base address* + `offset` ∗ *size of Short*. This operation must be atomic with respect to all other raw memory accesses to the address. When an exception is thrown, no data is transferred.

Parameters

`offset`—of short in the memory region.

`value`—The new value for the element.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

set(int, short)

Signature

```
public int
set(int offset,
    short[] values)
throws OffsetOutOfBoundsException,
       NullPointerException
```

Description

Copies from `values` to the memory region, from index `start` to elements where the n^{th} element is at the address *base address* + `(offset + n)` ∗ `stride` ∗ *element size in bytes*. Only the shorts in the intersection of `values` and the end of the memory region are transferred. When an exception is thrown, no data is transferred.

Parameters

`offset`—of first short in the memory region to be set.

`values`—The source of the data to write.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or greater than or equal to the number of elements in the raw memory region.

`NullPointerException`—when `values` is null.

Returns

the number of elements actually transferred to `values`.

set(int, short, int, int)

Signature

```
public int
set(int offset,
    short[] values,
```

```
        int start,
        int count)
    throws OffsetOutOfBoundsException,
           ArrayIndexOutOfBoundsException,
           IllegalArgumentException,
           NullPointerException
```

Description

Copies `values` to the memory region, where `offset` is first short in the memory region to write and `start` is the first index in `values` from which to read. The number of bytes transferred is the minimum of `count`, the *size* of the memory region minus `offset`, and length of `values` minus `start`. When an exception is thrown, no data is transferred.

Parameters

`offset`—of the first short in the memory region to set.

`values`—The array from which to retrieve the shorts.

`start`—The first index in array to copy.

`count`—The maximum number of shorts to copy.

Throws

`OffsetOutOfBoundsException`—when `offset` is negative or either `offset` or `offset + count` is greater than or equal to the size of this raw memory area.

`ArrayIndexOutOfBoundsException`—when `start` is negative or either `start` or `start + count` is greater than or equal to the size of values.

`NullPointerException`—when `values` is null.

Returns

the number of shorts actually transferred.

13.3.2 Classes

13.3.2.1 DirectMemoryBufferFactory

---

public class DirectMemoryBufferFactory

Inheritance

java.lang.Object
  DirectMemoryBufferFactory

Description

A factory class for generating raw byte buffers. This enables the infrastructure to limit the address ranges from which a buffer may be taken. The address range managed by a `DirectMemoryBufferFactory` instance may overlap that of another `DirectMemoryBufferFactory` instance.

Since RTSJ 2.0

13.3.2.1.1 Constructors

DirectMemoryBufferFactory(DirectMemoryRegion, long, long)

Signature

```
public
DirectMemoryBufferFactory(DirectMemoryRegion region,
                          long base,
                          long size)
throws MemoryInUseException,
       RangeOutOfBoundsException
```

Description

Creates a factory for allocating buffers in a particular address range. Whether the address is physical or virtual is system dependent.

Parameters

`region`—The area of memory a DMA controller can reference, from which this factory takes its memory.

`base`—The base address of a memory range in `region` for buffer allocation.

`size`—The number of bytes in the memory range.

Throws

`MemoryInUseException`—when the memory area provided is already in use by or reserved for a `javax.realtime.MemoryArea`, program code, or other sytem or VM structure.

`RangeOutOfBoundsException`—when the memory region overlaps with another or cannot be used for DMA.

13.3.2.1.2 Methods

allocateByteBuffer(int)

Signature

```
public javax.realtime.device.DirectMemoryByteBuffer
allocateByteBuffer(int capacity)
```

Description

Creates a direct byte buffer with the given capacity within the range of this factory.

Parameters

`capacity`—The number of bytes in the buffer.

Throws

`javax.realtime.StaticOutOfMemoryError`—when no memory is available.

Returns

the new buffer.

free(DirectMemoryByteBuffer)

Signature

```
public void
free(DirectMemoryByteBuffer buffer)
```

Description

Frees the memory associated with the given `DirectMemoryByteBuffer` instance. The capacity and limit of the buffer are both set to zero, so data can no longer be transferred with the buffer. The buffer range can then be safely reallocated.

Parameters

`buffer`—The `DirectMemoryByteBuffer` to free.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `buffer` was not allocated from this factory.

`javax.realtime.StaticIllegalStateException`—when `buffer` has already been freed.

Open issue 13.3.1

Unless we get a better answer from the JDK team, we must have our own buffer class!

End of issue 13.3.1

inRange(DirectMemoryByteBuffer)

Signature

```
public boolean
inRange(DirectMemoryByteBuffer buffer)
```

Description

Checks to see whether or not the buffer's data area is within the range of this factory.

Parameters

`buffer`—The `DirectMemoryByteBuffer` to check.

Returns

`true` when and only when the buffer's data area is within the range of this factory; otherwise `false`.

addressOf(DirectMemoryByteBuffer)

Signature

```
public long
addressOf(DirectMemoryByteBuffer buffer)
```

Description

Gives the location of this buffer's data in memory. The address shall be in the address space of the DMA controller.

Parameters

`buffer`—The `DirectMemoryByteBuffer` of which to get the address.

Returns

the start address of the data range of this buffer.

writeFence(DirectMemoryByteBuffer)

Signature

```
public static void
writeFence(DirectMemoryByteBuffer buffer)
```

Description

Ensures that all changes to the `DirectMemoryByteBuffer` by the current thread have been flushed in a manner that makes them visible to other threads (including native threads), and behaves as a volatile store with respect to the Java Memory Model synchronization order.

This method shall invoke a memory barrier operation that is understood by the VM, runtime, native compiler, and platform to provide visibility to all changes to the associated buffer made before its invocation.

Parameters

`buffer`—The byte buffer which will be flushed.

readFence(DirectMemoryByteBuffer)

Signature

```
public static void
readFence(DirectMemoryByteBuffer buffer)
```

Description

Ensures that any previous changes to the memory represented by the given `DirectMemoryByteBuffer` by other threads (including native threads) will be visible when it is next accessed by the current thread, and behaves as a volatile load with respect to the Java Memory Model synchronization order.

This method shall invoke a memory barrier operation that is understood by the VM, runtime, native compiler, and platform to provide visibility for any changes to the associated buffer previously flushed with a call to `writeFence(DirectMemoryByteBuffer)` or its native equivalent on the buffer's memory.

Parameters

`buffer`—The byte buffer which will be updated.

13.3.2.2 DirectMemoryRegion

---

public class DirectMemoryRegion

Inheritance

java.lang.Object
  DirectMemoryRegion

Description

Defines the reachable memory for a given DMA controller in terms of the physical address space of the system.

Since RTSJ 2.0

13.3.2.2.1 Constructors

DirectMemoryRegion(long, long)

Signature

```
public
DirectMemoryRegion(long start,
                   long size)
throws StaticIllegalArgumentException
```

Description

Creates a DMA memory definition.

Parameters

`start`—The DMA address space in the physical address space of the main processor.

`size`—The number of bytes in the DMA address space.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `start` is less than zero or `start + size` is larger than the physical memory of the system.

13.3.2.2.2 Methods

---

regionAddressOf(long)

Signature

```
public long
regionAddressOf(long address)
throws StaticIllegalArgumentException
```

Description

Translates a physical address into a DMA region address.

Parameters

`address`—The address to translate.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the result is outside the DMA space.

Returns

the equivalent address in DMA space.

physicalAddressOf(long)

Signature

```
public long
physicalAddressOf(long address)
throws StaticIllegalArgumentException
```

Description

Translates a DMA space address into a physical address.

Parameters

`address`—The address to translate.

Throws

`javax.realtime.StaticIllegalArgumentException`—when the input is outside the DMA space.

Returns

the corresponding physical address.

13.3.2.3 Happening

---

public class Happening

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncEvent
      Happening

Interfaces

javax.realtime.ActiveEvent

Description

This class provides second level handling for external events such as interrupts. A happening can be triggered by an `InterruptServiceRoutine` or from native code. Application-defined `Happenings` can be identified by an application-provided name or a system-provided `id`, both of which must be unique. A system `Happening` has a name provided by the system which is a string beginning with `@`.

Since RTSJ 2.0

13.3.2.3.1 Constructors

Happening(String, HappeningDispatcher)

Signature

```
public
Happening(String name,
          HappeningDispatcher dispatcher)
throws StaticIllegalArgumentException
```

Description

Creates a happening with the given name.

Parameters

`name`—A string to name the happening.

`dispatcher`—To use when being triggered.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `name` is `null` or does not match the pattern full identifier naming convention, i.e., package plus `name`. An implementation may throw this exception for all names starting with java. and javax.

Happening(String)

Signature

```
public
Happening(String name)
throws StaticIllegalArgumentException
```

Description

Creates a happening with the given `name` and the default dispatcher.

Parameters

`name`—A string to name the happening.

Throws

javax.realtime.StaticIllegalArgumentException—when name is null or does not match the pattern full type naming convention, i.e., package plus name. An implementation may throw this exception for all names starting with java. and javax.

13.3.2.3.2 Methods

---

getHappening(String)

Signature

```
public static javax.realtime.device.Happening
getHappening(String name)
```

Description

Finds an active happening by its name.

Parameters

name—Identifies the happening to get.

Throws

javax.realtime.StaticIllegalArgumentException—when name is null.

Returns

a reference to the happening with the given name, or null, if no happening with the given name is found.

isHappening(String)

Signature

```
public static boolean
isHappening(String name)
```

Description

Determines whether or not there is an active happening with name given as parameter.

Parameters

name—A string that might name an active happening.

Throws

javax.realtime.StaticIllegalArgumentException—when name is null.

Returns

true only when there is a registered happening with the given name.

createId(String)

Signature

```
public static int
createId(String name)
throws StaticIllegalStateException
```

Description

Sets up a mapping between a `name` and a system-dependent ID. This can be called either in the constructor of an instance of `InterruptServiceRoutine` or in native code that sets up an interrupt service routine to link it with a `happening`. Once created, it cannot be removed.

This must take no more than linear time in the number of ID (`n`) registered, but should be `O(log2(n))`.

Parameters

`name`—A string to name a happening.

Throws

`javax.realtime.StaticIllegalStateException`—when `name` is already registered.

`javax.realtime.StaticIllegalArgumentException`—when `name` is `null`.

Returns

an ID assigned by the system.

getId(String)

Signature

```
public static int
getId(String name)
```

Description

Obtains the ID of `name`, when one exists or -1, when `name` is not registered.

This must take no more than linear time in the number of ID (`n`) registered, but should be `O(log2(n))`.

Parameters

`name`—A happening name string.

Throws

`javax.realtime.StaticIllegalArgumentException`—when `name` is `null`.

Returns

The ID, or -1 when no happening is found with that name.

get(int)

Signature

```
public static javax.realtime.device.Happening
get(int id)
```

Description

Gets the external event corresponding to a given `id`.

Parameters
`id`—The identifier of a registered signal.
Returns
the signal corresponding to `id`.

get(String)

Signature

```
public static javax.realtime.device.Happening
get(String name)
```

Description

Gets the external event corresponding to a given name.

Parameters
`name`—The name of a registered signal.
Throws
`javax.realtime.StaticIllegalArgumentException`—when `name` is `null`.

Returns
the signal corresponding to `name`.

trigger(int)

Signature

```
public static boolean
trigger(int id)
```

Description

Causes the event dispatcher corresponding to `happeningId` to be scheduled for execution. The implementation should be simple enough so that it can be done in the context of an `InterruptServiceRoutine.handle` method.

`trigger()` and any native code analog to it interact with other `javax.realtime.ActiveEvent` code effectively as if `trigger()` signals a POSIX counting semaphore that the happening is waiting on.

The implementation is encouraged to create (and document) a native code analog to this method that can be used without a Java context.

This method must execute in constant time.

Parameters
`id`—Identifies which happening to trigger.
Returns
`true` when a happening with ID `happeningId` was found, `false` otherwise.

getId

Signature

```
public final int
getId()
```

Description

Gets the number of this happening.

Returns

the happening number or -1, when not registered.

getName

Signature

```
public java.lang.String
getName()
```

Description

Gets the name of this happening.

Returns

the name of this happening.

isActive

Signature

```
public boolean
isActive()
```

Description

Determines the activation state of this happening, i.e., if it has been started.

Returns

`true` when active; `false` otherwise.

isRunning

Signature

```
public boolean
isRunning()
```

Description

Determines whether or not this `happening` is both active an enabled.

Returns

`true` when this `happening` is both active and enabled; `false` otherwise.

enable

Signature

```
public void
enable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

disable

Signature

```
public void
disable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

start

Signature

```
public void
start()
throws StaticIllegalStateException
```

Description

Starts this `happening`, i.e., changes its state to the active and enabled. Once a happening is started for the first time, when it is in a scoped memory it increments the scope count of that scope; otherwise, it becomes a member of the root set. An active and enabled happening dispatches its handlers when fired.

Throws

`javax.realtime.StaticIllegalStateException`—when this `happening` has already been started or its `name` is already in use by another happening that has been started.

See Section stop()

start(boolean)

Signature

```
public void
start(boolean disabled)
throws StaticIllegalStateException
```

Description

Starts this `happening`, but leaves it in the disabled state. When fired before being enabled, it does not dispatch its handlers.

Parameters
`disabled`—true for starting in a disabled state.
Throws
`javax.realtime.StaticIllegalStateException`—when this `happening` has already been started.

See Section stop()

stop

Signature

```
public boolean
stop()
throws StaticIllegalStateException
```

Description

Stops this `happening` from responding to the `fire` and `trigger` methods.

Throws
`javax.realtime.StaticIllegalStateException`—when this `happening` is not active.

Returns
`true` when `this` is in the *enabled* state; `false` otherwise.

trigger

Signature

```
public void
trigger()
```

Description

Causes the event dispatcher associated with `this` to be scheduled for execution. The implementation should be simple enough so that it can be done in the context of an `InterruptServiceRoutine.handle` method.

This method must execute in constant time.

getDispatcher

Signature

```
public javax.realtime.device.HappeningDispatcher
getDispatcher()
```

Description

Returns
the dispatcher associated with this event.

setDispatcher(HappeningDispatcher)

Signature

```
public javax.realtime.device.HappeningDispatcher
setDispatcher(HappeningDispatcher dispatcher)
```

Description

Returns

the dispatcher associated with this event.

addHandler(AsyncBaseEventHandler)

Signature

```
public void
addHandler(AsyncBaseEventHandler handler)
```

Description

Adds a handler to the set of handlers associated with this event. An instance of `AsyncBaseEvent` may have more than one associated handler. However, adding a handler to an event has no effect when the handler is already attached to the event.

The execution of this method is atomic with respect to the execution of the `fire()` method.

Note that there is an implicit reference to the handler stored in `this`. The assignment must be valid under any applicable memory assignment rules.

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(AsyncBaseEventHandler handler)
```

Description

Associates a new handler with this event and removes all existing handlers. The execution of this method is atomic with respect to the execution of the `fire()` method.

removeHandler(AsyncBaseEventHandler)

Signature

```
public void
removeHandler(AsyncBaseEventHandler handler)
```

Description

Removes a handler from the set associated with this event. The execution of this method is atomic with respect to the execution of the `fire()` method.

A removed handler continues to execute until its fireCount becomes zero and it completes.

When `handler` has a scoped non-default initial memory area and execution of this method causes `handler` to become unfirable, this method shall not return until all related finalization has completed.

13.3.2.4 HappeningDispatcher

---

public class HappeningDispatcher

Inheritance

java.lang.Object
  javax.realtime.ActiveEventDispatcher<HappeningDispatcher, Happening>
    HappeningDispatcher

Description

This class provides a means of dispatching a set of `Happening`.

Since RTSJ 2.0

13.3.2.4.1 Constructors

HappeningDispatcher(SchedulingParameters, RealtimeThreadGroup)

Signature

```
public
HappeningDispatcher(SchedulingParameters schedule,
                    RealtimeThreadGroup group)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

`schedule`—The parameters to use for scheduling this dispatcher.

`group`—The realtime thread group to use for the dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of `group` does not correspond to a valid affinity.

HappeningDispatcher(SchedulingParameters)

Signature

```
public
HappeningDispatcher(SchedulingParameters schedule)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

`schedule`—The parameters to use for scheduling this dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of the current thread grouo does not correspond to a valid affinity.

13.3.2.4.2 Methods

---

setDefaultDispatcher(HappeningDispatcher)

Signature

```
public static void
setDefaultDispatcher(HappeningDispatcher dispatcher)
```

Description

Sets the system default happening dispatcher.

Parameters

`dispatcher`—The default to use when no dispatcher is provided. When `null`, the happening dispatcher is set to the original system default.

register(Happening)

Signature

```
public synchronized void
register(Happening happening)
throws RegistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Registers a `Happening` with this dispatcher.

Parameters

`happening`—The instance to be registered.

Throws

`RegistrationException`—when `happening` is already registered.

`javax.realtime.StaticIllegalStateException`—when this object has been destroyed or its scheduling parameters are not compatible with the current scheduler.

`javax.realtime.ProcessorAffinityException`—when affinity is not a valid affinity or is not a subset of the affinity of its realtime thread group.

`javax.realtime.StaticIllegalArgumentException`—when `happening` is not stopped.

deregister(Happening)

Signature

```
public synchronized void
deregister(Happening happening)
throws DeregistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Unregisters a `Happening` from this dispatcher.

Parameters

`happening`—The instance to be unregistered.

Throws

`DeregistrationException`—when `happening` is not already registered.

`javax.realtime.StaticIllegalStateException`—when this object has been destroyed.

`javax.realtime.StaticIllegalArgumentException`—when `happening` is not stopped.

destroy

Signature

```
public void
destroy()
throws StaticIllegalStateException
```

Description

Releases all resources thereby making the dispatcher unusable.

Throws

`javax.realtime.StaticIllegalStateException`—when called on a dispatcher that has one or more registered `Happening` objects.

13.3.2.5 InterruptCeilingEmulation

public class InterruptCeilingEmulation

Inheritance

java.lang.Object
  javax.realtime.MonitorControl
    InterruptMasking
      InterruptCeilingEmulation

Description

The default monitor control policy for all instances of `InterruptServiceRoutine`. It is for use synchronizing between second level interrupt handler while the corresponding interrupt line is blocked. The ceiling used depends on the state of the interrupt service routine used as synchronization object: when registered, it is the hardware priority associated with its interrupt line; otherwise, it is the highest software priority available for priority ceiling emulation. When set on anything but an interrupt handler associated with a maskable interrupt, an `javax.realtime.StaticUnsupportedOperationException` is thrown.

See Section javax.realtime.PriorityCeilingEmulation

13.3.2.5.1 Methods

instance

Signature

```
public static javax.realtime.device.InterruptCeilingEmulation
instance()
```

Description

Obtain the instance of this class for a given interrupt. The instance returned is not affected by garbage collection and is universally reachable. It is also effectively immutable.

Returns

The instance of this class for the use with an instance of `InterruptServiceRoutine` associate with a maskable interrupt.

13.3.2.6 InterruptDescriptor

public class InterruptDescriptor

Inheritance

java.lang.Object
  InterruptDescriptor

Description

A class to manage valid interrupts and provide names for them. It provides both lookup and enumeration via a visitor. Both the names and the values are implementation dependent.

13.3.2.6.1 Methods

---

create(long, String)

Signature

```
public static javax.realtime.device.InterruptDescriptor
create(long id,
       String name)
throws StaticIllegalArgumentException,
       StaticIllegalStateException
```

Description

Create a new interrupt descriptor.

Parameters

`id`—the numerical ID of the new descriptor.

`name`—of the descriptor

Throws

`StaticIllegalArgumentException`—when `name` is `null`.

`StaticIllegalStateException`—when a descriptor with `name` already exists.

Returns

the corresponding interrupt descriptor object.

get(String)

Signature

```
public static javax.realtime.device.InterruptDescriptor
get(String name)
throws StaticIllegalArgumentException
```

Description

Get a memory interrupt descriptor by name.

Parameters

`name`—of the descriptor

Throws

`StaticIllegalArgumentException`—when `name` is `null`.

Returns
the interrupt descriptor object or `null`, when none with `name` exists.

isInterrupt(String)

Signature

```
public static boolean
isInterrupt(String name)
```

Description

Ask whether or not there is a memory interrupt descriptor of a given name.

Parameters
`name`—for which to search
Returns
`true` when there is one and `false` otherwise.

visitInterrupts(Consumer)

Signature

```
public static void
visitInterrupts(java.util.function.Consumer<InterruptDescriptor> visitor)
```

Description

Visit all valid interrupt identifiers. Each valid interrupt identifier corresponds to hardware interrupt line. Their values are system dependent.

Parameters
`visitor`—the code to execute on each descriptor.

getName

Signature

```
public final java.lang.String
getName()
```

Description

Obtains the name of this interrupt descriptor.

Returns
the interrupt descriptors name

getID

Signature

```
public final long
getID()
```

Description

Obtains the id of this interrupt descriptor.

Returns
the interrupt descriptors name

toString

Signature

```
public final java.lang.String
toString()
```

Description

Gets a printable representation for a descriptor.

Returns
the printable form of this memory interrupt descriptor.

13.3.2.7 InterruptInheritance

---

public class InterruptInheritance

Inheritance
java.lang.Object
javax.realtime.MonitorControl
InterruptMasking
InterruptInheritance

Description

An alternative monitor control policy for instances of `InterruptServiceRoutine`. It is for use synchronizing between and interrupt service routine and its second level interrupt handler while the corresponding interrupt line is blocked. Though masking only takes place when the interrupt service routine used as synchronization object is registered, eligibility inheritance is always applied. When set on anything but an interrupt handler associated with a maskable interrupt, an `javax.realtime.StaticUnsupportedOperationException` is thrown.

13.3.2.7.1 Methods

---

instance

Signature

```
public static javax.realtime.device.InterruptInheritance
instance()
```

Description

Obtain the instance of this class for a given interrupt. The instance returned is not affected by garbage collection and is universally reachable. It is also effectively immutable.

Returns

The instance of this class for the use with an instance of `InterruptServiceRoutine` associate with a maskable interrupt.

13.3.2.8 InterruptMasking

---

public abstract class InterruptMasking

Inheritance

java.lang.Object
  javax.realtime.MonitorControl
    InterruptMasking

Description

A monitor control policy for use with Interrupt Service Routines. Data shared between an interrupt service routine and a happening should use a subclass of this monitor control policy. Synchronizing on an object causes the corresponding interrupt of its `InterruptServiceRoutine` instance to be masked out when its routine is registered. When its routine is not registered, masking does not occur.

Monitor control policies of this type can only be set on interrupt service routines and interrupt service routines may only using this monitor control policy type.

13.3.2.9 InterruptServiceRoutine

---

public abstract class InterruptServiceRoutine

Inheritance

java.lang.Object
  InterruptServiceRoutine

Description

A class for defining a first level interrupt handler. The implementation must override the `handle` method to provide the code to be run when an interrupt occurs. This class must always be present in the Device module, but may do nothing in a context that does not provide direct access to interrupts, e.g., in user space on an operating system that does not support user space device drivers. Futhermore, it may only have its monitor set to one of type `InterruptMasking`. The default is `InterruptInheritance` for instance associated with a maskable interrupt and `InterruptUnmaskable` for one associated with an unmaskable interrupt.

Since RTSJ 2.0

13.3.2.9.1 Constructors

InterruptServiceRoutine(long, MemoryArea)

Signature

```
public
InterruptServiceRoutine(long Interrupt,
                        MemoryArea area)
throws NullPointerException,
       StaticIllegalArgumentException
```

Description

Creates an interrupt service routine for a particular interrupt line with a particular memory area. An interrupt line may only have one handler registered at any given time and an instance of this class may only be used for one interrupt. The default monitor control policy for an instance of this class is `InterruptInheritance`.

Parameters

`Interrupt`—A reference to the Interrupt associate with this handler.

`area`—The allocation context in which the `handle` method runs.

Throws

`NullPointerException`—when `area` is null.

`javax.realtime.StaticIllegalArgumentException`—when `area` is a memory area that cannot be accessed from an ISR.

13.3.2.9.2 Methods

getHandler(long)

Signature

```
public static javax.realtime.device.InterruptServiceRoutine
getHandler(long interrupt)
```

Description

Gets the `InterruptServiceRoutine` that is handling a given interrupt.

Parameters

`interrupt`—A system-dependent identifier for the interrupt.

Returns

the `InterruptServiceRoutine` registered to the given interrupt. When nothing is registered, `null` is returned.

getAffinity(long)

Signature

```
public static javax.realtime.Affinity
getAffinity(long interrupt)
throws StaticIllegalArgumentException
```

Description

Generally, the program cannot determine the affinity of interrupt handling; however, it is necessary for determining schedulability. This method provides that information, where possible.

Parameters

`interrupt`—The identifier for the interrupt to test

Throws

`javax.realtime.StaticIllegalArgumentException`—when `interrupt` is not in the set of descriptors managed by the `InterruptDescriptor` class.

Returns

an affinity when the system can determine the affinity of `interrupt` or `null` when it cannot.

isRegistered

Signature

```
public final boolean
isRegistered()
```

Description

Obtains the registration state.

Returns

true when registered, otherwise false.

register

Signature

```
public void
register()
throws RegistrationException,
       ScopedCycleException
```

Description

Registers this interrupt service routine with the system so that it can be triggered. Its initial memory area, if any, will be placed in the scope stack and have its reservation count increased. Registering may change the affinity, when the currently set affinity is not compatible with the affinities available for the specific interrupt for which this routine is registered.

Throws

`RegistrationException`—when `this` is already registered, some other `InterruptServiceRoutine` is registered for `interrupt`, or the `handle` method is synchronized.

`ScopedCycleException`—when the initial memory area for this `InterruptServiceRoutine` is already present in the scope tree at a different location than the rules for reservation would imply.

unregister

Signature

```
public void
unregister()
throws DeregistrationException
```

Description

Deregisters this interrupt service routine with the system so that it can no longer be triggered. Its initial memory area, if any, will have its reservation count decreased.

Throws

`DeregistrationException`—when this interrupt service routine is not registered.

handle

Signature

```
protected abstract void
handle()
```

Description

The code to execute for first level interrupt handling. A subclass defines this to give the required behavior. `RawMemory` classes may be used to access the associated device registers and a `Happening` may be triggered for second level interrupt handling.

The code used to implement this method should not block itself or induce a context switch, e.g., sleep or perform I/O. Only spin waits may be used. The effects of unbounded blocking and inducing a context switch here are undefined and could result in a deadlock. `Object.notify()` and `Object.notifyAll()` may be called, but `Happening.trigger` is preferred for ease of linking with the event handling system and `javax.realtime.RealtimeThread.release()` for releasing a realtime thread with `javax.realtime.AperiodicParameters`. In any case, `Object.wait()` should not be called.

Synchronizing with the code in a `handle()` method can only be done by sychronizing with the instance of `InterruptServiceRoutine` containing that `handle()` method. The `handle()` method itself may not be synchronized, since this generates unnecessary extra code which could cause blocking. Instead, the platform interrupt masking is used to ensure mutual exclusion. The containing instance can only have a monitor control policy of type `InterruptMasking`.

When a memory area is provided, that memory is entered before this method is invoked and exited after it returns. When no memory area is provided, the method may not allocate. Any attempt to allocate will result in an `OutOfMemoryError`.

Any exceptions thrown by this method cause the method to about and are silently caught and discarded by the infrastructure.

13.3.2.10 InterruptUnmaskable

---

public class InterruptUnmaskable

Inheritance

java.lang.Object
  javax.realtime.MonitorControl
    InterruptMasking
      InterruptUnmaskable

Description

A control policy for instances of `InterruptServiceRoutine` associated with an unmaskable interrupt. Since such an interrupt cannot be masked, synchronization is not possible. Synchronization on an object with this monitor policy always fails with an `javax.realtime.CeilingViolationException`. When set on anything but an interrupt handler associated with an unmaskable interrupt, an `javax.realtime.StaticUnsupportedOperationException` is thrown.

13.3.2.10.1 Methods

---

instance

Signature

```
public static javax.realtime.device.InterruptUnmaskable
instance()
```

Description

Obtain the instance of this class for a given interrupt. The instance returned is not affected by garbage collection and is universally reachable. It is also effectively immutable.

Returns

The instance of this class for the use with an instance of `InterruptServiceRoutine` associate with an unmaskable interrupt.

13.3.2.11 RawMemoryFactory

public class RawMemoryFactory

Inheritance

java.lang.Object
  RawMemoryFactory

Description

This class is the hub of a system that constructs special purpose objects to access particular types and ranges of raw memory. This facility is supported by the `register(RawMemoryRegionFactory)` methods. An application developer can use this method to add support for additional memory regions.

Each *create method* returns an object of the corresponding type, e.g., the `createRawByte(RawMemoryRegion, long, int, int)` method returns a reference to an object that implements the `RawByte` interface and supports access to the requested type of memory and address range. Each *create method* is permitted to optimize error checking and access based on the requested memory type and address range.

The usage pattern for raw memory, assuming the necessary factory has been registered, is illustrated by this example.

```
// Get an accessor object that can access memory starting at
// baseAddress, for size bytes.
RawInt memory =
  RawMemoryFactory.getDefaultFactory().
    createRawInt(RawMemoryFactory.MEMORY_MAPPED_REGION,
                 address, count, stride, false);
// Use the accessor to load from and store to raw memory.
int loadedData = memory.getInt(someOffset);
memory.setInt(otherOffset, intVal);
```

When an application needs to access a class of memory that is not already supported by a registered factory, the developer must implement and register a factory that implements the `RawMemoryRegionFactory`) which can create objects to access memory in that region.

A raw memory region factory is identified by a `RawMemoryRegion` that is used by each *create method*, e.g., `createRawByte(RawMemoryRegion, long, int, int)`, to locate the appropriate factory. The name is provided to `register(RawMemoryRegionFactory)` through the factory's `RawMemoryRegionFactory.getName` method.

The `register(RawMemoryRegionFactory)` method is only used by the application code when it needs to add support for a new type of raw memory.

Whether a given `offset` addresses a high-order or low-order byte of an aligned `short` in memory is determined by the value of the `javax.realtime.RealtimeSystem.BYTE_ORDER` static byte variable in class `javax.realtime.RealtimeSystem`, by the start address of the object, and by the `offset` given the `stride` of the object. Regardless of the byte ordering, accessor methods continue to select bytes starting at `offset` from the base address and continuing toward greater addresses.

A raw memory region cannot contain references to Java objects. Such a capability would be unsafe (since it could be used to defeat Java's type checking) and error prone (since it is sensitive to the specific representational choices made by the Java compiler).

Atomic loads and stores on raw memory are defined in terms of physical memory. This memory may be accessible to threads outside the JVM and to non-programmed access (e.g., DMA). Consequently, atomic access must be supported by hardware. This specification is written with the assumption that all suitable hardware platforms support atomic loads from raw memory for aligned bytes, shorts, and ints. Atomic access beyond the specified minimum may be supported by the implementation.

Storing values into raw memory is more hardware dependent than loading values. Many processor architectures do not support atomic stores of variables except for aligned stores of the processor's word size. For instance, storing a byte into memory might require reading a 32-bit quantity into a processor register, updating the register to reflect the new byte value, then restoring the whole 32-bit quantity. Changes to other bytes in the 32-bit quantity that take place between the load and the store are lost.

Some processors have mechanisms that can be used to implement an atomic store of a byte, but those mechanisms are often slow and not universally supported.

This class need not support unaligned access to data; but if it does, it is not required of the implementation to make such access atomic. Accesses to data aligned on its natural boundary will be atomic if the processor implements atomic loads and stores of that data size.

Except where noted, accesses to raw memory are not atomic with respect to the memory or with respect to tasks. A raw memory region could be updated by another task, or even unmapped in the middle of an access method, or even *removed* mid method.

The characteristics of raw-memory access are necessarily platform dependent. This specification provides a minimum requirement for the RTSJ platform, but it also supports optional system properties that identify a platform's level of support for atomic raw put and get. The properties can be represented by a four-dimensional sparse array of access type, data type, alignment, and atomicity with boolean values indicating whether that combination of access attributes is atomic. The default value for array entries is false. The array is described in the following table.

The true values in the table are represented by properties of the following form. javax.realtime.atomicaccess_<access>_<type>_<alignment>_atomicity=true for example,

Table 13.1: Properties Array

Attribute	Values	Comment
Access type	read, write	
Data type	byte, short, int, long, float, double	
Alignment	0	aligned
	1 to one less than data type size	the first byte of the data is the value of *alignment* bytes away from natural alignment.
Atomicity	processor	means access is atomic with respect to other tasks on processor.
	smp	means access is *processor* atomic, and atomic with respect to all processors in an SMP.
	memory	means that access is *smp* atomic, and atomic with respect to all access to the memory including DMA.

```
javax.realtime.atomicaccess_read_byte_0_memory=true
```

Table entries with a value of false may be explicitly represented, but since false is the default value, such properties are redundant.

All raw memory access is treated as volatile, and *serialized*. The infrastructure must be forced to read memory or write to memory on each call to a raw memory objects's getter or setter method, and to complete the reads and writes in the order they appear in the program order.

Since RTSJ 2.0

13.3.2.11.1 Fields

MEMORY_MAPPED_REGION

```
public static final RawMemoryRegion MEMORY_MAPPED_REGION
```

Description

This raw memory region is predefined for requesting access to memory mapped I/O devices.

IO_PORT_MAPPED_REGION

```
public static final RawMemoryRegion IO_PORT_MAPPED_REGION
```

Description

This raw memory region is predefined for access to I/O device space implemented by processor instructions, such as the x86 `in` and `out` instructions.

13.3.2.11.2 Constructors

RawMemoryFactory

Signature

```
public
RawMemoryFactory()
```

Description

Creates an empty factory. For a factory with support for the platform defined regions, use `getDefaultFactory` instead. This is only useful after a `RawMemoryRegionFactory` has been added with `register(RawMemoryRegionFactory)`.

13.3.2.11.3 Methods

---

getDefaultFactory

Signature

```
public static javax.realtime.device.RawMemoryFactory
getDefaultFactory()
```

Description

Gets the factory with support for the platform defined regions. Create when it has not already been created. Ensure that at least the RawMemoryRegionFactory is registered in the default factory.

Returns

the platform-defined factory.

register(RawMemoryRegionFactory)

Signature

```
public void
register(RawMemoryRegionFactory factory)
throws RegistrationException,
       NullPointerException
```

Description

Adds support for a new memory region.

Parameters

`factory`—The `RawMemoryRegionFactory` instance to use for creating `RawMemory` objects for the `RawMemoryRegion` instances it makes available.

Throws

`RegistrationException`—when the `factory` already is already registered.

`NullPointerException`—when `factory` is null.

deregister(RawMemoryRegionFactory)

Signature

```
public void
deregister(RawMemoryRegionFactory factory)
throws DeregistrationException,
       NullPointerException
```

Description

Removes support for a new memory region.

Parameters

`factory`—The `RawMemoryRegionFactory` to be made unavailable.

Throws

`DeregistrationException`—when `factory` is not registered.

`NullPointerException`—when `factory` is null.

createRawByte(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawByte
createRawByte(RawMemoryRegion region,
              long base,
              int count,
              int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawByte` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByte* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawByte` and supports access to the specified range in the memory region.

createRawByteReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawByteReader
createRawByteReader(RawMemoryRegion region,
                    long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawByteReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByteReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawByteReader` and supports access to the specified range in the memory region.

createRawByteWriter(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawByteWriter
createRawByteWriter(RawMemoryRegion region,
                    long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawByteWriter` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawByteWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawByteWriter` and supports access to the specified range in the memory region.

createRawShort(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawShort
createRawShort(RawMemoryRegion region,
               long base,
               int count,
               int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawShort` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawShort* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawShort` and supports access to the specified range in the memory region.

createRawShortReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawShortReader
createRawShortReader(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawShortReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawShortReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements RawShortReader and supports access to the specified range in the memory region.

createRawShortWriter(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawShortWriter
createRawShortWriter(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements RawShortWriter and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawShortWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements RawShortWriter and supports access to the specified range in the memory region.

createRawInt(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawInt
createRawInt(RawMemoryRegion region,
             long base,
             int count,
             int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawInt` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` ∗ *size of RawInt* ∗ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawInt` and supports access to the specified range in the memory region.

createRawIntReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawIntReader
createRawIntReader(RawMemoryRegion region,
                   long base,
```

```
                    int count,
                    int stride)
    throws SecurityException,
           IllegalArgumentException,
           OffsetOutOfBoundsException,
           SizeOutOfBoundsException,
           UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawIntReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawIntReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawIntReader` and supports access to the specified range in the memory region.

createRawIntWriter(RawMemoryRegion, long, int, int)

Signature

```
    public javax.realtime.device.RawIntWriter
    createRawIntWriter(RawMemoryRegion region,
                    long base,
                    int count,
                    int stride)
    throws SecurityException,
           IllegalArgumentException,
```

```
        OffsetOutOfBoundsException,
        SizeOutOfBoundsException,
        UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawIntWriter` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawIntWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawIntWriter` and supports access to the specified range in the memory region.

createRawLong(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawLong
createRawLong(RawMemoryRegion region,
              long base,
              int count,
              int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawLong` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawLong* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawLong` and supports access to the specified range in the memory region.

createRawLongReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawLongReader
createRawLongReader(RawMemoryRegion region,
                    long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawLongReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawLongReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawLongReader` and supports access to the specified range in the memory region.

createRawLongWriter(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawLongWriter
createRawLongWriter(RawMemoryRegion region,
                    long base,
                    int count,
                    int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawLongWriter` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawLongWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawLongWriter` and supports access to the specified range in the memory region.

createRawFloat(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawFloat
createRawFloat(RawMemoryRegion region,
               long base,
               int count,
               int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawFloat` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawFloat* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawFloat` and supports access to the specified range in the memory region.

createRawFloatReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawFloatReader
createRawFloatReader(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawFloatReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawFloatReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

SizeOutOfBoundsException—when the memory addressed by the object would extend into an invalid range for raw memory.

UnsupportedRawMemoryRegionException—when `region` is not registered.

Returns

an object that implements RawFloatReader and supports access to the specified range in the memory region.

createRawFloatWriter(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawFloatWriter
createRawFloatWriter(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements RawFloatWriter and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawFloatWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

OffsetOutOfBoundsException—when `base` is not in a invalid range for raw memory.

SizeOutOfBoundsException—when the memory addressed by the object would extend into an invalid range for raw memory.

UnsupportedRawMemoryRegionException—when `region` is not registered.

Returns

an object that implements RawFloatWriter and supports access to the specified range in the memory region.

createRawDouble(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawDouble
createRawDouble(RawMemoryRegion region,
                long base,
                int count,
                int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements RawDouble and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawDouble* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements RawDouble and supports access to the specified range in the memory region.

createRawDoubleReader(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawDoubleReader
createRawDoubleReader(RawMemoryRegion region,
                      long base,
                      int count,
                      int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawDoubleReader` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawDoubleReader* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawDoubleReader` and supports access to the specified range in the memory region.

createRawDoubleWriter(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawDoubleWriter
createRawDoubleWriter(RawMemoryRegion region,
                      long base,
                      int count,
                      int stride)
throws SecurityException,
       IllegalArgumentException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException
```

Description

Creates an instance of a class that implements `RawDoubleWriter` and accesses memory of `region` in the address range described by `base`, `stride`, and `count`. The actual extent of the memory addressed by the object is `stride` $*$ *size of RawDoubleWriter* $*$ `count`. The object is allocated in the current memory area of the calling thread.

Parameters

`region`—The address space from which the new instance should be taken.

`base`—The starting physical address accessible through the returned instance.

`count`—The number of memory elements accessible through the returned instance.

`stride`—The distance to the next element as a multiple of element size, where `1` means the elements are adjacent in memory.

Throws

`SecurityException`—when the caller does not have permissions to access the given memory region or the specified range of addresses.

`IllegalArgumentException`—when `base` is negative, `count` is not greater than zero, or `stride` is less than one.

`OffsetOutOfBoundsException`—when `base` is not in a invalid range for raw memory.

`SizeOutOfBoundsException`—when the memory addressed by the object would extend into an invalid range for raw memory.

`UnsupportedRawMemoryRegionException`—when `region` is not registered.

Returns

an object that implements `RawDoubleWriter` and supports access to the specified range in the memory region.

13.3.2.12 RawMemoryRegion

---

public class RawMemoryRegion

Inheritance

java.lang.Object
RawMemoryRegion

Description

RawMemoryRegion is a class for typing raw memory regions. It is returned by the `RawMemoryRegionFactory.getRegion` methods of the raw memory region factory classes, and it is used with methods such as `RawMemoryFactory.createRawByte(RawMemoryRegion, long, int, int)` and `RawMemoryFactory.createRawDouble(RawMemoryRegion, long, int, int)` methods to identify the region from which the application wants to get an accessor instance.

Since RTSJ 2.0

13.3.2.12.1 Methods

---

get(String)

Signature

```
public static javax.realtime.device.RawMemoryRegion
get(String name)
throws StaticIllegalArgumentException
```

Description

Get a memory region type by name.

Parameters

`name`—of the region

Throws

`StaticIllegalArgumentException`—when `name` is `null`.

Returns

the region type object or `null`, when none with `name` exists.

isRawMemoryRegion(String)

Signature

```
public static boolean
isRawMemoryRegion(String name)
```

Description

Ask whether or not there is a memory region type of a given name.

Parameters

`name`—for which to search

Returns

`true` when there is one and `false` otherwise.

getName

Signature

```
public final java.lang.String
getName()
```

Description

Obtains the name of this region type.

Returns

the region types name

toString

Signature

```
public final java.lang.String
toString()
```

Description

Gets a printable representation for a Region.

Returns

the name of this memory region type.

13.4 Rationale

As with alternative memory management, support for device access has been improved in several ways: typed access to device memory, and extensions for DMA, and a new first-level interrupt handling API, as well as package separation. Package separation was discussed in the rationale for alternative memory management. Each of the other changes was driven by its own set of requirements. Still they where designed to produce a coherent set of features for the new specification.

13.4.1 Typed Raw Memory

Raw memory in the `RTSJ` refers to any memory in which only objects of primitive types can be stored; *Java objects or their references cannot be stored in raw memory.* `RTSJ` Version 2.0 provides two categories:

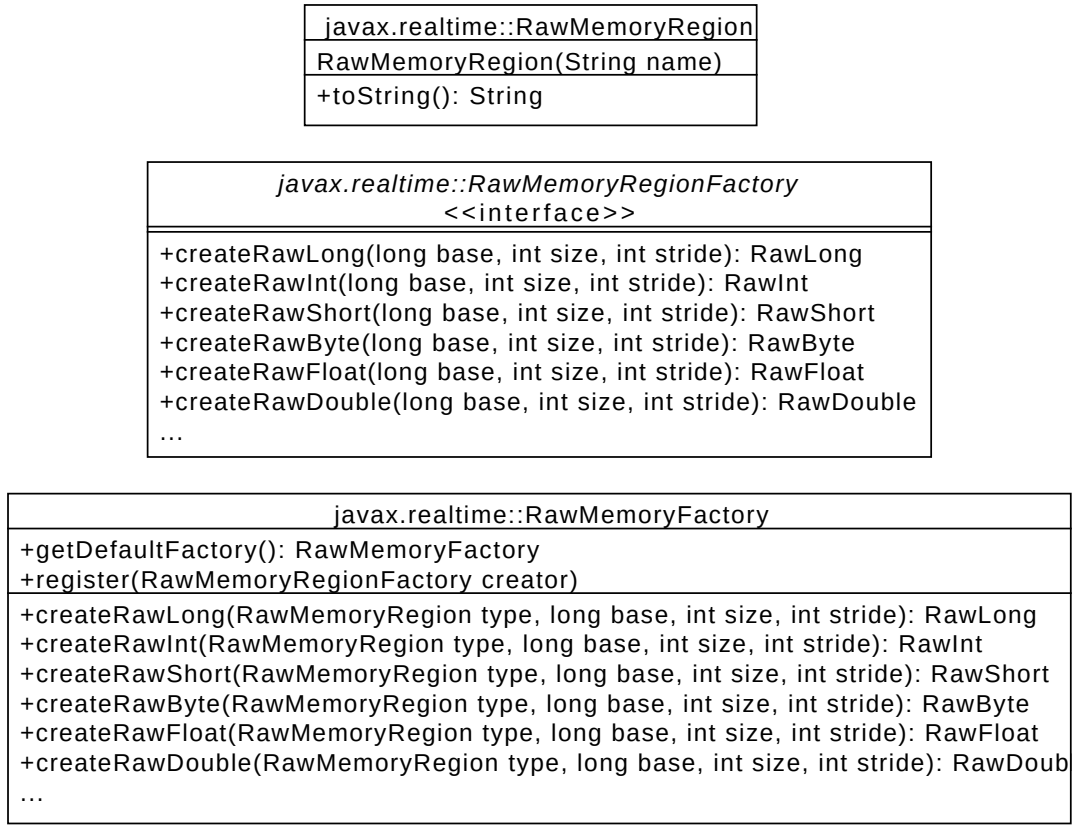
1. memory that is used to access memory-mapped device registers, and
2. logical memory that can be used to access port-based device registers.

Each of these categories of memory is represented by an instance of `RawMemoryRegion`. In addition, the application can define other regions outside these two, either for accessing device registers in some other address space or for other purposes, such as emulating device access.

Java's primitive types are partitioned into two groups: integral (short, int, long, byte) and real (float, double) types, including arrays of each type. For integral types, individual interfaces are also defined to facilitate greater type security during

access. Objects that support these interfaces are created by factory methods, which again have predefined interfaces. Such objects are called *accessor* objects as they encapsulate the access protocol to the raw memory.

Figure 13.5: Creating Raw Memory Accessors



Control over all these objects is managed by the `RawMemoryFactory` class that provides a set of static methods, as shown in Figure 13.5. There are two groups of methods:

1. those that enable a factory to be registered, and
2. those that request the creation of *accessor* object for a particular memory type at a particular address.

The latter consists of methods to create Java-primitive-type accessor objects, which will throw exceptions if the appropriate addresses are not on correct boundaries to enable the underlying machine instructions to be used without causing hardware exceptions (e.g., `createRawByteReader`).

As with interrupt handling, some realtime JVMs may not be able to support all of the memory categories. However, the expectation is that for all supported categories, they will also provide and register the associated factories for object creation.

For the case of `IO_PORT_MAPPED` raw memory, the accessor objects will need to arrange to execute the appropriate machine instructions to access the device registers.

Consider the simple case where a device has two device registers: a control/status register that is a 32 bits integer, and a data register that is a 64 bits long. The registers

have been memory mapped to locations: 0x20 and 0x24 respectively. Assuming the realtime JVM has registered a factory for the `IO_MEMORY_MAPPED_REGION` raw memory name, then the following code will create the objects that facilitate the memory access.

```
1 RawMemoryFactory factor = RawMemoryFactory.getDefault();
2 RawInt controlReg =
3   factory.createRawInt(RawMemoryFactory.IO_MEMORY_MAPPED_REGION,
        0x20);
4 RawLong dataReg =
5   factory.createRawLong(RawMemoryFactory.IO_MEMORY_MAPPED_REGION,
         0x24);
```

The above definitions reflect the structure of the actual registers. The JVM will check that the memory locations are on the correct boundaries and that they can be accessed without any hardware exceptions being generated. If they cannot, the create methods will throw an appropriate exceptions. If successfully created, all future access to the `controlReg` and `dataReg` will be exception free. The registers can be manipulated by calling the appropriate methods, as in the following example.

```
1 dataReg.setLong(l);
2     // where l is of type long and is data to be sent to the
          device
3 controlReg.setInt(i);
4     // where i is of type int and is the command to the device
```

In the general case, programmers themselves may create their own memory categories and provide associated factories (that may use the implementation-defined factories). These factories are written in Java and are, therefore, constrained by what the language allows them to do. Typically, they will use the JVM-supplied raw memory types to facilitate access to a device's external memory.

The facilities provided by the `RTSJ` allow an application to support the notion of removable memory. When this memory is inserted or removed, an asynchronous event can be set up to fire, thereby alerting the application that the device has become active. Of course, any removable memory has to be treated with extreme caution. Hence, the `RTSJ` facilities allow it only to be accessed as a raw memory device.

13.4.2 Direct Memory Access

Direct Memory Access (DMA) requires access to memory outside of the heap. It is often crucial for performance in embedded systems; however, it does cause problems both from a realtime analysis perspective and from a JVM-implementation perspective. The latter is the primary concern here.

There are a few crucial points to note about DMA and the `RTSJ`.

1. The `RTSJ` does not address issues of persistent objects, so the input and output of Java objects to devices (other than by using the Java serialization mechanism) is not supported.

2. The RTSJ requires that RTSJ programs can be compiled by regular Java compilers. Different bytecode compilers, and their supporting JVMs, use different representation for objects. Java arrays, even of primitive types, are objects, and the data they contain might not be stored in contiguous memory.
3. The package java.nio.channels provides a mechanism for I/O that was not specifically designed for DMA, but provides an applicable pattern for it.

For these reasons, without explicit knowledge of the compiler and JVM, allowing any DMA into any RTSJ memory area is a very dangerous action; therefore, the RTSJ provides some special support for DMA. Unfortunately, it would be difficult to find a general pattern to fit all DMA controllers; however, with raw memory and raw byte buffers, one could construct a higher level API that would cover most DMA controllers. Even so, there will always be odd cases that would still not fit the general pattern, especially for embedded systems. For this reason, only this low level API is provided.

The DMA interface is designed to minimize the points where actual physical addresses are provided. If nothing else, this reduces the number of places where security checks are needed. Actual physical addresses are only needed when a DirectMemoryRegion is created. When a DMA buffer is needed, the application developer can draw it from one of the previously defined regions. When exact addresses are needed for each buffer, a DirectMemoryRegion can be defined for each buffer. Otherwise, a large region can be defined for each controller and the system can manage allocation out of these regions.

In general, the JVM must know what interrupts are available to it, whether or not they are maskable, and how to mask them. Most likely, this information is provide via a configuration parameter or file. It should be sufficient to describe masking as a raw memory region name, an address, and possibly a bit in a mask. Of course, the JVM would need to support that raw memory region in the default raw memory factory. The JVM need not know about interrupts that are not made available to the JVM.

13.4.3 Interrupt Handling

Handling interrupts is a necessary part of many embedded systems. Interrupt handlers have traditionally been implemented in assembler code or C. With the growing popularity of high-level concurrent languages, there has been interest in better integration between the interrupt handling code and the application. Ada, for example, allows a "protected" procedure to be called directly from an interrupt [3].

Regehr [7] defines the terms used for the core components of interrupts and their handlers as follows:

1. *Interrupt*—a hardware supported asynchronous transfer of control mechanism initiated by an event external to the processor. Control of the processor is transferred through an interrupt vector.
2. *Interrupt vector*—a dedicated (or configurable) location that specifies the location of an interrupt handler.
3. *Interrupt handler*—code that is reachable from the interrupt vector.
4. *An interrupt controller*—a peripheral device that manages interrupts for the

processor.

He further identifies the following problems with programming interrupt-driven software on single processors:

1. Stack overflow—the difficulty determining how much call-chain stack is required to handle an interrupt. The problem is compounded if the stack is borrowed from the currently executing thread or process.
2. Interrupt overload—the problem of ensuring that noninterrupt-driven processing is not swamped by unexpected or misbehaving interrupts.
3. Real-time analysis—the need to have appropriate schedulability analysis models to bound the impact of interrupt handlers.

The problems above are accentuated in multiprocessor systems where interrupts can be handled globally. Fortunately, many multiprocessor systems allow interrupts to be bound to particular processors. For example, the ARM Cortex A9-MPCore supports the Arm Generic Interrupt Controller[1]. This enables a target list of CPUs to be specified for each hardware interrupt. Software generated interrupts can also be sent to the list or set up to be delivered to all but the requesting CPU or only the requesting CPU.

Regehr's problems are all generic and can be solved irrespective of the language used to implement the handlers. In general they can be addressed by a combination of techniques.

1. Stack overflow—static analysis techniques can normally be used to determine the worst-case stack usage of all interrupt handlers. When stack is borrowed from the executing thread, this amount must be added to the worst-case stack usage of all threads.
2. Interrupt overload—this is typically managed by aperiodic server technology in combination with interrupt masking (see Section 13.6 of [3]).
3. Real-time analysis—again, this can be catered for in modern schedulability analysis techniques, such as response-time analysis (see Section 14.6 of [3]).

From a `RTSJ` perspective, the following distinctions are useful

1. The *first-level interrupt handlers* are the code that the platform executes in response to the hardware interrupts (or traps). A first-level interrupt is assumed to be executed at an execution eligibility (priority) and by a processor dictated by the underlying platform (which may be controllable at the platform level). On some `RTSJ` implementations it will not be possible to write Java code for these handlers. Implementations that do enable Java-level handlers may restrict the code that can be written. For example, the handler code should not suspend itself or throw unhandled exceptions. The `RTSJ` 2.0 optional `InterruptServiceRoutine` class supports first level interrupt handling.
2. The *external event handler* is the code that the JVM executes as a result of being notified that an external event (be it an operating system signal, an ISR or some other program) is targeted at the `RTSJ` application. The programmer should be able to specify the processor affinity and execution eligibility of this code. In `RTSJ` 2.0, all external events are represented by instances of the `Happening` interface. Every happening has an associated dispatcher which is responsible for the initial response to an occurrence of the event.

[1] See http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0375a/Cegbfjhf.html

3. A happening dispatcher is able to find one or more associated `RTSJ` asynchronous events and fire them. This then releases the associated asynchronous event handlers.

An new monitor control policy was added to separate synchronization with an interrupt service routine from other types of synchronization. This is to ensure that the interrupt masking policy is independent of all task schedulers. Furthermore, other types of monitor control policies should not have any inherent knowledge of interrupt masking.

Chapter 14

Interprocess Signaling

On many operating systems, it is possible for one process to signal another. POSIX provides a well defined means of signaling other processes and receiving signals from them, therefore one would like to be able to use this facility when it or a similar mechanism is available. The POSIX module provides the means to do this. It provides a common idiom for binding signals to instances of `AsyncEventHandler`. The C standard has incorporates some of these facilities, so a useful subset may be provided on systems that do not support POSIX, but do support this subset.

14.1 Definitions

Signal — A notification between two system processes or threads in a process, which may or may not contain a data packet.
Realtime Signal — A special type of signal that carries a bit of data with it.

14.2 Semantics

The POSIX interface provides two main facilities: sending signals and receiving signals. These are supported by a means of determining which signals are supported on an implementation. In addition, not only stateless signals, but also signals with data are also supported. All classes are in the `javax.realtime.posix` package.

Signals can be identified both by a name and by an integer value. The names of the form SIGRT<n>, where <n> is some number from zero to a system defined maximum value, are reserved for realtime signals, i.e., signals with a payload. All other names are for normal signals, i.e., stateless signals. These two sets have distinct sets of integer values, though two normal signal names may map to the same integer value. The integer values are system dependent.

Some signals have predefined uses. For example, `SIG_SEGV` is used to signal an application that the program has attempted to reference the content of an address that is not available in the current address space. There is even a signal that can never be caught because it terminates the process before anything else can happen.

Therefore, an implementation must document what signals an `RTSJ` runtime or virtual machine uses, whether or not the signal handler can be overridden, and what

would happen when a program attaches a handler to that signal or sends that signal to another instance of the virtual machine. Whenever possible, an RTSJ program should be able to handle any signal it receives. The only exception is SIG_KILL, which might never reaches the program.

14.2.1 POSIX Signals

The Signal class represents POSIX signals and is required on platforms that provide POSIX signals. As with a Happening, it is a subclass of AsyncEvent and implements ActiveEvent. Unlike Happening, it cannot be instantiated by the user. Instead, an instance exists for each POSIX signal defined on the system. They can be retrieved either by name or number using the Signal.get(int) and Signal.get(String) methods.

14.2.2 POSIX Realtime Signals

The RealtimeSignal class represents POSIX realtime events. It also implements ActiveEvent, but as a subclass of AsyncLongEvent, so that it can pass the data sent with its signal. As with Signal, it cannot be instantiated by the user, rather an instance exists for each POSIX signal defined on the system, which can be retrieved either by name or number using the RealtimeSignal.get(int) and RealtimeSignal.get(String) methods.

14.3 javax.realtime.posix

14.3.1 Classes

14.3.1.1 RealtimeSignal

---

public class RealtimeSignal

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncLongEvent
      RealtimeSignal

Interfaces

javax.realtime.ActiveEvent

Description

An `javax.realtime.ActiveEvent` subclass for defining a POSIX realtime signal. A realtime signal, as defined in POSIX 1003.1b, is a signal that may carry a numerical value with it and that have a special queuing system to handle it. It is capable of handling a realtime signal with its associated payload, as well as sending it to another process described by its process id. The name formatting is `SIGRT` followed by the number of the realtime signal to be used. For example `SIGRT0`, or `SIGRTMIN`, for the first realtime signal, `SIGRT1` for the second and `SIGRTMAX` for the last one.

Here is an example of using of the class:

```
class SendRealtimeSignalToSelf
{
  public static void main(String[] args) throws POSIXInvalidSignalException
  {
    RealtimeSignal rs = RealtimeSignal.get("SIGRTMIN");
    LongConsumer lc = (l) -> { System.out.println("The payload is " + l); };
    rs.setHandler(new AsyncLongEventHandler(lc));
    rs.start(); // register the signal
    rs.send(Signal.getProcessId(), 420); // send the signal this process
    rs.disable(); //disable the signal, so the handler no longer executes
    rs.send(Signal.getProcessId(), 1997);
    // the signal is sent to this process, it will be handled, but
    // the handlers will not be executed
    rs.stop(); // deregister the signal
  }
}
```

The current state of the implementation of the POSIX mechanism on most system does not enable guaranteeing that one can send or receive realtime signal with payloads whose size is above 16 bits. In the following, the system numeric

value of the realtime signal is referred to as ID. For example, in most POSIX systems, `SIGRTMIN`'s value is 34.

This class requires the following permissions:

Method	POSIXPermission Action
`RealtimeSignal.addHandler`	handle
`RealtimeSignal.setHandler`	handle, override
`RealtimeSignal.removeHandler`	override
`RealtimeSignal.send`	send
`RealtimeSignal.start`	control
`RealtimeSignal.stop`	control

See Section Signal
See Section RealtimeSignalDispatcher
Since RTSJ 2.0

14.3.1.1.1 Methods

---

isRealtimeSignal(String)

Signature

```
public static boolean
isRealtimeSignal(String name)
```

Description

Determines whether or not the given name represents a realtime signal.

Parameters

`name`—The name of the signal check.

Returns

`true` when a signal with the given name is defined, but `false` in all other cases.

isRealtimeSignal(int)

Signature

```
public static boolean
isRealtimeSignal(int id)
```

Description

Determines whether or not the given id represents a realtime signal.

Parameters
`id`—The numerical signal identifier to check.
Returns
`true` when a signal with the given id is defined, but `false` in all other cases.

getId(String)

Signature

```
public static int
getId(String name)
throws POSIXInvalidSignalException
```

Description

Gets the ID of a supported POSIX realtime signal by its name.

Parameters
`name`—The name of the signal whose ID should be determined.
Throws
`POSIXInvalidSignalException`—when no signal with the given name exists or `name` is `null`.

Returns
the ID of the signal named by `name`.

get(String)

Signature

```
public static javax.realtime.posix.RealtimeSignal
get(String name)
throws POSIXInvalidSignalException
```

Description

Gets a POSIX realtime signal by its name.

Parameters
`name`—The name of the signal to get.
Throws
`POSIXInvalidSignalException`—when no signal with the given name exists or `name` is `null`.

Returns
the realtime signal with name.

get(int)

Signature

```
public static javax.realtime.posix.RealtimeSignal
get(int id)
throws POSIXInvalidSignalException
```

Description

Gets a POSIX realtime signal by its ID.

Parameters

`id`—The identifier of a POSIX realtime signal.

Throws

`POSIXInvalidSignalException`—when no signal with the given identifier `id` exists.

Returns

the realtime signal corresponding to ID or `null` when no signal with that ID exists.

getMinId

Signature

```
public static int
getMinId()
```

Description

Determines the lowest system id for realtime signals.

Returns

the equivalent of `getId(String)` called with the string `"SIGRTMIN"` or `"SIGRTO"`.

getMaxId

Signature

```
public static int
getMaxId()
```

Description

Determines the highest system id for realtime signals.

Returns

the equivalent of `getId(String)` called with the string `"SIGRTMAX"`.

getId

Signature

```
public int
getId()
```

Description

Gets the name of this realtime signal.

Returns
the ID of this signal.

getName

Signature

```
public final java.lang.String
getName()
```

Description

Gets the name of this signal.

Returns
the name of this signal.

getDispatcher

Signature

```
public javax.realtime.posix.RealtimeSignalDispatcher
getDispatcher()
```

Description

Returns
the dispatcher associated with this event.

setDispatcher(RealtimeSignalDispatcher)

Signature

```
public javax.realtime.posix.RealtimeSignalDispatcher
setDispatcher(RealtimeSignalDispatcher dispatcher)
```

Description

Returns
the dispatcher associated with this event.

isActive

Signature

```
public boolean
isActive()
```

Description

Determines the activation state of this signal, i.e., whether or not it has been started.

Returns
`true` when active; `false` otherwise.

isRunning

Signature

```
public boolean
isRunning()
```

Description

Determines the firing state (releasing or skipping) of this signal, i.e., whether or not is active and enabled.

Returns

`true` when releasing, `false` when skipping.

enable

Signature

```
public void
enable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

disable

Signature

```
public void
disable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

start

Signature

```
public final synchronized void
start()
throws StaticIllegalStateException
```

Description

Starts this `RealtimeSignal`, i.e., changes to a running state: active and enabled. An active realtime signal is a source of activation for its memory area and is a member of the root set when in the heap. An active signal can be triggered, but it must be running to dispatch its handlers.

Throws

`javax.realtime.StaticIllegalStateException`—when this `RealtimeSignal` is active.

See Section stop()

start(boolean)

Signature

```
public final synchronized void
start(boolean disabled)
throws StaticIllegalStateException
```

Description

Starts this `RealtimeSignal`, i.e., changes to an active state. An active realtime signal is a source of activation for its memory area and is a member of the root set when in the heap. When called with `disabled` equal to `false`, it will also be running. An active signal can be triggered, but it must be running to dispatch its handlers.

Parameters

`disabled`—`true` for starting in a disabled state.

Throws

`javax.realtime.StaticIllegalStateException`—when this `RealtimeSignal` is active.

See Section stop()

stop

Signature

```
public final boolean
stop()
throws StaticIllegalStateException
```

Description

Stops this `RealtimeSignal`, i.e., change its state to inactive. A stopped realtime signal ceases to be a source of activation and no longer causes any `ActiveEvent` attached to it to be a source of activation.

Throws

`javax.realtime.StaticIllegalStateException`—when this `RealtimeSignal` is inactive.

Returns

`true` when `this` was *enabled*; `false` otherwise.

send(long, long)

Signature

```
public boolean
send(long pid,
     long payload)
throws POSIXSignalPermissionException,
       POSIXInvalidTargetException
```

Description

Sends this signal to another process.

Parameters

`pid`—The identifier of the process to which to send the signal.

`payload`—The long value associated with a fire.

Throws

`POSIXSignalPermissionException`—when the process does not have permission to send the target.

`POSIXInvalidTargetException`—when the target does not exist.

addHandler(AsyncBaseEventHandler)

Signature

```
public void
addHandler(AsyncBaseEventHandler handler)
```

Description

Adds a handler to the set of handlers associated with this event. An instance of `AsyncBaseEvent` may have more than one associated handler. However, adding a handler to an event has no effect when the handler is already attached to the event.

The execution of this method is atomic with respect to the execution of the `fire()` method.

Note that there is an implicit reference to the handler stored in `this`. The assignment must be valid under any applicable memory assignment rules.

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(AsyncBaseEventHandler handler)
```

Description

Associates a new handler with this event and removes all existing handlers. The execution of this method is atomic with respect to the execution of the `fire()` method.

removeHandler(AsyncBaseEventHandler)

Signature

```
public void
removeHandler(AsyncBaseEventHandler handler)
```

Description

Removes a handler from the set associated with this event. The execution of this method is atomic with respect to the execution of the `fire()` method.

A removed handler continues to execute until its fireCount becomes zero and it completes.

When `handler` has a scoped non-default initial memory area and execution of this method causes `handler` to become unfirable, this method shall not return until all related finalization has completed.

14.3.1.2 RealtimeSignalDispatcher

---

public class RealtimeSignalDispatcher

Inheritance

java.lang.Object
javax.realtime.ActiveEventDispatcher<RealtimeSignalDispatcher, RealtimeSignal>
RealtimeSignalDispatcher

Description

Provides a means of dispatching a set of `RealtimeSignal` instances, each when its respective signal is triggered. An application can provide its own dispatcher, providing the priority for the internal dispatching thread. This dispatching thread calls the `javax.realtime.AsyncLongEvent.fire` method on the instance of `RealtimeSignal` associated with the signal each time its signal is triggered. This class requires the following permissions:

Method	Required Action for POSIXPermission
`RealtimeSignalDispatcher.setDefaultDispatcher`	system

See Section RealtimeSignal
See Section POSIXPermission
Since RTSJ 2.0

14.3.1.2.1 Constructors

RealtimeSignalDispatcher(SchedulingParameters, RealtimeThreadGroup)

Signature

```
public
RealtimeSignalDispatcher(SchedulingParameters schedule,
                         RealtimeThreadGroup group)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given `javax.realtime.SchedulingParameters`.

Parameters

`schedule`—Parameters for scheduling this dispatcher.

`group`—Container for this dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of `group` does not correspond to a valid affinity.

RealtimeSignalDispatcher(SchedulingParameters)

Signature

```
public
RealtimeSignalDispatcher(SchedulingParameters schedule)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given `javax.realtime.SchedulingParameters`.

Parameters

`schedule`—Parameters for scheduling this dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of the current thread group does not correspond to a valid affinity.

14.3.1.2.2 Methods

---

setDefaultDispatcher(RealtimeSignalDispatcher)

Signature

```
public static void
setDefaultDispatcher(RealtimeSignalDispatcher dispatcher)
```

Description

Sets the system default realtime signal dispatcher.

Parameters

`dispatcher`—The instance to be used when the next realtime signal is started. When `null`, the realtime signal dispatcher is set to the original system default.

register(RealtimeSignal)

Signature

```
public void
register(RealtimeSignal signal)
throws RegistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Registers `signal` with this dispatcher.

Parameters

`signal`—The signal object to register.

Throws

`RegistrationException`—when `signal` is already registered.

`javax.realtime.StaticIllegalStateException`—when this object has been destroyed or its scheduling parameters are not compatible with the current scheduler.

`javax.realtime.ProcessorAffinityException`—when affinity is not a valid affinity or is not a subset of the affinity of its realtime thread group.

`javax.realtime.StaticIllegalArgumentException`—when `signal` is not stopped or when `signal` is `null`.

deregister(RealtimeSignal)

Signature

```
public void
deregister(RealtimeSignal signal)
throws DeregistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Deregisters the `signal` from this dispatcher.

Parameters

`signal`—The signal object to deregister.

Throws

`DeregistrationException`—when `signal` is not already registered.

javax.realtime.StaticIllegalStateException—when this object has been destroyed.

javax.realtime.StaticIllegalArgumentException—when `signal` is not stopped or when `signal` is `null`.

destroy

Signature

```
public void
destroy()
throws StaticIllegalStateException
```

Description

Releases all reasources thereby making the dispatcher unusable.

Throws

javax.realtime.StaticIllegalStateException—when called on a dispatcher that has one or more registered `RealtimeSignal` objects.

14.3.1.3 Signal

---

public class Signal

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncEvent
      Signal

Interfaces

javax.realtime.ActiveEvent

Description

An `javax.realtime.ActiveEvent` subclass for defining a POSIX realtime signal. Signal is capable of handling a signal that come from other process as well as sending it to another process described by its process id. The name of all the supported signal begins with `SIG`, such as `SIGTERM`, `SIGABRT`, etc. The signal that is possible to send or handle are the one available on the system.

Here is an example of using of the class:

```
class SendSignalToSelf
{
  public static void main(String[] args)
    throws POSIXSignalPermissionException,
      POSIXInvalidTargetException,
      POSIXInvalidSignalException
  {
```

```
    Signal signal = Signal.get("SIGFPE");
    Runnable run = () -> { System.out.println("Signal handled!"); };
    signal.setHandler(new AsyncEventHandler(run));
    signal.start(); // register the signal
    signal.send(Signal.getProcessId()); // send the signal to this process
    signal.disable(); //disable the signal, to no longer executed the handler
    signal.send(Signal.getProcessId());
    // the signal to this process, it will be handle, but the handlers
    // will not be executed
    signal.stop(); // deregister the signal
  }
}
```

In the following, ID is used as the system numeric value of the realtime signal, for example, in most POSIX systems, `SIGHUP` has the value of 1.

Here is the list of all handled signals, but depending of the running system, this set of usable signal may be smaller.

Signal Name	Description
SIGHUP	Hangup (POSIX).
SIGINT	Interrupt (ANSI).
SIGQUIT	Quit (POSIX).
SIGILL	Illegal instruction (ANSI).
SIGTRAP	Trace trap (POSIX), optional signal.
SIGABRT	Abort (ANSI).
SIGBUS	BUS error (4.2 BSD), optional signal.
SIGFPE	Floating point exception.
SIGKILL	Kill, unblockable (POSIX).
SIGUSR1	User-defined signal 1 (POSIX).
SIGSEGV	Segmentation violation (ANSI).
SIGUSR2	User-defined signal 2 (POSIX).
SIGPIPE	Broken pipe (POSIX)
SIGALRM	Alarm clock (POSIX).
SIGTERM	Termination (ANSI).
SIGSTKFLT	Stack fault.
SIGCHLD	Child status has changed (POSIX).
SIGCONT	Continue (POSIX), optional signal.
SIGSTOP	Stop, unblockable (POSIX), optional signal.
SIGTSTP	Keyboard stop (POSIX), optional signal.

SIGTTIN	Background read from tty (POSIX), optional signal.
SIGTTOU	Background write to tty (POSIX), optional signal.
SIGURG	Urgent condition on socket (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGXCPU	CPU limit exceeded (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGXFSZ	File size limit exceeded (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGVTALRM	Virtual alarm clock (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGPROF	Profiling alarm clock (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGWINCH	Window size change (4.3 BSD, Sun). Not part of POSIX 9945-1-1996 standard.
SIGIO	I/O now possible (4.2 BSD). Not part of POSIX 9945-1-1996 standard.
SIGPWR	Power failure restart (System V). Not part of POSIX 9945-1-1996 standard.
SIGSYS	Bad system call, optional signal.
SIGIOT	IOT instruction (4.2 BSD), optional signal, same as SIGABRT.
SIGPOLL	Pollable event occurred (System V), same as SIGIO. Not part of POSIX 9945-1-1996 standard.
SIGCLD	Same as SIGCHLD (System V), optional signal.
SIGEMT	Not part of POSIX 9945-1-1996 standard.
SIGLOST	Not part of POSIX 9945-1-1996 standard.
SIGCANCEL	Not part of POSIX 9945-1-1996 standard.
SIGFREEZE	Not part of POSIX 9945-1-1996 standard.

SIGLWP	Not part of POSIX 9945-1-1996 standard.
SIGTHAW	Not part of POSIX 9945-1-1996 standard.
SIGWAITING	Not part of POSIX 9945-1-1996 standard.
SIGUNUSED	Since glibc 2.26, not defined, same as SIGSYS.
SIGINFO	A synonym for SIGPWR.

Since it is possible that several signal name have the same numerical id, the notion of preferred signal is provided. When several available signal names refers to the same number, the system chooses the name to give to the number as the name that comes first in the list above among all the synonyms. Thus, the method `get(int)` will returned the preferred name for the signal, even if several signals are available with the same number. A call to the method `get(String)` could also return a Signal whose name is not the name given as parameter, but the preferred name instead.

This class requires the following permissions:

Method	POSIXPermission Action
`Signal.addHandler`	handle
`Signal.addHandler`	handle, override
`Signal.removeHandler`	override
`Signal.send`	send
`Signal.start`	control
`Signal.stop`	control

See Section RealtimeSignal
See Section SignalDispatcher
See Section POSIXPermission
Since RTSJ 2.0

14.3.1.1.3.1 Methods

isSignal(String)

Signature

```
public static boolean
isSignal(String name)
```

Description

Determines if the given name represents a POSIX signal.

Parameters

`name`—The string passed as the name of the signal.

Returns

`true` when a signal with the given name is defined, but in all other cases `false`.

isSignal(int)

Signature

```
public static boolean
isSignal(int id)
```

Description

Determines if the given name represents a POSIX signal.

Parameters

`id`—The int passed as the numerical identifier of the signal.

Returns

`true` when a signal with the given id is defined, but in all other cases `false`.

getId(String)

Signature

```
public static int
getId(String name)
throws POSIXInvalidSignalException
```

Description

Gets the ID of a supported signal by its name.

Parameters

`name`—The `name` of the signal for which to search.

Throws

`POSIXInvalidSignalException`—when no signal with the given name exists or `name` is `null`.

Returns

the ID of the signal named by `name`.

get(String)

Signature

```
public static javax.realtime.posix.Signal
get(String name)
throws POSIXInvalidSignalException
```

Description

Gets a supported signal by its name.

Parameters

`name`—The `name` identifying the signal to get.

Throws

`POSIXInvalidSignalException`—when no signal with the given name exists or `name` is `null`.

Returns

the signal associated with `name`.

get(int)

Signature

```
public static javax.realtime.posix.Signal
get(int id)
throws POSIXInvalidSignalException
```

Description

Gets a supported signal by its ID.

Parameters

`id`—The identifier of a registered signal.

Throws

`POSIXInvalidSignalException`—when no signal with the given identifier `id` exists.

Returns

the signal corresponding to `id` or `null` when no signal with the given `id` exists.

getProcessId

Signature

```
public static long
getProcessId()
```

Description

Obtains the OS Id of the JVM process. When running in kernel space, the result is VM dependent and must be documented. This number returned is only usable with the `Signal.send` and `RealtimeSignal.send` methods.

Returns

the OS process `ID`.

getId

Signature

```
public int
getId()
```

Description

Gets the number of this signal.

Returns

the signal number.

getName

Signature

```
public java.lang.String
getName()
```

Description

Gets the name of this signal.

Returns

the name of this signal.

getDispatcher

Signature

```
public javax.realtime.posix.SignalDispatcher
getDispatcher()
```

Description

Returns

the dispatcher associated with this event.

setDispatcher(SignalDispatcher)

Signature

```
public javax.realtime.posix.SignalDispatcher
setDispatcher(SignalDispatcher dispatcher)
```

Description

Returns

the dispatcher associated with this event.

isActive

Signature

```
public boolean
isActive()
```

Description

Determines the activation state of this signal, i.e., whether or not it is registered with a dispatcher.

Returns

`true` when active; `false` otherwise.

isRunning

Signature

```
public boolean
isRunning()
```

Description

Determines the firing state, releasing or skipping, of this signal, i.e., whether or not it is active and enabled.

Returns

`true` when releasing, `false` when skipping.

enable

Signature

```
public void
enable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

disable

Signature

```
public void
disable()
```

Description

Since RTSJ 2.0 Inherited by AyncEvent

start

Signature

```
public void
start()
throws StaticIllegalStateException
```

Description

Starts this `Signal` in the enabled state, i.e., changes its state to running: active and enabled. An active signal is a source of activation for its memory area and is a member of the root set when in the heap. A running signal can be triggered. Entering the active state causes it to be registered with its dispatcher.

Throws

`javax.realtime.StaticIllegalStateException`—when this `Signal` is active.

See Section stop()

start(boolean)

Signature

```
public void
start(boolean disabled)
throws StaticIllegalStateException
```

Description

Starts this `Signal`, i.e., changes to an active state. An active signal is a source of activation when in a scoped memory and is a member of the root set when in the heap. When called with `disabled` equal to `false`, it will also be running. An active signal can be triggered, but it must be running to dispatch its handlers.

Parameters

`disabled`—`true` for starting in a disabled state.

Throws

`javax.realtime.StaticIllegalStateException`—when this `Signal` is active.

See Section stop()

stop

Signature

```
public boolean
stop()
throws StaticIllegalStateException
```

Description

Stops this `Signal`. A stopped signal, i.e., inactive signal, ceases to be a source of activation and no longer causes any `ActiveEvent` attached to it to be a source of activation. This causes it to be deregistered from its dispatcher.

Throws

javax.realtime.StaticIllegalStateException—when this Signal is inactive.

Returns

`true` when `this` was *enabled* and `false` otherwise.

send(long)

Signature

```
public boolean
send(long pid)
throws POSIXSignalPermissionException,
       POSIXInvalidTargetException
```

Description

Sends this signal to another process or process group.

On POSIX systems running in user space, the following holds:

- when pid is positive, the signal is sent to pid;
- when pid equals 0, the signal is sent to every process in the process group of the current process;
- when pid equals -1, the signal is sent to every process for which the calling process has permission to send signals, except for possibly OS-defined system processes; otherwise
- when pid is less than -1, the signal is sent to every process in the process group -pid.

POSIX.1-2001 requires the underlying mechanism of `signal.send(-1)` to send Signal to all processes for which the current process may signal, except possibly for some OS-defined system processes.

For an RTVM running in kernel space, the meaning of the `pid` is implementation dependent, though it should be as closed to the standard definition as possible.

Parameters

`pid`—ID of the process to which to send the signal.

Throws

POSIXSignalPermissionException—when the process does not have permission to send the target.

POSIXInvalidTargetException—when the target does not exist.

addHandler(AsyncBaseEventHandler)

Signature

```
public void
addHandler(AsyncBaseEventHandler handler)
```

Description

Adds a handler to the set of handlers associated with this event. An instance of `AsyncBaseEvent` may have more than one associated handler. However, adding

a handler to an event has no effect when the handler is already attached to the event.

The execution of this method is atomic with respect to the execution of the `fire()` method.

Note that there is an implicit reference to the handler stored in `this`. The assignment must be valid under any applicable memory assignment rules.

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(AsyncBaseEventHandler handler)
```

Description

Associates a new handler with this event and removes all existing handlers. The execution of this method is atomic with respect to the execution of the `fire()` method.

removeHandler(AsyncBaseEventHandler)

Signature

```
public void
removeHandler(AsyncBaseEventHandler handler)
```

Description

Removes a handler from the set associated with this event. The execution of this method is atomic with respect to the execution of the `fire()` method.

A removed handler continues to execute until its fireCount becomes zero and it completes.

When `handler` has a scoped non-default initial memory area and execution of this method causes `handler` to become unfirable, this method shall not return until all related finalization has completed.

14.3.1.4 SignalDispatcher

---

public class SignalDispatcher

Inheritance

java.lang.Object
  javax.realtime.ActiveEventDispatcher<SignalDispatcher, Signal>
    SignalDispatcher

Description

Provides a means of dispatching a set of `Signal`s. An application can provide its own dispatcher, providing the priority for the internal dispatching thread. This dispatching thread calls the `javax.realtime.AsyncEvent.fire` method on the instance of `Signal` associated with the signal each time its signal is triggered.

This class requires the following permissions:

Method	Required Action for POSIXPermission
`SignalDispatcher.setDefaultDispatcher`	system

See Section Signal
See Section POSIXPermission
Since RTSJ 2.0

14.3.1.4.1 Constructors

SignalDispatcher(SchedulingParameters, RealtimeThreadGroup)

Signature

```
public
SignalDispatcher(SchedulingParameters scheduling,
                 RealtimeThreadGroup group)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given `javax.realtime.SchedulingParameters`.

Parameters

`scheduling`—Parameters for scheduling this dispatcher.

`group`—Container for this dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `schedule` and the affinity of `group` does not correspond to a valid affinity.

SignalDispatcher(SchedulingParameters)

Signature

```
public
SignalDispatcher(SchedulingParameters scheduling)
throws StaticIllegalStateException
```

Description

Creates a new dispatcher, whose dispatching thread runs with the given `javax.realtime.SchedulingParameters`.

Parameters

`scheduling`—For scheduling this dispatcher.

Throws

`StaticIllegalStateException`—when the intersection of affinity in `scheduling` and the affinity of `group` does not correspond to a valid affinity.

14.3.1.4.2 Methods

---

setDefaultDispatcher(SignalDispatcher)

Signature

```
public static void
setDefaultDispatcher(SignalDispatcher dispatcher)
```

Description

Sets the system default signal dispatcher.

Parameters

`dispatcher`—An instance to be used when the next signal is started. When `null`, the signal dispatcher is set to the original system default.

register(Signal)

Signature

```
public synchronized void
register(Signal signal)
throws RegistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Registers a POSIX signal with this dispatcher.

Parameters

`signal`—The signal instance to register.

Throws

`RegistrationException`—when `signal` is already registered.

`javax.realtime.StaticIllegalStateException`—when this object has been destroyed or its scheduling parameters are not compatible with the current scheduler.

`javax.realtime.ProcessorAffinityException`—when affinity is not a valid affinity or is not a subset of the affinity of its realtime thread group.

`javax.realtime.StaticIllegalArgumentException`—when `signal` is not stopped or when `signal` is `null`.

deregister(Signal)

Signature

```
public synchronized void
deregister(Signal signal)
throws DeregistrationException,
       StaticIllegalStateException,
       StaticIllegalArgumentException
```

Description

Deregisters the POSIX Signal from this dispatcher.

Parameters

`signal`—The signal instance to deregister.

Throws

`DeregistrationException`—when `signal` is not already registered.

`javax.realtime.StaticIllegalStateException`—when this object has been destroyed.

`javax.realtime.StaticIllegalArgumentException`—when `signal` is not stopped or when `signal` is `null`.

destroy

Signature

```
public void
destroy()
throws StaticIllegalStateException
```

Description

Releases all resources thereby making the dispatcher unusable.

Throws

`javax.realtime.StaticIllegalStateException`—when called on a dispatcher that has one or more registered `Signal` objects.

14.4 Rationale

POSIX is the most widely supported standard for operating systems, both conventional and realtime. Providing support for sending and receiving signals as encapsulated in the `Signal` and `RealtimeSignal` enables realtime java programs to interact, not just with the environment, but also other processes in a system. Even for systems that are not strictly POSIX compatible, one can implement this interface for encapsulating similar functionality in a common API.

The old interface was not consistent with the event and handler model used by `Timer` and other `AsyncEventHandler` types. Providing a new module for posix signal handling was used as a means of fixing this inconsistency. Thus the `javax.realtime.posix` contains new classes for interacting with signals using the event and handler model, as well as adding support for realtime signals.

The `Signal` and `RealtimeSignal` classes are singletons for each underlying signal. This provides minimum delay, but makes isolation more difficult. For OSGi and other modular platforms, this can be circumvented at a small additional cost. The application just needs to provide a handler for each isolation group that just dispatches to a secondary event for handlers in that group. This is the same mechanism that can be used to emulate the deprecated `AsyncEvent.bindTo(String)`.

Chapter 15

Resource Enforcement

Resource enforcement provides a means of ensuring that parts of a system remain withing their design limits. It is a separate module because the implementation is complex and it is not needed by all realtime systems. Enforcement is of particular value in dynamic systems such as frameworks, such as OSGi.

15.1 Definitions

Cost Enforcement — An automatic means of controlling the processor usage of a task or group of tasks.

Limit — The maximum amount of a resource available for use.

15.2 Semantics

The `javax.realtime.enforcement` package defines a hierarchy of resource management classes. The top class is `ResourceConstraint`. Each supported resource type has its own subclass of `ResourceConstraint`. Each constraint type has a unique root constraint from which all other constrains are descendant. When a child constraint is added, it takes part of the resource allocation of its parent. Thus the hierarchy describes a complete partitioning of the system for that resource.

Though instances of each subclass thereof manages a particular resource, there is some common semantics. Each instance of a `ResourceConstraint` subclass may be associated with one and only one `RealtimeThreadGroup` instance. Each task that is bound to that realtime thread group is called a *member* of that resource constraint. All tasks bound directly to a child thread group not associated with another resource constraint of the same type are also members. Figure 15.1 illustrates this partitioning for `ProcessingConstraint` with color coded domains.

When a resource constraint is created, it is not active until it is started. Only then is the resource budget taken from the parent. The budget is returned when the constraint is stopped. A constraint must be active when it is associated with a `RealtimeThreadGroup` instance. The exact semantics of activation are dependent on the resource type and how time sensitive it is. Figure 15.2 illustrates setting up and tearing down enforcement with `ProcessingConstraint`.

Figure 15.1: Enforcement Partitioning Hierarchy

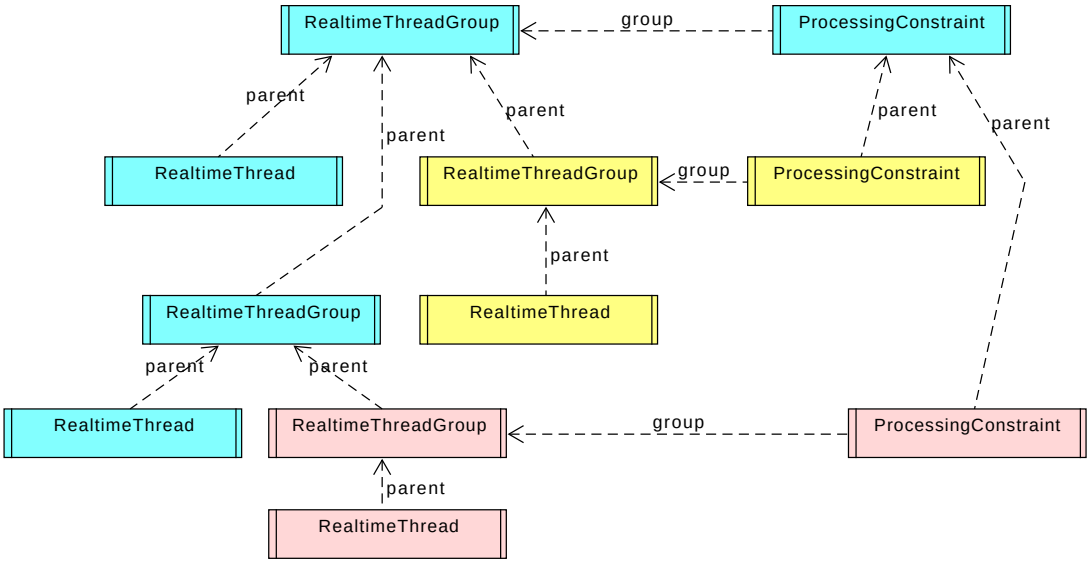
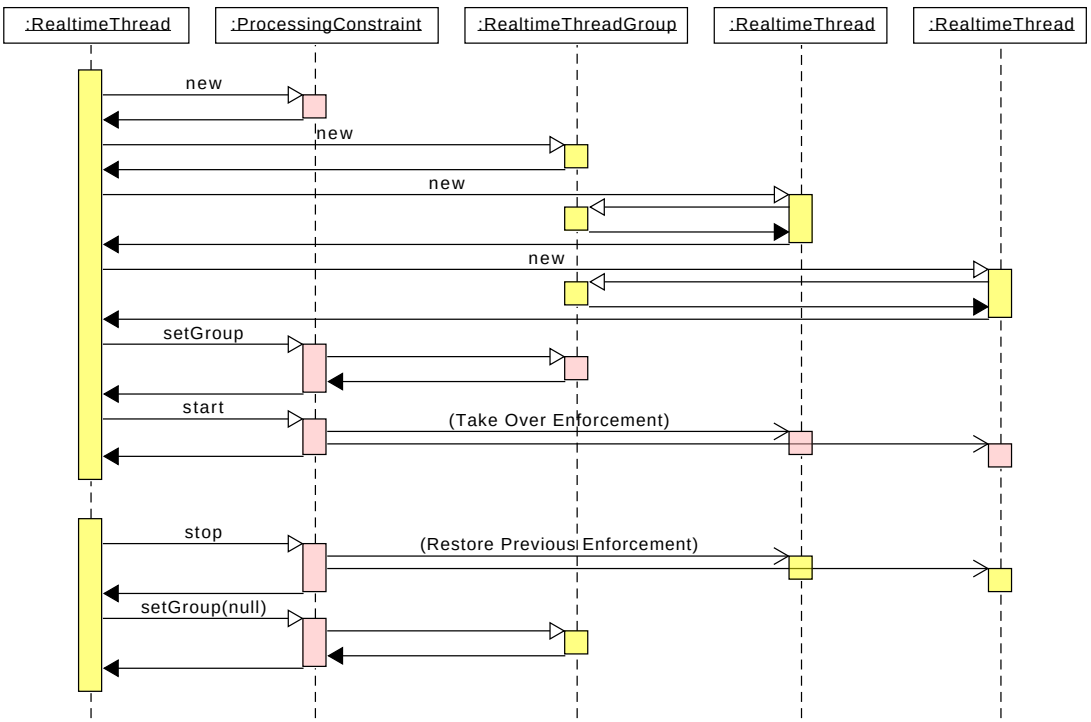


Figure 15.2: Starting and Stopping Enforcement



15.2.1 Processing Constraint

A processing constraint is defined by an instance of the `ProcessingConstraint`, a subclass of `ResourceConstraint`. Managing CPU usage is time sensitive; therefore, cost enforcement needs to be automatic to be effective. Processing constraint is based on a reservation model of enforcement. Each reservation period is assigned a fixed budget for computation. An instance of `ProcessingConstraint` intervenes in scheduling by lowering the priority of its monitored tasks.

The precision of intervention is limited by the precision of the clock being used to measure time times the number of CPUs involved in the enforcement. The precision of enforcement is limited by the drive precision of the clock being used. In any event, cost enforcement, cost overrun handlers, and deadline overrun handlers are fired with the resolution specified for hard cost enforcement.

Cost and overrun handlers are provided for monitoring the system. In normal operation, they should not be fired. They are not needed for enforcement. They simply provide a means of tracing overruns and provide additional mitigation for overruns.

1. The deadline of a processing constraint is defined to be its period.
2. A deadline miss for the processing constraint is triggered when any member of the processing constraint consumes CPU time at a time greater than the deadline for the most recent release of the processing constraint.
3. When a processing constraint misses a deadline:
   (a) when the processing constraint has a miss handler, it is released for execution,
   (b) otherwise, the processing constraint has no miss handler, no action is taken.
4. The cost of a processing constraint is defined by the value returned by invoking the `getCost` method of the processing constraint object.
5. When a processing constraint is initially released, its current CPU consumption is zero and as the members of the processing constraint execute, the current CPU consumption increases. The current CPU consumption is set to zero in response to certain actions as described below.
6. Whenever, due to either execution of the members of the processing constraint or a change in the group's cost, the current CPU consumption becomes greater than or equal to the current cost of the processing constraint, then a cost overrun is triggered. The implementation is required to document the granularity at which the current CPU consumption is updated.
7. When a cost underrun handler has been set, it is released at the end of any cost period, where the minimal cost has not been consumed by the tasks in the group.
8. When the affinity of the group contains more than one processor, the granularity enforced may be as large as the base granularity times the number of processors in the group's affinity.
9. When a cost overrun is triggered, the cost overrun handler associated with the processing constraint, if any, is released.
10. When cost enforcement is supported, enabled, and triggered, the processing constraint enters the enforced state. For each member of the processing

constraint:
   (a) the schedulable is placed into the enforced state; and
   (b) when a schedulable is in the enforced state, the base scheduler schedules that schedulable effectively as if it has a base priority lower than that of a notional idle task.
11. When the release event occurs for a processing constraint, the action taken depends on the state of the processing constraint.
   (a) When the processing constraint is not in the enforced state, the current CPU consumption for the group is set to zero.
   (b) Otherwise, the processing constraint is in the enforced state. It is removed from the enforced state, the current CPU consumption of the group is set to zero, and each member of the group is removed from the enforced state.
12. Changes to the cost, minimum and maximum, take effect immediately.
   (a) When the new cost is less than or equal to the current CPU consumption, and the old cost was greater than the current CPU consumption, a cost overrun is triggered.
   (b) When the new cost is greater than the current CPU consumption there are two case:
      i. when the processing constraint is enforced, then the processing constraint behaves as defined in semantic 11;
      ii. otherwise, no cost monitoring and enforcement action occurs.
13. Changes to other parameters take place as follows:
   (a) changes to **period** take effect at each release, so the next period is set based on the current value of the processing constraint's period;
   (b) changes to **OverrunHandler** take effect at each release, so the overrunHandler is set based on the current value of the processing constraint's overrunHandler;
   (c) changes to **MissHandler** take effect at each release, so the missHandler is set based on the current value of the processing constraint's missHandler; and
   (d) changes to **UnderrunHandler** take effect at each release, so the underrunHandler is set based on the current value of the processing constraint's underrunHandler.
14. Changes to the membership of the processing constraint take effect immediately.
15. The start time for the processing constraint may be relative or absolute.
   (a) When the start time is absolute, the processing constraint behaves effectively as if the initial release time were the start time.
   (b) When the start time is relative, the initial release time is computed relative to the time that the processing constraint is constructed.

Note that until a processing constraint starts (i.e., `start` has been called and start time has been reached) it will perform no cost monitoring or enforcement on the Schedulables that it contains. Once a processing constraint is started, it behaves effectively as if it runs continuously until the defining `ProcessingConstraint` object is freed. The start time does not affect limits placed on the group that are inherited from `ThreadGroup` or `RealtimeThreadGroup`, such as affinity and scheduling

parameters.

15.2.2 Heap Memory Constraints

The class `HeapConstraint` is a subclasss of `ResourceConstraint` for managing heap memory. It is similar to `ProcessingConstraint` except it targets heap memory consumption instead of CPU consumption. Instance can be used to partition heap memory between parts of an application. The start and stop methods take effect immediately.

15.2.3 Immortal Memory Constraints

The class `ImmortalConstraint` is a subclasss of `ResourceConstraint` for managing immortal memory. It is similar to `HeapConstraint` except it targets immortal memory consumption instead of heap consumption. Instance can be used to partition immortal memory between parts of an application. The start and stop methods take effect immediately.

15.2.4 Backing Store Constraints

The class `BackingStoreConstraint` is a subclasss of `ResourceConstraint` for managing backing store. It is similar to `HeapConstraint` except it targets backing store consumption instead of heap consumption. Instance can be used to partition backing store between parts of an application. The start and stop methods take effect immediately. `BackingStoreConstrain` instances only have effect, when the Alternate Memory Module of package `javax.realtime.memory` is available.

15.2.5 System Configuration

Each resource type may be changed between a monitoring mode and an enforcement mode. This means that a system can collect statistics during development and then use enforcement when deployed. Changing this mode is protect by the security manager.

15.3 javax.realtime.enforce

15.3.1 Classes

15.3.1.1 BackingStoreConstraint

---

public class BackingStoreConstraint

Inheritance
java.lang.Object
ResourceConstraint<BackingStoreConstraint>
BackingStoreConstraint

Description

A constraint to limit the amount of baking store available to a task.

Since RTSJ 2.0

15.3.1.1.1 Constructors

BackingStoreConstraint(BackingStoreConstraint, long)

Signature

```
public
BackingStoreConstraint(BackingStoreConstraint parent,
                       long limit)
```

Description

Creates a new group under `parent` named `name`.

Parameters

`parent`—Parent of the memory group

`limit`—The maximum backing storage for the new constraint.

15.3.1.1.2 Methods

---

isEnforcing

Signature

```
public static boolean
isEnforcing()
```

Description

Determine whether or not enforcing is in effect.

Returns
`true` when yes and `false` when not.

setEnforcing(boolean)

Signature

```
public static void
setEnforcing(boolean state)
```

Description

Set the enforcing state.

Parameters
`state`—The new enforcing state.

getRootConstraint

Signature

```
public static javax.realtime.enforce.BackingStoreConstraint
getRootConstraint()
```

Description

Get the root instance for this constraint type.

Returns
the root constraint.

currentConstraint

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint()
```

Description

Determine the processing constraint for the current execution context.

Returns
the constraint for this context.

currentConstraint(Thread)

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint(Thread thread)
```

Description

Determine the processing constraint for the give execution context.

Parameters

`thread`—The given execution context.

Returns

the constraint for this context.

getLimit

Signature

```
public long
getLimit()
```

Description

Determine the total amount of a backing store under the control of this resource constraint instance.

Returns

the total amount under control of this instance in bytes.

lent

Signature

```
public long
lent()
```

Description

Determine how much of the resource has been lent to its children.

Returns

the amount lent in number of bytes.

used

Signature

```
public long
used()
```

Description

Determine how much of the resource have been used of the amount available.

Returns

the amount used in number of bytes.

available

Signature

```
public long
available()
```

Description

Determine how much of the resource are available for use, i.e., the amount of the limit minus amount lent.

Returns
the amount used in number of bytes.

15.3.1.2 HeapConstraint

---

public class HeapConstraint

Inheritance
java.lang.Object
ResourceConstraint<HeapConstraint>
HeapConstraint

Description

A constraint to limit the amount of heap memory available to a task.

Since RTSJ 2.0

15.3.1.2.1 Constructors

HeapConstraint(HeapConstraint, long)

Signature

```
public
HeapConstraint(HeapConstraint parent,
               long limit)
```

Description

Create a new contraint with the given parent.

Parameters
`parent`—the contraint from which this constraint derives its limit.
`limit`—the amount of memory to take from its parent to manage.

15.3.1.2.2 Methods

---

isEnforcing

Signature

```
public static boolean
isEnforcing()
```

Description

Determine whether or not enforcing is in effect.

Returns
`true` when yes and `false` when not.

setEnforcing(boolean)

Signature

```
public static void
setEnforcing(boolean state)
```

Description

Set the enforcing state.

Parameters
`state`—The new enforcing state.

getRootConstraint

Signature

```
public static javax.realtime.enforce.HeapConstraint
getRootConstraint()
```

Description

Get the root instance for this constraint type.

Returns
the root constraint.

currentConstraint

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint()
```

Description

Determine the processing constraint for the current execution context.

Returns
the constraint for this context.

currentConstraint(Thread)

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint(Thread thread)
```

Description

Determine the processing constraint for the give execution context.

Parameters
`thread`—The given execution context.
Returns
the constraint for this context.

getLimit

Signature

```
public long
getLimit()
```

Description

Determine the total amount of a memory under the control of this resource constraint instance.

Returns
the total amount under control of this instance in bytes.

lent

Signature

```
public long
lent()
```

Description

Determine how much of the resource has been lent to its children.

Returns
the amount lent in number of bytes.

used

Signature

```
public long
used()
```

Description

Determine how much of the resource have been used of the amount available.

Returns
the amount used in number of bytes.

available

Signature

```
public long
available()
```

Description

Determine how much of the resource are available for use, i.e., the amount of the limit minus amount lent.

Returns

the amount used in number of bytes.

15.3.1.3 ImmortalConstraint

---

public class ImmortalConstraint

Inheritance

java.lang.Object
  ResourceConstraint<ImmortalConstraint>
    ImmortalConstraint

Description

A constraint to limit the amount of immortal memory available to a task.

Since RTSJ 2.0

15.3.1.3.1 Constructors

ImmortalConstraint(ImmortalConstraint, long)

Signature

```
public
ImmortalConstraint(ImmortalConstraint parent,
                   long limit)
```

Parameters

`parent`—the contraint from which this constraint derives its limit.

`limit`—the amount of memory to take from its parent to manage.

15.3.1.3.2 Methods

---

isEnforcing

Signature

```
public static boolean
isEnforcing()
```

Description

Determine whether or not enforcing is in effect.

Returns

`true` when yes and `false` when not.

setEnforcing(boolean)

Signature

```
public static void
setEnforcing(boolean state)
```

Description

Set the enforcing state.

Parameters

`state`—The new enforcing state.

getRootConstraint

Signature

```
public static javax.realtime.enforce.ImmortalConstraint
getRootConstraint()
```

Description

Get the root instance for this constraint type.

Returns

the root constraint.

currentConstraint

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint()
```

Description

Determine the processing constraint for the current execution context.

Returns

the constraint for this context.

currentConstraint(Thread)

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint(Thread thread)
```

Description

Determine the processing constraint for the give execution context.

Parameters

`thread`—The given execution context.

Returns

the constraint for this context.

getLimit

Signature

```
public long
getLimit()
```

Description

Determine the total amount of a memory under the control of this resource constraint instance.

Returns

the total amount under control of this instance in bytes.

lent

Signature

```
public long
lent()
```

Description

Determine how much of the resource has been lent to its children.

Returns

the amount lent in number of bytes.

used

Signature

```
public long
used()
```

Description

Determine how much of the resource have been used of the amount available.

Returns

the amount used in number of bytes.

available

Signature

```
public long
available()
```

Description

Determine how much of the resource are available for use, i.e., the amount of the limit minus amount lent.

Returns

the amount used in number of bytes.

15.3.1.4 ProcessingConstraint

---

public class ProcessingConstraint

Inheritance

java.lang.Object
  ResourceConstraint<ProcessingConstraint>
    ProcessingConstraint

Description

A class for handling contraining CPU used by tasks as a group via their `javax.realtime.RealtimeThreadGroup` instance. As with `ThreadGroup` and `RealtimeThreadGroup`, instances of `ProcessingConstraint` can be nested. The cost of the group, including all tasks in its subgroups not subject to another `ProcessingConstraint` instance, can be both tracked and limited over a given period, by bounding the execution demands of those tasks.

A processing constraint has an associated affinity. The precision of cost monitoring is dependent on the number of processors in the affinity. In the worst case, it is the base precision times the number of processors in the processing group. The default affinity is that which was inherited from the parent `ProcessingConstraint`.

For all tasks with a reference to an instance of `ProcessingConstraint p`, no more than `p.cost` will be allocated to the execution of these tasks on the processors associated with its processing group in each interval of time given by `p.period` after the time indicated by `p.start`. No execution of the tasks will be allowed on any processor other than these processors.

For each running task subject to a processing group, there must always be at least one processor in the intersection between a task object's affinity and its processing group's affinity regardless of the group's monitoring state.

Logically, a `ProcessingConstraint` represents a virtual server. This server has a start time, a period, a cost (budget), and a deadline equal to `period`. The server can only logically execute when

- (a) it has not consumed more execution time in its current release than the cost (budget) parameter,

- (b) one of its associated tasks is executable and is the most eligible of the executable tasks.

When the server is logically executable, the associated tasks are executed.

When the cost has been consumed, any `overrunHandler` is released, and the server is not eligible for logical execution until the period is finished. At this point, its allocated cost (budget) is replenished. When the server is logically executable when its deadline expires, any associated `missHandler` is released. When the server is logically executable when its next release time occurs, any associated `underrunHandler` is released.

The deadline and cost parameters of all the associated schedulable objects have the same impact as they would if the objects were not bound to a processing group.

Processing group parameters use `javax.realtime.HighResolutionTime` values for cost period, and start time. Since those times are expressed as a `javax.realtime.HighResolutionTime`, the values use accurate timers with nanosecond granularity. The actual resolution available and even the quantity it measures depends on the clock associated with each time value.

When a reference to a `javax.realtime.RealtimeThreadGroup` instance is given as a parameter to a `ResourceConstraint.setGroup`, that processing constraint is associated with all the task under the realtime thread group. It takes effect at the next period after the start time. Changes to the values in the `ProcessingConstraint` object affect those tasks at period boundaries.

The implementation must use copy semantics for each `javax.realtime.HighResolutionTime` parameter value. The value of each time object should be copied at the time it is passed to the parameter object, and the object reference must not be retained. Only changes to a `ProcessingConstraint` object caused by methods on that object are immediately visible to the scheduler. For instance, invoking `setPeriod()` on a `ProcessingConstraint` object will make the change, then notify the scheduler that the parameter object has changed. At that point the scheduler's view of the processing group parameters object is updated. Invoking a method on the `RelativeTime` object that affects the period for this object may change the period but it does not pass the change to the scheduler at that time. That new value for period must not change the behavior of the SOs that use the parameter object until a setter method on the `ProcessingConstraint` object is invoked or the object is used in a constructor for an SO.

The following table gives the default parameter values for the constructors.

Caution: This class is explicitly unsafe in multithreaded situations when it is being changed. No synchronization is done. It is assumed that users of this class who are mutating instances will be doing their own synchronization at a higher level.

Caution: The `cost` parameter time should be considered to be measured against the target platform.

Since RTSJ 2.0

15.3.1.4.1 Constructors

Table 15.1: ProcessingConstraint Default Values

Attribute	Default Value
period	No default. A value must be supplied
cost	No default. A value must be supplied
minimum	`null`, no minimum
overrunHandler	None
missHandler	None
underrunHandler	None

ProcessingConstraint(ProcessingConstraint, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingConstraint(ProcessingConstraint parent,
                     RelativeTime period,
                     RelativeTime cost,
                     AsyncEventHandler overrun,
                     RelativeTime minimum,
                     AsyncEventHandler underrun)
```

Description

Creates a `ProcessingConstraint`

Parameters

`parent`—The parent `ProcessingConstraint` of this `ProcessingConstraint`.

`period`—An amount of time for cost and overrun monitoring and for cost enforcement.

`cost`—The maximum total execution time of all tasks in the group during a given `period`.

`overrun`—It is called when the the total execution of all tasks in the group exceeds `cost` for a given `period`.

`minimum`—The least amount of processing time that should be avaiable for all the tasks in this group together.

`underrun`—A handler to be called at the end of period when the total processing time of all tasks was less than `minimum` in the last `period`.

ProcessingConstraint(ProcessingConstraint, RelativeTime, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingConstraint(ProcessingConstraint parent,
                     RelativeTime period,
                     RelativeTime cost,
                     AsyncEventHandler overrun)
```

Description

Equivalent to `ProcessingConstraint(ProcessingConstraint, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)` with the argument list `(parent, period, cost, overrun, null, null)`.

ProcessingConstraint(RelativeTime, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingConstraint(RelativeTime period,
                     RelativeTime cost,
                     AsyncEventHandler overrun)
```

Description

Equivalent to `ProcessingConstraint(ProcessingConstraint, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)` with the argument list `(currentConstraint(), period, cost, overrun, null, null)`.

15.3.1.4.2 Methods

---

isEnforcing

Signature

```
public static boolean
isEnforcing()
```

Description

Determine whether or not enforcing is in effect.

Returns

`true` when yes and `false` when not.

setEnforcing(boolean)

Signature

```
public static void
setEnforcing(boolean state)
```

Description

Set the enforcing state.

Parameters

`state`—The new enforcing state.

getRootConstraint

Signature

```
public static javax.realtime.enforce.BackingStoreConstraint
getRootConstraint()
```

Description

Get the root instance for this constraint type.

Returns

the root constraint.

currentConstraint

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint()
```

Description

Determine the processing constraint for the current execution context.

Returns

the constraint for this context.

currentConstraint(Thread)

Signature

```
public static javax.realtime.enforce.ProcessingConstraint
currentConstraint(Thread thread)
```

Description

Determine the processing constraint for the give execution context.

Parameters

`thread`—The given execution context.

Returns

the constraint for this context.

enforcingCost

Signature

```
public static boolean
enforcingCost()
```

Description

Determines whether or not cost is being enforced for releases.

Returns

`true` when enforcing code.

enforceCost

Signature

```
public static void
enforceCost()
throws StaticUnsupportedOperationException
```

Description

Starts cost enforcement at next release, when supported. Subsequent invocations have no effect.

Throws

`StaticUnsupportedOperationException`—when cost enforcement is not supported.

getGranularity

Signature

```
public static long
getGranularity()
```

Description

Determines the measurement granularity of cost monitoring and cost enforcement.

Returns

the granularity in nanoseconds.

See Section setGranularity

setGranularity(long)

Signature

```
public static void
setGranularity(long nanos)
throws StaticIllegalArgumentException
```

Description

Sets the measurement granularity of cost monitoring and cost enforcement. The system provides a lower bound for this. When `nanos` is below this lower bound, granularity silently is set to the lower bound. In general, the lower bound is the precision of the realtime clock.

Note that the ganularity applies to a single processor. When a processing group spans more than one processor, the precision of cost monitoring or enforcement is this ganularity times the number of active processors. This is because more than one task could be running at the same time and cost can be measured at most once per the elapse of this ganularity.

Parameters

`nanos`—the new granularity in nanoseconds.

Throws

`StaticIllegalArgumentException`—when `nanos` is less than one.

getEffectiveStart(AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStart(AbsoluteTime dest)
```

Description

Obtains the actual time of the group's start as recorded by the system. When the start time is absolute, that is the effective start time; otherwise, the effective start is computed relative to the time that the processing group is constructed.

Parameters

`dest`—A time value to fill.

Returns

either, a new instance of `AbsoluteTime`, when `dest` is `null`, or `dest` otherwise. In either case, its value is the time at which this group actually started.

getEffectiveStart

Signature

```
public javax.realtime.AbsoluteTime
getEffectiveStart()
```

Description

Obtains the actual time of the group's start as recorded by the system.

Equivalent to `getEffectiveStart(AbsoluteTime)` where `dest` is set to `null`.

Returns

a reference to a new instance of `AbsoluteTime` that represents the time at which this group started.

getPeriod(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getPeriod(RelativeTime dest)
```

Description

Gets the value of `period` in the provided `javax.realtime.RelativeTime` object.

Parameters

`dest`—An instance of `RelativeTime` which will be set to the currently configured `period`. If `dest` is null, a new `RelativeTime` will be created in the current allocation context.

Returns

a reference to `dest`, or a newly created object if `dest` is null.

getPeriod

Signature

```
public javax.realtime.RelativeTime
getPeriod()
```

Description

Gets the value of `period`.
Equivalent to `getPeriod(null)`.

Returns

a reference to a newly allocated instance of `javax.realtime.RelativeTime` that represents the value of `period`.

setPeriod(RelativeTime)

Signature

```
public javax.realtime.enforce.ProcessingConstraint
setPeriod(RelativeTime period)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `period`.

Parameters

`period`—The new value for `period`. There is no default value. When `period` is `null` an exception is thrown.

Throws

`StaticIllegalArgumentException`—when `period` is `null`, or its time value is not greater than zero.

Returns

`this`

getLimit

Signature

```
public javax.realtime.RelativeTime
getLimit()
```

Description

Gets the value of `cost`.
Equivalent to `getMaximumCost(null)`.

Returns

a reference to a newly allocated object containing the value of `cost`.

getLimit(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getLimit(RelativeTime dest)
```

Description

Gets the value of `cost` in the provided `javax.realtime.RelativeTime` object.

Parameters

`dest`—An instance of `RelativeTime` which will be set to the currently configured `cost`. If `dest` is null, a new `RelativeTime` will be created in the current allocation context.

Returns

a reference to `dest`, or a newly created object if `dest` is null.

setLimit(RelativeTime)

Signature

```
public javax.realtime.enforce.ProcessingConstraint
setLimit(RelativeTime cost)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `cost`.

Parameters

`cost`—The new value for `cost`. When `null`, an exception is thrown.

Throws

`StaticIllegalArgumentException`—when `cost` is `null` or its time value is less than zero.

Returns

`this`

lent

Signature

```
public javax.realtime.RelativeTime
lent()
```

Description

Gets the cost lent to all children constraints.

Returns

the cost lent in an new object.

getCost

Signature

```
public javax.realtime.RelativeTime
getCost()
```

Description

Gets the cost available to this constraint $({limit} - {lent})$.

Returns

the cost available in an new object.

getCost(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getCost(RelativeTime dest)
```

Description

Gets the cost available to this constraint $({limit} - {lent})$.

Parameters

`dest`—It is the instance to use for returning the time. If `dest` is null, the result will be returned in a newly allocated object.

Returns

`dest` containing the available cost.

lent(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
lent(RelativeTime dest)
```

Description

Gets the cost lent to all children constraints.

Parameters

`dest`—It is the instance to use for returning the time. If `dest` is null, the result will be returned in a newly allocated object.

Returns

`dest` containing the cost lent.

used

Signature

```
public javax.realtime.RelativeTime
used()
```

Description

Gets the cost used in the current period so far.

Returns

an new object containing the cost used in the current period.

used(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
used(RelativeTime dest)
```

Description

Gets the cost used in the current period so far.

Parameters

`dest`—The instance to use for returning the time. If `dest` is null, the result will be returned in a newly allocated object.

Returns

`dest` containing the cost of the current period

lastUsed

Signature

```
public javax.realtime.RelativeTime
lastUsed()
```

Description

Gets the total cost used in the last period.

Returns

A new object containing the cost of the last period

lastUsed(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
lastUsed(RelativeTime dest)
```

Description

Gets the total cost used in the last period.

Parameters

`dest`—It is the instance to use for returning the time. If `dest` is null, the result will be returned in a newly allocated object.

Returns

`dest` containing the cost of the last period

getMinimumCost(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getMinimumCost(RelativeTime dest)
```

Description

Gets the value of `minimum` and returns it in the provided `javax.realtime.RelativeTime` object.

Parameters

`dest`—An instance of `RelativeTime` which will be set to the currently configured `minimum`. If `dest` is null, a new `RelativeTime` will be created in the current allocation context.

Returns

a reference to `dest`, or a newly created object if `dest` is null.

getMinimumCost

Signature

```
public javax.realtime.RelativeTime
getMinimumCost()
```

Description

Gets the value of `minimum` and returns it in a newly allocated object. Equivalent to `getMinimumCost(null)`.

Returns

a reference to the value of `minimum`.

setMinimumCost(RelativeTime)

Signature

```
public javax.realtime.enforce.ProcessingConstraint
setMinimumCost(RelativeTime cost)
throws StaticIllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `minimum`.

Parameters

`cost`—The new value for `minimum`. When `null`, an exception is thrown.

Throws

`StaticIllegalArgumentException`—when `minimum` is `null` or its time value is less than zero.

Returns

`this`

getCostUnderrunHandler

Signature

```
public javax.realtime.AsyncEventHandler
getCostUnderrunHandler()
```

Description

Gets the cost underrun handler.

Returns

a reference to an instance of `javax.realtime.AsyncEventHandler` that is cost overrun handler of `this`.

setCostUnderrunHandler(AsyncEventHandler)

Signature

```
public javax.realtime.enforce.ProcessingConstraint
setCostUnderrunHandler(AsyncEventHandler handler)
throws IllegalAssignmentError
```

Description

Sets the cost underrun handler.

Parameters

`handler`—This handler is invoked when the `run()` method of the schedulables attempts to execute for more than `cost` time units in any period. When `null`, no handler is attached, and any previous handler is removed.

Throws

`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

Returns
`this`

getCostOverrunHandler

Signature

```
public javax.realtime.AsyncEventHandler
getCostOverrunHandler()
```

Description

Gets the cost overrun handler.

Returns
a reference to an instance of `javax.realtime.AsyncEventHandler` that is cost overrun handler of `this`.

setCostOverrunHandler(AsyncEventHandler)

Signature

```
public javax.realtime.enforce.ProcessingConstraint
setCostOverrunHandler(AsyncEventHandler handler)
throws IllegalAssignmentError
```

Description

Sets the cost overrun handler.

Parameters
`handler`—This handler is invoked when the `run()` method of the schedulables attempts to execute for more than `cost` time units in any period. When `null`, no handler is attached, and any previous handler is removed.

Throws
`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

Returns
`this`

15.3.1.5 ResourceConstraint

---

public abstract class ResourceConstraint<T extends ResourceConstraint<T>>

Inheritance
java.lang.Object
ResourceConstraint<T extends ResourceConstraint<T>>

Description

The base class for all measurable constraints. There are several types of resource constraints typified by the value of `<T>` in the each concrete subclass. Each type is responsible for constraining on resource for a group of tasks (instances of `javax.realtime.Schedulable` and other instances of `java.lang.Thread`). A task is only ever associated with one instance of a given type of `ResourceConstraint` via its `RealtimeThreadGroup` nearest instance, i.e., the first `RealtimeThreadGroup` found that has an associated instance of `<T>` when traversing up the thread group hierarchy from its immediate thread group.

Since RTSJ 2.0

15.3.1.5.1 Constructors

ResourceConstraint(T)

Signature

```
public
ResourceConstraint(T parent)
```

Description

Create a new contraint with the given parent.

Parameters

`parent`—the contraint from which this constraint derives its limit.

15.3.1.5.2 Methods

---

start

Signature

```
public void
start()
```

Description

Start applying this constraint to is tasks.

stop

Signature

```
public void
stop()
```

Description

Stop applying this constraint to is tasks.

getGroup

Signature

```
public javax.realtime.RealtimeThreadGroup
getGroup()
```

Description

Determine the associated realtime thread group.

Returns

the associated group

setGroup(RealtimeThreadGroup)

Signature

```
public javax.realtime.RealtimeThreadGroup
setGroup(RealtimeThreadGroup group)
```

Description

Change the associated realtime thread group.

Parameters

`group`—the new thread group, or `null` when just removing the old one.

Returns

the old thread group or `null` when there was none.

visitBorrowers(Consumer)

Signature

```
public void
visitBorrowers(java.util.function.Consumer<T> visitor)
```

Description

Do something on each child constraint.

Parameters

`visitor`—the code to execute on each child.

visitUsers(Consumer)

Signature

```
public void
visitUsers(java.util.function.Consumer<javax.realtime.Schedulable> visitor)
```

Description

Do something on each task subject to this constraint.

Parameters

`visitor`—the code to execute on each task.

15.4 Rationale

The `ResourceConstraint` classes were added in `RTSJ` 2.0 to support the notion of a subsystem constrained by the greater system configuration. Each resource type provides its own hierarchy for partitioning its resource within the system. Each instance is associated with `RealtimeThreadGroup` defined the part of the system that should be managed. A combination of security manager policy and the `RealtimeThreadGroup` hierarchy may be used to constrain any supported resource type.

15.4.1 ProcessingConstraint

`ProcessingConstraint` generalizes the existing notion of cost monitoring and enforcement for schedulables to groups of schedulables. A `ProcessingConstraint` instance can be used to apply cost monitoring and enforcement to a collection of tasks, including Java threads. However, note that placing a Java thread directly in a `RealtimeThreadGroup` subject to a `ProcessingConstraint`, may allow it to obtain realtime priorities. This can be avoided by placing the Java threads in a Java `ThreadGroup` which is in turn the child of an appropriately-configured `RealtimeThreadGroup` and applying security manager restrictions.

Chapter 16

System and Options

Implementations of this specification run on many operating systems and this specification itself supports several variants, therefore a means of querying and handling this variation is required. For instance, though many realtime operating systems support the POSIX standard, many do not. There are even ones that vary in their degree of compliance. Also, the type of garbage collection provided may vary from one implementation to another. This specification offers the means and facilities to manage these differences by providing the following:

- a class that contains operations and semantics that affect the entire system;
- the security semantics required by the additional features in the entirety of this specification, which are additional to those required by implementations of the Java Language Specification; and
- a class that provides some basic information about the garbage collector.

16.1 Semantics

There are three classes with semantics that do not fall into other categories: `RealtimeSystem`, `RealtimeSecurity`, and `GarbageCollection`. Their overall semantics is detailed below. Thereafter, semantics applying to methods, constructors, and fields of theses classes are provided.

16.1.1 RealtimeSystem

`RealtimeSystem` is a required class, which provides basic information about the `RTSJ` extensions supported by the system. Via this class, a program can query the default monitor policy, the realtime security manager, and other realtime properties of the system. Starting from version 2.0, a program can also ask what modules are supported. The enumeration `RTSJModule` supports this capability.

16.1.2 Realtime Security

Security for the classes in `javax.realtime` and its subpackages is provided by a set of permission classes, all of which are subclasses of `RealtimePermission`. These classes control access to key realtime features. Particularly critical is access to memory

outside the heap. Core RTSJ features also have security checks. These should enable an application to restrict the use of the RTSJ, particularly for dynamically loaded code. Of particular concern are classes that can create or control resources, such as creating threads, both explicitly and implicitly, controlling scheduling and affinity, creating persistent objects, and accessing resources outside RTSJ memory areas.

Detailed information is provided in the class documentation below, where the arguments types are described in the subsequent table.

- AffinityPermission

Method	Target	Action
Affinity.setProcessorAddedEvent	Group	monitor
Affinity.setProcessorRemovedEvent	Group	monitor

- CoreMemoryPermission

Method	Target	Action
MemoryArea.executeInArea	Area	enter
MemoryArea.enter	Area	enter
MemoryArea.newArray	—	allocate
MemoryArea.newInstance	—	allocate

- SchedulingPermission

Method	Target	Action
Scheduler.reschedule	Group	control
ProcessingConstraint.ProcessingConstraint	Group	control
ProcessingConstraint.enforceCost	Group	control
RealtimeThreadGroup.setMaxEligibility	Group	tune
ProcessingConstraint.setPeriod	Group	tune
ProcessingConstraint.setLimit	Group	tune
ProcessingConstraint.setMinimumCost	Group	tune
ProcessingConstraint.setCostOverrunHandler	Group	monitor
ProcessingConstraint.setCostUnderrunHandler	Group	monitor
Scheduler.setDefaultScheduler	—	system
ProcessingConstraint.setGranularity	—	system
MonitorControl.setMonitorControl	—	system

- `TaskPermission`

Method	Target	Action
`AsyncBaseEvent.addHandler`	—	handle
`AsyncBaseEvent.setHandler`	—	handle, override
`AsyncBaseEvent.removeHandler`	—	override
`RealtimeThread.RealtimeThread`	—	create
`ConfigurationParameters.setDefaultRunner`	—	system

- `TimePermission`

Method	Target	Action
`Clock.Clock`	—	create
`Clock.setRealtimeClock`	—	system
`Clock.setUniversalClock`	—	system
`Timer.Timer`	—	create
`Timer.enable`	—	control
`Timer.disable`	—	control
`Timer.start`	—	control
`Timer.stop`	—	control
`TimeDispatcher.register`	—	system
`TimeDispatcher.deregister`	—	system
`TimeDispatcher.destroy`	—	system
`TimeDispatcher.setDefaultDispatcher`	—	system

- `POSIXPermission`

Method	Target	Action
`RealtimeSignal.send`	Signals	send
`RealtimeSignal.enable`	Signals	control
`RealtimeSignal.disable`	Signals	control
`RealtimeSignal.start`	Signals	control
`RealtimeSignal.stop`	Signals	control
`RealtimeSignalDispatcher.register`	—	system
`RealtimeSignalDispatcher.deregister`	—	system
`RealtimeSignalDispatcher.destroy`	—	system
`RealtimeSignalDispatcher.setDefaultDispatcher`	—	system
`Signal.send`	Signals	send
`Signal.enable`	Signals	control
`Signal.disable`	Signals	send
`Signal.start`	Signals	control
`Signal.stop`	Signals	control
`SignalDispatcher.register`	—	system
`SignalDispatcher.deregister`	—	system
`SignalDispatcher.destroy`	—	system
`SignalDispatcher.setDefaultDispatcher`	—	system

- `DirectMemoryPermission`

Method	Target	Action
`DirectMemoryBufferFactory.`	Addresses	define
`DirectMemoryBufferFactory`		
`DirectMemoryBufferFactory.allocateByteBuffer`	Store	map
`DirectMemoryBufferFactory.free`	Group	override

- `HappeningPermission`

Method	Target	Action
`Happening.createId`	Names	create
`Happening.Happening`	Names	create
`Happening.enable`	Names	control
`Happening.disable`	Names	control
`Happening.start`	Names	control
`Happening.stop`	Names	control
`HappeningDispatcher.register`	—	system
`HappeningDispatcher.deregister`	—	system
`HappeningDispatcher.destroy`	—	system
`HappeningDispatcher.setDefaultDispatcher`	—	system

- `RawMemoryPermission`

Method	Target	Action
`RawMemoryFactory.register`	Addresses	define
`RawMemoryFactory.deregister`	Addresses	define
`RawMemoryFactory.deregister`	Addresses	define
`RawMemoryFactory.createRawByte`	Store	map
`RawMemoryFactory.createRawByteReader`	Store	map
`RawMemoryFactory.createRawByteWriter`	Store	map
...		
`RawMemoryFactory.createRawDouble`	Store	map
`RawMemoryFactory.createRawDoubleReader`	Store	map
`RawMemoryFactory.createRawDoubleWriter`	Store	map

- `PhysicalMemoryPermission`

Method	Target	Action
`PhysicalMemoryFactory.associate`	Addresses	define
`PhysicalMemoryFactory.createImmortalMemory`	Store	map
`PhysicalMemoryFactory.createLTMemory`	Store	map
`PhysicalMemoryFactory.createPinnableMemory`	Store	map
`PhysicalMemoryFactory.createStackedMemory`	Store	map

- `ScopedMemoryPermission`

Method	Target	Action
`LTMemory.LTMemory`	Store	map
`PinnableMemory.PinnableMemory`	Store	map
`StackedMemory.StackedMemory`	Store	map
`ScopedMemory.joinAndEnter`	Area	enter

In order to make the system easier to understand, targets are kept as consistent as possible in accordance with the following table.

Target	Values	Example
Addresses	a set of address ranges or `*`	0x10000100-0x10000200, 0x10000400-0x10000500
Area	a memory area type or `*`	`StackedMemory`
Group	either `current` or `*`	`current`
Signals	a list of signal names or `*`	SIGINT, SIGSTOP
Store	an amount of backing store or `*`	1024k
—	no specific target	

Similarly, each action is also used for similar functions in different permission classes in accordance with the following table.

Action	description
allocate	allows critical memory allocation
control	allows changing the mode of realtime tasks
create	allows creating critical realtime objects
define	allows defining a range of memory for later use
enter	allows entering a memory area
handle	allows event handling
map	allows mapping defined memory into the system
monitor	allows resource monitoring
override	allows overriding code from another part of the system
send	allows sending signals
system	allows a critical operation
tune	allows system tuning

16.1.3 GarbageCollection

It is extremely difficult to characterize garbage collectors in a uniform manner. The only information that can be provided by all collectors is the preemption latency. Each implementation may provide its own subclass of `GarbageCollector` to provide additional information, which may be queried via reflection.

16.1.4 Compliance Version

Determining the current version is supported by a system property. When an application calls the method, `System.getProperty("javax.realtime.version")`, the return value will be a string of the form, "x.y.z". Where 'x' is the major version number and 'y' and 'z' are minor version numbers. These version numbers state to which version of the `RTSJ` the underlying implementation claims conformance. The first release of the `RTSJ`, dated 11/2001, was numbered 1.0.0. A release conforming to the version defined by this specification should return the string `"2.0.0"`.

16.2 javax.realtime

16.2.1 Enumerations

16.2.1.1 RTSJModule

---

public enum RTSJModule

Inheritance
java.lang.Object
  java.lang.Enum<RTSJModule>
    RTSJModule

Description

Modules an RTSJ implementation may provide.

Since RTSJ 2.0

16.2.1.1.1 Enumeration Constants

CORE
`public static final RTSJModule CORE`

Description

Indicates the presence of the core module.

CONTROL
`public static final RTSJModule CONTROL`

Description

Indicates the presence of the CONTROL module.

DEVICE
`public static final RTSJModule DEVICE`

Description

Indicates the presence of the device access module.

MEMORY
`public static final RTSJModule MEMORY`

Description

Indicates the presence of the alternative memory areas module.

POSIX

```
public static final RTSJModule POSIX
```

Description

Indicates the presence of the POSIX module.

SCJ

```
public static final RTSJModule SCJ
```

Description

Indicates the presence of the all APIs needed to implement the SCJ. This is not actually a module, since these APIs are covered in the other modules. Thus either this is set alone for a pure implement of SCJ or this is set and at least all other packages that contain an API needed by the SCJ are set. Other configurations are forbidden.

16.2.1.1.2 Methods

---

values

Signature

```
public static javax.realtime.RTSJModule[]
values()
```

Description

valueOf(String)

Signature

```
public static javax.realtime.RTSJModule
valueOf(String name)
```

Description

value

Signature

```
public int
value()
```

Description

Determines the numeric value of an element of this enumeration. This value can be used in bit sets to determine the presence of the given element.

Returns
a number with a single bit set representing this element.

in(int)

Signature

```
public boolean
in(int value)
```

Description

Given an int representing a set of enumeration elements via bit value, sees whether or not this element is contained within that set.

Parameters
`value`—The set to test against.
Returns
`true` when and only when `value` has the bit set that represents `this`.

16.2.2 Classes

16.2.2.1 AffinityPermission

---

public class AffinityPermission

Inheritance
java.lang.Object
  java.security.Permission
    RealtimePermission
      AffinityPermission

Description

The core module provides a permission for the security manager to administer CPU affinities. The following table describes the actions to check. Each permission can be limited to the current `ThreadGroup` by specifying the target `group` or it can apply to all, either with no target or through the target `*`.

Action Name	Description	Risks of grant
control	Changes the affinity of a task	CPU Assignment Risk
monitor	One could change the event used to monitor adding or removing a processor.	Lost Events Risk

The risk classes are defined in `RealtimePermission`.

Since RTSJ 2.0

16.2.2.1.1 Constructors

AffinityPermission(String, String)

Signature

```
public
AffinityPermission(String target,
                   String actions)
```

Description

Creates a new `AffinityPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`StaticIllegalArgumentException`—when `target` or `action` is empty.

16.2.2.1.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.2.2.2 CoreMemoryPermission

---

public class CoreMemoryPermission

Inheritance
java.lang.Object
  java.security.Permission
    RealtimePermission
      CoreMemoryPermission

Description

Memory permission are divided into those for the core module and those for the memory module. The following table describes the actions to check for the core module. The name of a primordial memory area type can be given.

Action Name	Description	Risks of grant
enter	Allows execution in a given area.	Memory Leak Risk
allocate	Allows the creation of an object in Immortal without entering it.	Can cause a Memory Leak Risk

The wildcard `*`, or no target, allows access to primordial memory area. The risk classes are defined in `RealtimePermission`.

Since RTSJ 2.0

16.2.2.2.1 Constructors

CoreMemoryPermission(String)

Signature

```
public
CoreMemoryPermission(String actions)
```

Description

Creates a new `CoreMemoryPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`StaticIllegalArgumentException`—when `action` is empty.

CoreMemoryPermission(String, String)

Signature

```
public
CoreMemoryPermission(String target,
                     String actions)
```

Description

Creates a new `CoreMemoryPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`target`—The names of the memory area class for the action, or `*` for all memory areas.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`StaticIllegalArgumentException`—when `action` is empty.

16.2.2.2.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns

the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.2.2.3 GarbageCollector

---

public abstract class GarbageCollector

Inheritance
java.lang.Object
GarbageCollector

Description

The system shall provide dynamic and static information characterizing the temporal behavior and imposed overhead of any garbage collection algorithm provided by the implementation. This information shall be made available to applications via methods on subclasses of `GarbageCollector`. Implementations are allowed to provide any set of methods in subclasses as long as the temporal behavior and overhead are sufficiently categorized. The implementations are also required to fully document the subclasses.

A reference to the garbage collector responsible for heap memory is available from `RealtimeSystem.currentGC()`.

16.2.2.3.1 Methods

---

getPreemptionLatency

Signature

```
public abstract javax.realtime.RelativeTime
getPreemptionLatency()
```

Description

Preemption latency is a measure of the maximum time a schedulable object may have to wait for the collector to reach a safe point.

Schedulables which may not use the heap preempt garbage collection immediately, but other schedulables must wait until the collector reaches a safe point. For many garbage collectors the only safe point is at the end of garbage collection, but an implementation of the garbage collector could permit a schedulable to preempt garbage collection before it completes. The `getPreemptionLatency` method gives such a garbage collector a way to report the worst-case interval between the release of a schedulable during garbage collection, and the time the schedulable starts execution or gains full access to heap memory, whichever comes later.

Returns

the worst-case preemption latency of the garbage collection algorithm represented by `this`. The returned object is allocated in the current allocation context. When there is no constant that bounds garbage collector preemption latency, this method shall return a relative time with `Long.MAX_VALUE` milliseconds. The number of nanoseconds in this special value is unspecified.

16.2.2.4 RealtimePermission

---

public abstract class RealtimePermission

Inheritance

java.lang.Object
  java.security.Permission
    RealtimePermission

Description

All permission classes in the RTSJ inherit from this class. The following table lists common risk classes that correspond to granting specific permissions.

Risk Class	Description
CPU Assignment Risk	Interferes with critical tasks by assigning too many other tasks to the same CPU.
Encapsulation Risk	Could break out of encapsulation.
External Risk	Could adversely effect other processes on the system.

Interference Risk	Could interfere with the function of other parts of the system.
Load Risk	Could increase the load on the system.
Lost Events Risk	Another task could no longer receive the expected events.
Memory Leak Risk	Could cause memory to be lost to the system.
Scheduling Risk	Interferes with the timeliness of other parts of the system.
Device Range Risk	Could specify memory outside the desired Device range.
Device Map Risk	Could map too much or too little Device memory.
DMA Range Risk	Could specify memory outside the desired DMA range.
DMA Map Risk	Could map too much or too little DMA memory for DMA.
Physical Range Risk	Could specify memory outside the desired Physical range.
Physical Map Risk	Could take too much memory.

Since RTSJ 2.0

16.2.2.4.1 Constructors

RealtimePermission(String)

Signature

```
protected
RealtimePermission(String actions)
```

Description

Creates a new `RealtimePermission` object for a given set of actions, i.e., the symbolic names of actions. The `target` string specifies additional limitations on the actions.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `actions` is `null`.

`StaticIllegalArgumentException`—when `actions` is empty.

RealtimePermission(String, String)

Signature

```
protected
RealtimePermission(String target,
                   String actions)
```

Description

Creates a new `RealtimePermission` object for a given set of actions, i.e., the symbolic names of actions. The `target` string specifies additional limitations on the actions.

Parameters

`target`—Specifies the domain for the actions, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `actions` is `null`.

`StaticIllegalArgumentException`—when `target` or `actions` is empty.

16.2.2.4.2 Methods

---

equals(Object)

Signature

```
public abstract boolean
equals(Object other)
```

Description

Compare two Permission objects for equality.

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public abstract java.lang.String
getActions()
```

Description

Obtain the actions as a String in canonical form.

Returns
the actions represented as a string.

hashCode

Signature

```
public abstract int
hashCode()
```

Description

Obtain the hash code value for this object.

Returns
the hash code value.

implies(Permission)

Signature

```
public abstract boolean
implies(Permission permission)
```

Description

Checks if the given permission's actions are "implied by" this object's actions. This method is used by the AccessController to determine whether or not a requested permission is implied by another permission that is known to be valid in the current execution context.

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.2.2.5 RealtimeSystem

---

public class RealtimeSystem

Inheritance
java.lang.Object
RealtimeSystem

Description

`RealtimeSystem` provides a means for tuning the behavior of the implementation by specifying parameters such as the maximum number of locks that can be in use concurrently, and the monitor control policy. In addition, `RealtimeSystem` provides a mechanism for obtaining access to the security manager, garbage collector, and scheduler, to query or set parameters.

16.2.2.5.1 Fields

BIG_ENDIAN
`public static final byte BIG_ENDIAN`

Description

Value indicating that the highest order byte of a bit word is stored at the lowest byte address: the int 0x0A0B0C0D is stored in the byte sequence 0x0A, 0x0B, 0x0C, 0x0D. and the long 0x0102030405060708 is stored in the sequence 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08.

LITTLE_ENDIAN
`public static final byte LITTLE_ENDIAN`

Description

Value indicating that the lowest order byte of a word is stored at the lowest byte address: the int 0x0A0B0C0D is stored in the byte sequence 0x0D, 0x0C, 0x0B, 0x0A and the long 0x0102030405060708 is stored in the sequence 0x08, 0x07, 0x06, 0x05, 0x04, 0x03, 0x02, 0x01.

PDP_ENDIAN
`public static final byte PDP_ENDIAN`

Description

Value indicating a mixed endian mode used by among others the PDP-11: the int 0x0A0B0C0D is stored in the byte sequence 0x0B, 0x0A, 0x0D, 0x0C, and the long 0x0102030405060708 is stored in the sequence 0x03, 0x04, 0x01, 0x02, 0x07, 0x08, 0x05, 0x06.

Since RTSJ 2.0

CROSS_ENDIAN
`public static final byte CROSS_ENDIAN`

Description

Value indicating a mixed endian mode: the int 0x0A0B0C0D is stored in the byte sequence 0x0D, 0x0C, 0x0B, 0x0A, u * and the long 0x0102030405060708 is stored in the sequence 0x05, 0x06, 0x07, 0x08, 0x01, 0x02, 0x03, 0x04.

Since RTSJ 2.0

BYTE_ORDER
`public static final byte BYTE_ORDER`

Description

The byte ordering of the underlying hardware.

Deprecated RTSJ 2.0

16.2.2.5.2 Methods

getByteOrder

Signature

```
public static byte
getByteOrder()
```

Description

Obtains the byte order of the byte order of the system.

Returns

one of the defined byte order constants.

currentGC

Signature

```
public static javax.realtime.GarbageCollector
currentGC()
```

Description

Returns a reference to the currently active garbage collector for the heap.

Returns

a `GarbageCollector` object which is the current collector collecting objects on the conventional Java heap.

getConcurrentLocksUsed

Signature

```
public static int
getConcurrentLocksUsed()
```

Description

Gets the maximum number of locks that have been used concurrently. This value can be used for tuning the concurrent locks parameter, which is used as a hint by systems that use a monitor cache.

Returns

an integer, whose value is the maximum number of locks that have been used concurrently. When the number of concurrent locks is not tracked by the implementation, returns -1. Note that when the number of concurrent locks is not tracked, the number of available concurrent locks is effectively unlimited.

getMaximumConcurrentLocks

Signature

```
public static int
getMaximumConcurrentLocks()
```

Description

Gets the maximum number of locks that can be used concurrently without incurring an execution time increase as set by the `setMaximumConcurrentLocks()` methods.

Note that any relationship between this method and `setMaximumConcurrentLocks` is implementation-specific. This method returns the actual maximum number of concurrent locks the platform can currently support, or `Integer.MAX_VALUE` when there is no maximum. The `setMaximumConcurrentLocks` method gives the implementation a hint as to the maximum number of concurrent locks it should expect.

Returns

an integer, whose value is the maximum number of locks that can be in simultaneous use.

setMaximumConcurrentLocks(int)

Signature

```
public static void
setMaximumConcurrentLocks(int numLocks)
```

Description

Sets the anticipated maximum number of locks that may be held or waited on concurrently. Provides a hint to systems that use a monitor cache as to how much space to dedicate to the cache.

Parameters

`numLocks`—An integer, whose value becomes the number of locks that can be in simultaneous use without incurring an execution time increase. When `number` is less than or equal to zero nothing happens. When the system does not use this hint this method has no effect other than on the value returned by `getMaximumConcurrentLocks()`.

setMaximumConcurrentLocks(int, boolean)

Signature

```
public static void
setMaximumConcurrentLocks(int number,
                          boolean hard)
```

Description

Sets the anticipated maximum number of locks that may be held or waited on concurrently. Provides a limit for the size of the monitor cache on systems that provide one when hard is true.

Parameters

`number`—The maximum number of locks that can be in simultaneous use without incurring an execution time increase. When `number` is less than or equal to zero nothing happens. When the system does not use this hint this method has no effect other than on the value returned by `getMaximumConcurrentLocks()`.

`hard`—When true, `number` sets a limit. When a lock is attempted which would cause the number of locks to exceed `number` then a `ResourceLimitError` is thrown. When the system does not limit use of concurrent locks, this parameter is silently ignored.

setSecurityManager(RealtimeSecurity)

Signature

```
public static void
setSecurityManager(RealtimeSecurity manager)
```

Description

Sets a new realtime security manager.

Parameters

`manager`—A `RealtimeSecurity` object which will become the new security manager.

Throws

`StaticSecurityException`—when security manager has already been set.

getInitialMonitorControl

Signature

```
public static javax.realtime.MonitorControl
getInitialMonitorControl()
```

Description

Returns the monitor control object that represents the initial monitor control policy.

Returns

the initial monitor control policy.

Since RTSJ 1.0.1

supports(RTSJModule)

Signature

```
public static boolean
supports(RTSJModule module)
```

Description

Determines whether or not a particular module is supported.

Parameters

`module`—The identifier of the module to be checked for support.

Returns

`true` when `module` is supported; otherwise `false`.

Since RTSJ 2.0

modules

Signature

```
public static int
modules()
```

Description

The set of modules supported.

Returns

an integer representing all the modules supported.

Since RTSJ 2.0

hasUniversalClock

Signature

```
public static boolean
hasUniversalClock()
```

Description

Determines whether or not this system supports a universal time clock.

Returns

`true` when the system can provide a universal time clock.

canEnforceCost

Signature

```
public static boolean
canEnforceCost()
```

Description

Determines whether or not hard cost enforcement is supported.

Returns

`true` when cost enforcement is supported; otherwise `false`.

Since RTSJ 2.0

canEnforceAllocationRate

Signature

```
public static boolean
canEnforceAllocationRate()
```

Description

Determines whether or not allocation rate enforcement is supported.

Returns

`true` when allocation rate enforcement is supported, otherwise `false`.

Since RTSJ 2.0

setDefaultConfiguration(ConfigurationParameters)

Signature

```
public static void
setDefaultConfiguration(ConfigurationParameters parameters)
```

Description

Sets the default configuration used to by tasks that are not explicitly provided with one.

Parameters

`parameters`—contains the new default configuration.

Since RTSJ 2.0

getDefaultConfiguration

Signature

```
public static javax.realtime.ConfigurationParameters
getDefaultConfiguration()
```

Description

Determines the current configurations used by tasks that are not explicitly provided with one.

Returns

the current configurations.

Since RTSJ 2.0

16.2.2.6 SchedulingPermission

---

public class SchedulingPermission

Inheritance

java.lang.Object
  java.security.Permission

RealtimePermission
SchedulingPermission

Description

Scheduling has its own security permission that covers APIs in `Scheduler`, `RealtimeThreadGroup`, and `javax.realtime.enforce.ProcessingConstraint`. The following table describes the actions to check. Either the permission is limited to the current `ThreadGroup` by specifying the target `group` or it can apply to all, either with no target or the target `*`.

Action Name	Description	Risks of grant
system	Changes system wide behavior, such as how scheduling is done.	Scheduling Risk
control	Changes someone else's scheduling limits or raises your own limits.	Scheduling Risk
monitor	Adds overrun and underrun handlers to someone else's group.	Load Risk
tune	Changes task scheduling.	Scheduling Risk

The wildcard `*` is allowed for both signal and action. The risk classes are defined in `RealtimePermission`.

Since RTSJ 2.0

16.2.2.6.1 Constructors

SchedulingPermission(String, String)

Signature

```
public
SchedulingPermission(String target,
                     String actions)
```

Description

Creates a new `SchedulingPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters
`target`—Specifies the domain for the action, or `*` for no limit on the permission.
`actions`—The names of the actions to allow, or `*` for all actions.
Throws
`NullPointerException`—when `action` is `null`.
`StaticIllegalArgumentException`—when `target` or `action` is empty.

SchedulingPermission(String)

Signature

```
public
SchedulingPermission(String actions)
```

Description

Creates a new `SchedulingPermission` object for a given action, i.e., the symbolic name of an action.

Parameters
`actions`—The names of the actions to allow, or `*` for all actions.
Throws
`NullPointerException`—when `action` is `null`.
`StaticIllegalArgumentException`—when `action` is empty.

16.2.2.6.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters
`other`—is the object with which to compare.
Returns
`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.2.2.7 TaskPermission

---

public class TaskPermission

Inheritance
java.lang.Object
  java.security.Permission
    RealtimePermission
      TaskPermission

Description

Task permissions are for controlling threads and handlers, as well as creating clocks. The following table describes the actions to check. For all but `create`, which takes no target, either the permission is limited to the current `ThreadGroup` by specifying the target `group`, or it can apply to all with no target or the target `*`.

Action Name	Description	Risks of grant
control	Enables controlling the activity of a task.	Scheduling Risk
create	Enables new thread, timers, and tasks to be created.	Scheduling Risk
handle	Adds handler to an asynchronous event.	Load Risk
override	Interference Risk.	
system	Changes system wide tasking behavior.	Load and Scheduling Risk

The risk classes are defined in `RealtimePermission`.

Since RTSJ 2.0

16.2.2.7.1 Constructors

TaskPermission(String, String)

Signature

```
public
TaskPermission(String target,
               String actions)
```

Description

Creates a new `TaskPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`StaticIllegalArgumentException`—when `target` or `action` is empty.

TaskPermission(String)

Signature

```
public
TaskPermission(String actions)
```

Description

Creates a new `TaskPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`StaticIllegalArgumentException`—when `action` is empty.

16.2.2.7.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns

the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.2.2.8 TimePermission

---

public class TimePermission

Inheritance
java.lang.Object
java.security.Permission
RealtimePermission
TimePermission

Description

Time permissions are for controlling clocks and timers. The following table describes the actions to check. For all but `create`, which takes no target, either the permission is limited to the current `ThreadGroup` by specifying the target `group`, or it can apply to all with no target or the target `*`.

Action Name	Description	Risks of grant
control	Enables controlling the activity of a timer	Scheduling Risk
create	Enables new timers to be created	Scheduling Risk
handle	Adds handler to a timer	Load Risk
override	Change existing handlers	Interference Risk
system	Changes system wide timer and clock behavior	Load and Scheduling Risk

The risk classes are defined in RealtimePermission.

Since RTSJ 2.0

16.2.2.8.1 Constructors

TimePermission(String, String)

Signature

```
public
TimePermission(String target,
               String actions)
```

Description

Creates a new TimePermission object for a given action, i.e., the symbolic name of an action. The target string specifies additional limitations on the action.

Parameters

target—Specifies the domain for the action, or * for no limit on the permission.

actions—The names of the actions to allow, or * for all actions.

Throws

NullPointerException—when action is null.

StaticIllegalArgumentException—when target or action is empty.

TimePermission(String)

Signature

```
public
TimePermission(String actions)
```

Description

Creates a new TimePermission object for a given action, i.e., the symbolic name of an action.

Parameters

actions—The names of the actions to allow, or * for all actions.

Throws

NullPointerException—when action is null.

StaticIllegalArgumentException—when action is empty.

16.2.2.8.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns

the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns

the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters

`permission`—is the permission to check.

Returns

`true` when yes and `false` otherwise.

16.3 javax.realtime.device

16.3.1 Classes

16.3.1.1 DirectMemoryPermission

---

public class DirectMemoryPermission

Inheritance

java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      DirectMemoryPermission

Description

The device management module provides a permission for the security manager to control access to DMA memory. The following table describes the actions to check. An address range can be given as the target or * for any legal address range.

Action Name	Description	Risks of grant
define	Defines a DMA address range for use by raw memory.	DMA Range Risk
map	Maps a DMA address range for use by a DMA object.	DMA Mapping risk

The risk classes are defined in `javax.realtime.RealtimePermission`.

Since RTSJ 2.0

16.3.1.1.1 Constructors

DirectMemoryPermission(String, String)

Signature

```
public
DirectMemoryPermission(String target,
                       String actions)
```

Description

Creates a new `DirectMemoryPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

16.3.1.1.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns

the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.3.1.2 HappeningPermission

---

public class HappeningPermission

Inheritance
java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      HappeningPermission

Description

The device management module provides a permission for the security manager to control happenings. The following table describes the actions to check. For all but `create`, which takes no arguments, either the permission is limited to the current `ThreadGroup` by specifying the target `group` or it can apply to all, either with no target or with the target `*`.

Action Name	Description	Risks of grant
create	Enables new thread, timers, and tasks to be created.	Scheduling Risk
handle	Allows adding a handler to a Happening.	Load Risk
override	Enables handlers to be removed.	Interference Risk
system	Changes system's wide happening behavior.	Scheduling and Load Risk

The risk classes are defined in `javax.realtime.RealtimePermission`.

Since RTSJ 2.0

16.3.1.2.1 Constructors

HappeningPermission(String, String)

Signature

```
public
HappeningPermission(String target,
                    String actions)
```

Description

Creates a new `HappeningPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

HappeningPermission(String)

Signature

```
public
HappeningPermission(String actions)
```

Description

Creates a new `HappeningPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `action` is empty.

16.3.1.2.2 Methods

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters
`other`—is the object with which to compare.
Returns
`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.3.1.3 RawMemoryPermission

---

public class RawMemoryPermission

Inheritance
java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      RawMemoryPermission

Description

The device management module provides a permission for the security manager to manage raw memory. The following table describes the actions to check. An address range can be given as the `target` or `*` for any.

Action Name	Description	Risks of grant
define	Defines a device address range for use by raw memory.	Device Range Risk
map	Maps a given amount of raw memory into a raw memory object.	Device Map Risk

The risk classes are defined in `javax.realtime.RealtimePermission`.

Since RTSJ 2.0

16.3.1.3.1 Constructors

RawMemoryPermission(String, String)

Signature

```
public
RawMemoryPermission(String target,
```

```
                        String actions)
    throws NullPointerException,
           StaticIllegalArgumentException
```

Description

Creates a new `RawMemoryPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

RawMemoryPermission(String)

Signature

```
public
RawMemoryPermission(String actions)
throws NullPointerException,
       StaticIllegalArgumentException
```

Description

Creates a new `RawMemoryPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `action` is empty.

16.3.1.3.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters
`other`—is the object with which to compare.
Returns
`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.4 javax.realtime.memory

16.4.1 Classes

16.4.1.1 PhysicalMemoryPermission

---

public class PhysicalMemoryPermission

Inheritance

java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      PhysicalMemoryPermission

Description

The alternate memory management module provides two permissions for the security manager to use. The following table describes the actions for checking the use of physical memory. An address range can be given as the target or * for any.

Action Name	Description	Risks of grant
define	Defines a physical address range for use by physical memory.	Physical Range Risk
map	Maps physical memory backing store for creating a memory area.	Physical Map Risk

The risk classes are defined in `javax.realtime.RealtimePermission`.

Since RTSJ 2.0

16.4.1.1.1 Constructors

PhysicalMemoryPermission(String, String)

Signature

```
public
PhysicalMemoryPermission(String target,
                         String actions)
```

Description

Creates a new `DirectMemoryPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

16.4.1.1.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns

the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.4.1.2 ScopedMemoryPermission

---

public class ScopedMemoryPermission

Inheritance
java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      ScopedMemoryPermission

Description

The alternate memory management module provides two permissions for the security manager to use. The following table describes the actions for checking the use of scoped memory. A signal name can be given as the target. The name of a scoped memory area type can be given for enter and a maximum amount of backing store can be used for global backing store.

Action Name	Description	Risks of grant
map	Uses a given amount of the global backing store.	Physical Map Risk
enter	Enters a scoped memory	Memory Risk
monitor	Visit root scoped memories	Encapsulation Risk

The wildcard `*` or no target allows access to any scoped memory area or any amount of backing store. The risk classes are defined in `javax.realtime.RealtimePermission`.

Since RTSJ 2.0

16.4.1.2.1 Constructors

ScopedMemoryPermission(String, String)

Signature

```
public
ScopedMemoryPermission(String target,
                       String actions)
```

Description

Creates a new `DirectMemoryPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies additional limitations on the action.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

16.4.1.2.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters

`other`—is the object with which to compare.

Returns

`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.5 javax.realtime.posix

16.5.1 Classes

16.5.1.1 POSIXPermission

---

public class POSIXPermission

Inheritance
java.lang.Object
  java.security.Permission
    javax.realtime.RealtimePermission
      POSIXPermission

Description

The POSIX module provides one permission class for the security manager to use. This permission applies to both `Signal` and `RealtimeSignal`. The following table describes the actions for checking the use of signals. A signal name (like `SIGHUP`) or `*` can be given as target.

Action Name	Description	Risks of grant
handle	Adds a handle to the given signal.	Load Risk
override	Removes a handler that belongs to another realtime thread group.	Interference Risk
send	Sends a given signal.	External Risk
control	Starts or stops this signal.	Scheduling Risk
system	Changes system's wide signaling behavior.	Scheduling and Load Risk

The wildcard `*` is allowed for both signal and action. The risk classes are defined in `javax.realtime.RealtimePermission`.

See Section Signal
See Section RealtimeSignal
See Section SignalDispatcher
See Section RealtimeSignalDispatcher
Since RTSJ 2.0

16.5.1.1.1 Constructors

POSIXPermission(String, String)

Signature

```
public
POSIXPermission(String target,
                String actions)
```

Description

Creates a new `POSIXPermission` object for a given action, i.e., the symbolic name of an action. The `target` string specifies for which POSIX signal the action applies.

Parameters

`target`—Specifies the domain for the action, or `*` for no limit on the permission.

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `target` or `action` is empty.

POSIXPermission(String)

Signature

```
public
POSIXPermission(String actions)
```

Description

Creates a new `POSIXPermission` object for a given action, i.e., the symbolic name of an action.

Parameters

`actions`—The names of the actions to allow, or `*` for all actions.

Throws

`NullPointerException`—when `action` is `null`.

`javax.realtime.StaticIllegalArgumentException`—when `action` is empty.

16.5.1.1.2 Methods

---

equals(Object)

Signature

```
public boolean
equals(Object other)
```

Description

Parameters
`other`—is the object with which to compare.
Returns
`true` when yes and `false` otherwise.

getActions

Signature

```
public java.lang.String
getActions()
```

Description

Returns
the actions represented as a string.

hashCode

Signature

```
public int
hashCode()
```

Description

Returns
the hash code value.

implies(Permission)

Signature

```
public boolean
implies(Permission permission)
```

Description

Parameters
`permission`—is the permission to check.
Returns
`true` when yes and `false` otherwise.

16.6 Rationale

This specification accommodates the variation in underlying systems in a number of ways. The `RealtimeSystem` class functions in similar capacity to `java.lang.System`. Similarly, the `RealtimeSecurity` class functions corresponds to `java.lang.SecurityManager`.

The concept of optionally required classes provides additional flexibility. Such classes provide a commonality that can be relied upon by program logic that intends to execute on implementations that support a given function, such as `Signal` and `RealtimeSignal` encapsulate common functionality for POSIX compliant systems.

Finally, the `GarbageCollector` class provides some basic information about the garbage collector, but this information is necessarily very limited. The specification does not require a deterministic garbage collector, and even with such a collector, the variation between collectors is quite large. For example, work-based collectors do not have garbage collector threads, so many of the parameters for thread-based collectors would not make sense for a work-based collector. Data that is easy to collect with one type of collector can be quite costly to collect with another. For this reason, collector information is provided via a factory method so that the return class can be extended to provide additional, implementation-defined information.

Chapter 17

Exceptions

As with other Java specifications, the RTSJ uses throwables, exceptions and errors, to signal conditions that are abnormal, incorrect, or disallowed. In cases where these exceptional and error conditions are thrown as a result of executing or emulating a Java bytecode or performing operations compatible with standard I/O or class instantiation, the conventional Java exceptions and errors are used. They are taken primarily from the java.lang package, but also a few from the java.lang.reflect and java.io packages as well. In cases where a conventional Java exception is defined that would fit the exceptional condition, a static subclass is used. In other cases, new static exceptions are defined in the javax.realtime package. These static exception classes provide

- additional exception classes required for other sections of this specification,
- the ability to throw exceptions without allocating memory, and
- the ability to asynchronously transfer the control of program logic (see AsynchronouslyInterruptedException).

The ability to throw exceptions without memory allocation is important for using scoped and immortal memory; otherwise, throwing an exception would require much larger scopes to ensure against memory exhaustion.

17.1 Semantics

In order to balance compatibility with conventional Java against effective memory management for realtime system, this specification uses four categories of throwables. The first category consists of those that can be thrown by an RTSJ method, but are the result of executing a byte code instruction:

- java.lang.ArithmeticException,
- java.lang.ArrayIndexOutOfBoundsException,
- java.lang.ClassCastException,
- java.lang.IllegalAccessException,
- java.lang.IndexOutOfBoundsException,
- java.lang.NullPointerException,
- java.lang.StringIndexOutOfBoundsException, and
- java.lang.OutOfMemoryError.

The second category is similar, but result from class loading or I/O:

- java.lang.InstantiationException,
- java.lang.ExceptionInInitializerError,
- java.nio.BufferOverflowException,
- java.nio.InvalidMarkException,
- java.nio.ReadOnlyBufferException, and
- java.lang.reflect.InvocationTargetException.

The third category is exceptions that have the same meaning as conventional Java exception but are thrown directly by an `RTSJ` method:

`RTSJ` Throwable	extends
`AsynchronouslyInterruptedException`	InterruptedException
`ConstructorCheckedException`	InstantiationException
`StaticIllegalArgumentException`	IllegalArgumentException
`StaticIllegalStateException`	IllegalStateException
`IllegalTaskStateException`	IllegalThreadStateException
`StaticSecurityException`	IllegalArgumentException
`StaticUnsupportedOperationException`	UnsupportedOperationException
`StaticOutOfMemoryError`	OutOfMemoryError

These classes all implement the interface `StaticThrowable`. The last category consists of exceptions that are defined only in the `RTSJ`. Each of these extend one of

- `StaticCheckedException`,
- `StaticRuntimeException`, or
- `StaticError`,

depending on what kind of exception it is. All three of these classes also implement `StaticThrowable`. Except for how information associated with a `Throwable` is stored and managed, the semantics of the classes that implement `StaticThrowable` are the same as for all other Java throwables. All classes in this section are required. Semantics that apply to particular classes, constructors, methods, and fields will be found in the class description and the constructor, method, and field detail sections.

All exceptions defined in this section implement `StaticThrowable` and thus are statically allocated. There is at most one instance of each of these exceptions and errors, managed by the runtime. The message and stack information they would normally carry is held in a thread-local data structure. This means this information is only valid within the context of the thread that threw the `StaticThrowable`, and there only until a new `StaticThrowable` is thrown.

The thread-local storage used by instances of `StaticThrowable` is controlled by the `ConfigurationParameters` associated with the active task when the exception is thrown. This may be the system default `ConfigurationParameters` (set on `RealtimeSystem`) in the case of Java threads or a `Schedulable` for which no `ConfigurationParameters` was provided, or it may be the `ConfigurationParameters` explicitly set for a `Schedulable`.

Though the `AsynchronouslyInterruptedException` and `Timed` classes are exceptions, they provide additional functionality for supporting Asynchronous Transfer of Control (ATC). This functionality is more closely related to asynchronous operation than to exception handling. For this reason and because they are not in the

core module, they are not described in this chapter, but rather in Chapter 8 on asynchrony.

17.2 javax.realtime

17.2.1 Interfaces

17.2.1.1 StaticThrowable

---

public interface StaticThrowable<T extends StaticThrowable<T>>

Description

A marker interface to indicate that a `Throwable` is intended to be created once and reused. `Throwables` that implement this interface keep their state in a `ThreadLocal` data structure instead of the object itself. This means that data is only valid until the next `StaticThrowable` is thrown in the context of the current thread. Instances of `AsyncBaseEventHandler` always have some instance of `Thread` when executing. Having a marker interface makes it easier to provide checking tools to ensure the proper throw sequence for all `Throwables` thrown from application code.

`Throwables` which implement this interface should define a `get()` method that returns the singleton `Throwable` of that class. It should also fill the stack backtrace and clear the message and cause.

An application which throws a static exception should use the following paradigm:

`throw LateStartException.get().init(message, cause);`

The message must be initialized before the cause, because initMessage is defined on `StaticThrowable` but not `Throwable`. Setting the message and the cause are both optional.

Applications which define a static throwable by implementing `StaticThrowable` should extend one of predefined classes: `StaticError`, `StaticCheckedException`, or `StaticRuntimeException`. When this is not possible because one needs to extend an existing conventional Java exception, the new throwable must override its methods and redirect them to the local instance of `StaticThrowableStorage`. For example, the following code snippet reimplements `initMessage` using `StaticThrowableStorage`:

```
public Throwable initMessage(String message)
{
  StaticThrowableStorage.getCurrent().initMessage(message);
  return this;
}
```

Stack trace, message, and cause must be stored in and retrieved from this thread's local storage structure.

See Section ConfigurationParameters
Since RTSJ 2.0

17.2.1.1.1 Methods

init

Signature

```
public T extends javax.realtime.StaticThrowable<T>
init()
```

Description

Store the message of the calling exception in the instance of `StaticThrowableStorage` associated with this task. This is the only method not defined in `java.lang.Throwable`.

Returns

`this` object.

Since RTSJ 2.0 implemented by all static throwables

init(String)

Signature

```
public T extends javax.realtime.StaticThrowable<T>
init(String message)
```

Description

Store the message of the calling exception in the instance of `StaticThrowableStorage` associated with this task. This is the only method not defined in `java.lang.Throwable`.

Parameters

`message`—Text to be saved describing the exception's cause.

Returns

`this` object.

Since RTSJ 2.0 implemented by all static throwables

init(String, Throwable)

Signature

```
public T extends javax.realtime.StaticThrowable<T>
init(String message,
     Throwable cause)
```

Description

Store the message of the calling exception in the instance of `StaticThrowableStorage` associated with this task. This is the only method not defined in `java.lang.Throwable`.

Parameters

`message`—Text to be saved describing the exception's cause.

`cause`—Another throwable that lead to this one being throwm.

Returns

`this` object.

Since RTSJ 2.0 implemented by all static throwables

init(Throwable)

Signature

```
public T extends javax.realtime.StaticThrowable<T>
init(Throwable cause)
```

Description

Store the message of the calling exception in the instance of `StaticThrowableStorage` associated with this task. This is the only method not defined in `java.lang.Throwable`.

Parameters

`cause`—Another throwable that lead to this one being throwm.

Returns

`this` object.

Since RTSJ 2.0 implemented by all static throwables

writeReplace

Signature

```
public java.lang.Object
writeReplace()
```

Description

Replace this objected with a special transport object when serializing.

Returns

the proxy object.

getSingleton

Signature

```
public javax.realtime.StaticThrowable<?>
getSingleton()
```

Description

For the case of legacy code that creates an RTSJ exception explicity, this provides a means of obtaining its singleton version.

Returns

the singleton version of this exception.

isStatic

Signature

```
public boolean
isStatic()
```

Description

Determine whether or not this is the static instance of this `Throwable`.

Returns

`true` when it is the singleton instance and `false` otherwise.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Gets the message describing the exception's cause from thread local memory.

Returns

the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Subclasses may override this message to get an error message that is localized to the default locale.

By default it returns `getMessage()`.

Returns

the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Store the cause of calling exception in the instance of `StaticThrowableStorage` associated with this task.

Parameters

`causingThrowable`—The reason why this `Throwable` gets thrown.

Throws

`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns

the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Gets the cause from thread local memory of the calling exception or `null` when no cause was set. The cause is another exception that was caught before the current exception is to be thrown.

Returns

the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Calls into the virtual machine to capture the current stack trace in the instance of `StaticThrowableStorage` associated with this task.

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

This method enables overriding the stack trace that was filled during construction of this object. It is intended to be used in a serialization context when the stack trace of a remote exception should be treated like a local.

Parameters

`new_stackTrace`—the stack trace to be used as replace.

Throws

`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Gets the stack trace created by fillInStackTrace for this `Throwable` from the current thread local storage as an array of StackTraceElements.

The stack trace does not need to contain entries for all methods that are actually on the call stack, the virtual machine may decide to skip some stack trace entries. Even an empty array is a valid result of this function.

Repeated calls of this function without intervening calls to fillInStackTrace will return the same result.

When memory areas of the RTSJ are used (see `MemoryArea`), and this `Throwable` was allocated in a different memory area than the current allocation context, the resulting stack trace will be allocated in either the same memory area `this` was allocated in or the current memory area, depending on which is the least deeply nested, thereby creating objects that are assignment compatible with both areas.

Returns

An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

Prints stack trace of this `Throwable` to System.err.

The printed stack trace contains the result of `toString()` as the first line followed by one line for each stack trace element that contains the name of the method or constructor, optionally followed by the source file name and source file line number when available.

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Prints the stack trace of this `Throwable` to the given stream.

The printed stack trace contains the result of `toString()` as the first line followed by one line for each stack trace element that contains the name of the method or constructor, optionally followed by the source file name and source file line number when available.

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter s)
```

Description

Prints the stack trace of this `Throwable` to the given PrintWriter.

The printed stack trace contains the result of `toString()` as the first line followed by one line for each stack trace element that contains the name of the method or constructor, optionally followed by the source file name and source file line number when available.

Parameters

`s`—The PrintWriter to write to.

17.2.2 Classes

17.2.2.1 AlignmentError

---

public class AlignmentError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      StaticError
        AlignmentError

Interfaces

javax.realtime.StaticThrowable

Description

The exception thrown on a request for a raw memory factory to return memory for a base address that is aligned such that the factory cannot guarantee that loads and stores based on that address will meet the factory's specifications. For instance, on many processors, odd addresses are unsuitable for anything but byte access.

Since RTSJ 2.0

17.2.2.1.1 Methods

get

Signature

```
public static javax.realtime.AlignmentError
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.AlignmentError
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.2 ArrivalTimeQueueOverflowException

public class ArrivalTimeQueueOverflowException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          EventQueueOverflowException
            ArrivalTimeQueueOverflowException

Description

When an arrival time occurs and should be queued, but the queue already holds a number of times equal to the initial queue length, an instance of this class is thrown.

Since RTSJ 1.0.1 this is unchecked
Since RTSJ 2.0 extends `EventQueueOverflowException`

17.2.2.2.1 Constructors

ArrivalTimeQueueOverflowException

Signature

```
public
ArrivalTimeQueueOverflowException()
```

Description

The default constructor for `ArrivalTimeQueueOverflowException`, but user code should use `get()` instead.

17.2.2.2.2 Methods

get

Signature

```
public static javax.realtime.ArrivalTimeQueueOverflowException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this `Throwable`.

Since RTSJ 2.0

17.2.2.3 CeilingViolationException

public class CeilingViolationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalArgumentException
          java.lang.IllegalThreadStateException
            IllegalTaskStateException
              CeilingViolationException

Description

This exception is thrown when a schedulable or `java.lang.Thread` attempts to lock an object governed by an instance of `PriorityCeilingEmulation` and the thread or SO's base priority exceeds the policy's ceiling.

Since RTSJ 2.0 implements StaticThrowable

17.2.2.3.1 Methods

---

get

Signature

```
public static javax.realtime.CeilingViolationException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getCeiling

Signature

```
public int
getCeiling()
```

Description

Gets the ceiling of the `PriorityCeilingEmulation` policy which was exceeded by the base priority of an SO or thread that attempted to synchronize on an object governed by the policy, which resulted in throwing of `this`.

Returns

the ceiling of the `PriorityCeilingEmulation` policy which caused this exception to be thrown.

getCallerPriority

Signature

```
public int
getCallerPriority()
```

Description

Gets the base priority of the SO or thread whose attempt to synchronize resulted in the throwing of this.

Returns
the synchronizing thread's base priority.

17.2.2.4 ConstructorCheckedException

---

public class ConstructorCheckedException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.ReflectiveOperationException
        java.lang.InstantiationException
          ConstructorCheckedException

Interfaces
javax.realtime.StaticThrowable

Description

To throw when `MemoryArea.newInstance` causes the constructor of the new instance to throw a checked exception.

Since RTSJ 2.0

17.2.2.4.1 Methods

---

get

Signature

```
public static javax.realtime.ConstructorCheckedException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns
the preallocated exception.

getSingleton

Signature

```
public javax.realtime.ConstructorCheckedException
getSingleton()
```

Description

Returns
the singleton version of this exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns
the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns
the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters
`causingThrowable`—The reason why this `Throwable` gets thrown.
Throws
`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.
Returns
the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns

the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] trace)
throws NullPointerException
```

Description

Parameters

`new_stackTrace`—the stack trace to be used as replace.

Throws

`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns

An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters

`s`—The PrintWriter to write to.

17.2.2.5 DeregistrationException

---

public class DeregistrationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          DeregistrationException

Interfaces

javax.realtime.StaticThrowable

Description

An exception to throw when trying to deregister an `ActiveEvent` from an `ActiveEventDispatcher` to which it is not registered.

Since RTSJ 2.0

17.2.2.5.1 Methods

---

get

Signature

```
public static javax.realtime.DeregistrationException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.DeregistrationException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.6 EventQueueOverflowException

---

public class EventQueueOverflowException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          EventQueueOverflowException

Interfaces
javax.realtime.StaticThrowable

Description

When an arrival time occurs and should be queued, but the queue already holds a number of times equal to the initial queue length, an instance of this class is thrown.

Since RTSJ 2.0 Generalizes `ArrivalTimeQueueOverflowException`

17.2.2.6.1 Methods

---

get

Signature

```
public static javax.realtime.EventQueueOverflowException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.EventQueueOverflowException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.7 ForEachTerminationException

---

public class ForEachTerminationException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException

StaticRuntimeException
ForEachTerminationException

Interfaces
javax.realtime.StaticThrowable

Description

An exception to throw when a visitor should terminate early. It is for use with the forEach method in collection classes. Since it is a StaticThrowable, it can be used without creating garbage.

17.2.2.7.1 Methods

get

Signature

```
public static javax.realtime.ForEachTerminationException
get()
```

Description

Gets the static instance of this class and initializes its stack trace.

Returns
the static singleton of this class.

getSingleton

Signature

```
public javax.realtime.ForEachTerminationException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.8 IllegalAssignmentError

public class IllegalAssignmentError

Inheritance
java.lang.Object
java.lang.Throwable
java.lang.Error
StaticError

IllegalAssignmentError

Interfaces

javax.realtime.StaticThrowable

Description

The exception thrown on an attempt to make an illegal assignment. For example, this will be thrown on any attempt to assign a reference to an object in scoped memory, an area of memory identified to be an instance of `javax.realtime.memory.ScopedMemory`, to a field of an object in immortal memory.

Since RTSJ 2.0 extends StaticError

17.2.2.8.1 Constructors

IllegalAssignmentError

Signature

```
public
IllegalAssignmentError()
```

Description

A constructor for `IllegalAssignmentError`, but the application should use `get()` instead, e.g., `IllegalAssignmentError.get().init()`.

17.2.2.8.2 Methods

---

get

Signature

```
public static javax.realtime.IllegalAssignmentError
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.IllegalAssignmentError
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.9 IllegalTaskStateException

---

public class IllegalTaskStateException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalArgumentException
          java.lang.IllegalThreadStateException
            IllegalTaskStateException

Interfaces

javax.realtime.StaticThrowable

Description

The exception thrown when a `Schedulable` instance attempts an operation which is illegal in its current state. For instance, changing parameters on such instances are only allowed when the scheduler is not active or the new parameters are consistent with the current scheduler.

Since RTSJ 2.0

17.2.2.9.1 Methods

---

get

Signature

```
public static javax.realtime.IllegalTaskStateException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns
the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns
the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns
the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters
`causingThrowable`—The reason why this `Throwable` gets thrown.
Throws
`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns
the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns

the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

Parameters

`new_stackTrace`—the stack trace to be used as replace.

Throws

`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns

An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters

`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.IllegalTaskStateException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.10 InaccessibleAreaException

public class InaccessibleAreaException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          InaccessibleAreaException

Interfaces

javax.realtime.StaticThrowable

Description

The specified memory area is not on the current thread's scope stack.

Since RTSJ 1.0.1 Becomes unchecked
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.10.1 Constructors

InaccessibleAreaException

Signature

```
public
InaccessibleAreaException()
```

Description

A constructor for `InaccessibleAreaException`, but application code should use `get()` instead.

InaccessibleAreaException(String)

Signature

```
public
InaccessibleAreaException(String description)
```

Description

A descriptive constructor for `InaccessibleAreaException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—Description of the error.

17.2.2.10.2 Methods

get

Signature

```
public static javax.realtime.InaccessibleAreaException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.InaccessibleAreaException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.11 LateStartException

public class LateStartException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      StaticCheckedException
        LateStartException

Interfaces

javax.realtime.StaticThrowable

Description

Exception thrown when a periodic realtime thread or timer is started after its assigned, absolute, start time.

Since RTSJ 2.0

17.2.2.11.1 Methods

get

Signature

```
public static javax.realtime.LateStartException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.LateStartException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.12 MITViolationException

public class MITViolationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          MITViolationException

Interfaces

javax.realtime.StaticThrowable

Description

Thrown by the `AsyncEvent.fire()` on a minimum interarrival time violation. More specifically, it is thrown under the semantics of the base priority scheduler's sporadic parameters' `mitViolationExcept` policy when an attempt is made to introduce a release that would violate the MIT constraint.

Since RTSJ 1.0.1 became unchecked
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.12.1 Constructors

MITViolationException

Signature

```
public
MITViolationException()
```

Description

A constructor for `MITViolationException`.

MITViolationException(String)

Signature

```
public
MITViolationException(String description)
```

Description

A descriptive constructor for `MITViolationException`.

Parameters
`description`—Description of the error.

17.2.2.12.2 Methods

---

get

Signature

```
public static javax.realtime.MITViolationException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.MITViolationException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.13 MemoryAccessError

---

public class MemoryAccessError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      StaticError
        MemoryAccessError

Interfaces

javax.realtime.StaticThrowable

Description

This error is thrown on an attempt to refer to an object in an inaccessible `MemoryArea`. For example, when logic in a `RealtimeThread` or `AsyncBaseEventHandler` configured with a `javax.realtime.memory.ScopedConfigurationParameters` object, attempts to refer to an object in a `HeapMemory` area.

Since RTSJ 2.0 extends StaticError

17.2.2.13.1 Constructors

MemoryAccessError

Signature

```
public
MemoryAccessError()
```

Description

A constructor for `MemoryAccessError`, but application code should use `get()` instead.

17.2.2.13.2 Methods

get

Signature

```
public static javax.realtime.MemoryAccessError
get()
```

Description

Obtains the singleton of this static `Throwable`. It is prepared for immediate throwing.

Returns

the single instance of this `Throwable`.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.MemoryAccessError
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.14 MemoryInUseException

public class MemoryInUseException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          MemoryInUseException

Interfaces

javax.realtime.StaticThrowable

Description

There has been attempt to allocate a range of physical or virtual memory that is already in use.

Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.14.1 Constructors

MemoryInUseException

Signature

```
public
MemoryInUseException()
```

Description

A constructor for `MemoryInUseException`, but application code should use `get()` instead.

MemoryInUseException(String)

Signature

```
public
MemoryInUseException(String description)
```

Description

A descriptive constructor for `MemoryInUseException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—Description of the error.

17.2.2.14.2 Methods

get

Signature

```
public static javax.realtime.MemoryInUseException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.MemoryInUseException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.15 MemoryScopeException

---

public class MemoryScopeException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          MemoryScopeException

Interfaces

javax.realtime.StaticThrowable

Description

When construction of any of the wait-free queues is attempted with the ends of the queue in incompatible memory areas. Also thrown by wait-free queue methods when such an incompatibility is detected after the queue is constructed.

Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.15.1 Constructors

MemoryScopeException

Signature

```
public
MemoryScopeException()
```

Description

A constructor for `MemoryScopeException`, but application code should use `get()` instead.

17.2.2.15.2 Methods

get

Signature

```
public static javax.realtime.MemoryScopeException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.MemoryScopeException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.16 MemoryTypeConflictException

public class MemoryTypeConflictException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          MemoryTypeConflictException

Interfaces

javax.realtime.StaticThrowable

Description

This exception is thrown when the `PhysicalMemoryManager` is given conflicting specifications for memory. The conflict can be between types in an array of memory type specifiers, or between the specifiers and a specified base address.

Since RTSJ 1.0.1 Changed to an unchecked exception.
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.16.1 Constructors

MemoryTypeConflictException

Signature

```
public
MemoryTypeConflictException()
```

Description

A constructor for `MemoryTypeConflictException`, but application code should use `get()` instead.

MemoryTypeConflictException(String)

Signature

```
public
MemoryTypeConflictException(String description)
```

Description

A descriptive constructor for `MemoryTypeConflictException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—A description of the exception.

17.2.2.16.2 Methods

---

get

Signature

```
public static javax.realtime.MemoryTypeConflictException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.MemoryTypeConflictException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.17 OffsetOutOfBoundsException

---

public class OffsetOutOfBoundsException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          OffsetOutOfBoundsException

Interfaces
javax.realtime.StaticThrowable

Description

When the constructor of an `ImmortalPhysicalMemory`, `LTPhysicalMemory`, `VTPhysicalMemory`, `RawMemoryAccess`, or `RawMemoryFloatAccess` is given an invalid address.

Since RTSJ 1.0.1 became unchecked
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.17.1 Constructors

OffsetOutOfBoundsException

Signature

```
public
OffsetOutOfBoundsException()
```

Description

A constructor for `OffsetOutOfBoundsException`, application code should use `get()` instead.

17.2.2.17.2 Methods

get

Signature

```
public static javax.realtime.OffsetOutOfBoundsException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.OffsetOutOfBoundsException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.18 POSIXInvalidSignalException

public class POSIXInvalidSignalException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          POSIXInvalidSignalException

Interfaces

javax.realtime.StaticThrowable

Description

An invalid POSIX signal number has been specified.

Since RTSJ 2.0

17.2.2.18.1 Methods

get

Signature

```
public static javax.realtime.POSIXInvalidSignalException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.POSIXInvalidSignalException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.19 POSIXInvalidTargetException

public class POSIXInvalidTargetException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      StaticCheckedException
        POSIXInvalidTargetException

Interfaces

javax.realtime.StaticThrowable

Description

The target of the signal does not exist.

Since RTSJ 2.0

17.2.2.19.1 Methods

get

Signature

```
public static javax.realtime.POSIXInvalidTargetException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.POSIXInvalidTargetException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.20 POSIXSignalPermissionException

public class POSIXSignalPermissionException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          POSIXSignalPermissionException

Interfaces

javax.realtime.StaticThrowable

Description

The process does not have permission to send the given signal to the given target.

Since RTSJ 2.0

17.2.2.20.1 Methods

get

Signature

```
public static javax.realtime.POSIXSignalPermissionException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.POSIXSignalPermissionException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.21 ProcessorAffinityException

public class ProcessorAffinityException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalArgumentException
          java.lang.IllegalThreadStateException
            IllegalTaskStateException
              ProcessorAffinityException

Description

Exception used to report processor affinity-related errors.

Since RTSJ 2.0

17.2.2.21.1 Methods

get

Signature

```
public static javax.realtime.ProcessorAffinityException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

17.2.2.22 RangeOutOfBoundsException

public class RangeOutOfBoundsException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      StaticCheckedException
        RangeOutOfBoundsException

Interfaces

javax.realtime.StaticThrowable

Description

Thrown when the memory region overlaps with another region in use or memory that may not be used.

Since RTSJ 2.0

17.2.2.22.1 Methods

get

Signature

```
public static javax.realtime.RangeOutOfBoundsException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.RangeOutOfBoundsException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.23 RegistrationException

---

public class RegistrationException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          RegistrationException

Interfaces
javax.realtime.StaticThrowable

Description

An exception to throw when trying to register an `ActiveEvent` with an `ActiveEventDispatcher` to which it is already registered.

Since RTSJ 2.0

17.2.2.23.1 Methods

---

get

Signature

```
public static javax.realtime.RegistrationException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.RegistrationException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.24 ResourceLimitError

---

public class ResourceLimitError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      StaticError
        ResourceLimitError

Interfaces

javax.realtime.StaticThrowable

Description

This error is thrown when an attempt is made to exceed a system resource limit, such as the maximum number of locks.

Since RTSJ 2.0 extends StaticError

17.2.2.24.1 Constructors

ResourceLimitError

Signature

```
public
ResourceLimitError()
```

Description

A constructor for `ResourceLimitError`, but application code should use `get()` instead.

ResourceLimitError(String)

Signature

```
public
ResourceLimitError(String description)
```

Description

A descriptive constructor for `ResourceLimitError`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—The reason for throwing this error.

17.2.2.24.2 Methods

---

get

Signature

```
public static javax.realtime.ResourceLimitError
get()
```

Description

Obtains the singleton of this static `throwable`. It is prepared for immediate throwing.

Returns

the single instance of this `throwable`.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.ResourceLimitError
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.25 ScopedCycleException

---

public class ScopedCycleException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          ScopedCycleException

Interfaces
javax.realtime.StaticThrowable

Description

Thrown when a schedulable attempts to enter an instance of `javax.realtime.memory.ScopedMemory` where that operation would cause a violation of the single parent rule.

Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.25.1 Constructors

ScopedCycleException

Signature

```
public
ScopedCycleException()
```

Description

A constructor for `ScopedCycleException`, but application code should use `get()` instead.

ScopedCycleException(String)

Signature

```
public
ScopedCycleException(String description)
```

Description

A descriptive constructor for `ScopedCycleException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—Description of the error.

17.2.2.25.2 Methods

get
Signature
```
public static javax.realtime.ScopedCycleException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Since RTSJ 2.0

getSingleton
Signature
```
public javax.realtime.ScopedCycleException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.26 SizeOutOfBoundsException

public class SizeOutOfBoundsException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          SizeOutOfBoundsException

Interfaces
javax.realtime.StaticThrowable

Description

To throw when the constructor of an `ImmortalPhysicalMemory`, `LTPhysicalMemory`, or `VTPhysicalMemory` is given an invalid size or when a memory access generated by a raw memory accessor instance (See `javax.realtime.device.RawMemory`.) would cause access to an invalid address.

Since RTSJ 1.0.1 became unchecked
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.26.1 Constructors

SizeOutOfBoundsException

Signature

```
public
SizeOutOfBoundsException()
```

Description

A constructor for `SizeOutOfBoundsException`, but application code should use `get()` instead.

SizeOutOfBoundsException(String)

Signature

```
public
SizeOutOfBoundsException(String description)
```

Description

A descriptive constructor for `SizeOutOfBoundsException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—The description of the exception.

17.2.2.26.2 Methods

---

get

Signature

```
public static javax.realtime.SizeOutOfBoundsException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.SizeOutOfBoundsException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.27 StaticCheckedException

---

public abstract class StaticCheckedException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      StaticCheckedException

Description

A base class for all checked exceptions defined in the specification which do not extend a conventional Java exception.

Since RTSJ 2.0

17.2.2.27.1 Constructors

StaticCheckedException

Signature

```
protected
StaticCheckedException()
```

Description

Enable this class to be extended.

StaticCheckedException(String)

Signature

```
protected
StaticCheckedException(String message)
```

Description

Enable this class to be extended.

Parameters

`message`—Text to descript the exception.

17.2.2.27.2 Methods

---

getMessage

Signature

```
public java.lang.String
getMessage()
```

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

getCause

Signature

```
public java.lang.Throwable
getCause()
```

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

printStackTrace

Signature

```
public void
printStackTrace()
```

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

17.2.2.28 StaticError

---

public abstract class StaticError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      StaticError

Description

A base class for all errors defined in the specification which do not extend a conventional Java error.

Since RTSJ 2.0

17.2.2.28.1 Constructors

StaticError

Signature

```
protected
StaticError()
```

Description

Enable this class to be extended.

StaticError(String)

Signature

```
protected
StaticError(String message)
```

Description

Enable this class to be extended.

Parameters

`message`—Text to descript the exception.

17.2.2.28.2 Methods

getSingleton

Signature

```
public abstract T extends javax.realtime.StaticThrowable<T>
getSingleton()
```

getMessage

Signature

```
public java.lang.String
getMessage()
```

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

getCause

Signature

```
public java.lang.Throwable
getCause()
```

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

printStackTrace

Signature

```
public void
printStackTrace()
```

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

17.2.2.29 StaticIllegalArgumentException

---

public class StaticIllegalArgumentException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalArgumentException
          StaticIllegalArgumentException

Interfaces

javax.realtime.StaticThrowable

Description

A version of `IllegalArgumentException` to be thrown by RTSJ methods that does not require allocation.

Since RTSJ 2.0

17.2.2.29.1 Methods

---

get

Signature

```
public static javax.realtime.StaticIllegalArgumentException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns

the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns

the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters

`causingThrowable`—The reason why this `Throwable` gets thrown.

Throws

`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns

the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns
the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns
a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] trace)
throws NullPointerException
```

Description

Parameters
`new_stackTrace`—the stack trace to be used as replace.
Throws
`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns
An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters

`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.StaticIllegalArgumentException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.30 StaticIllegalStateException

public class StaticIllegalStateException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalStateException
          StaticIllegalStateException

Interfaces

javax.realtime.StaticThrowable

Description

The exception thrown when a `Schedulable` instance attempts to access a memory which is illegal in the memories current state. For instance, some memory areas have limits from what other area they may be entered into.

Since RTSJ 2.0

17.2.2.30.1 Methods

get

Signature

```
public static javax.realtime.StaticIllegalStateException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns
the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns
the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters
`causingThrowable`—The reason why this `Throwable` gets thrown.
Throws
`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns
the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns
the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

Parameters

`new_stackTrace`—the stack trace to be used as replace.

Throws

`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns

An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters

`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.StaticIllegalStateException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.31 StaticOutOfMemoryError

---

public class StaticOutOfMemoryError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      java.lang.VirtualMachineError
        java.lang.OutOfMemoryError
          StaticOutOfMemoryError

Interfaces

javax.realtime.StaticThrowable

Description

A version of `OutOfMemoryError` that does not require allocation. It should be thrown from all RTSJ memory subclasses except `HeapMemory`. It is up to the implementation as to whether `HeapMemory` throws this exception or its parent.

Since RTSJ 2.0

17.2.2.31.1 Methods

---

get

Signature

```
public static javax.realtime.StaticOutOfMemoryError
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns

the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns

the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable cause)
```

Description

Parameters

`causingThrowable`—The reason why this `Throwable` gets thrown.

Throws

`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns

the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns

the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] trace)
throws NullPointerException
```

Description

Parameters
`new_stackTrace`—the stack trace to be used as replace.
Throws
`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns
An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters
`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter s)
```

Description

Parameters
`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.StaticOutOfMemoryError
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.32 StaticRuntimeException

---

public abstract class StaticRuntimeException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException

Description

A base class for all unchecked exceptions defined in the specification which do not extend a conventional Java exception.

Since RTSJ 2.0

17.2.2.32.1 Constructors

StaticRuntimeException

Signature

```
protected
StaticRuntimeException()
```

Description

Enable this class to be extended.

StaticRuntimeException(String)

Signature

```
protected
StaticRuntimeException(String message)
```

Description

Enable this class to be extended.

Parameters

`message`—Text to descript the exception.

17.2.2.32.2 Methods

---

getMessage

Signature

```
public java.lang.String
getMessage()
```

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

getCause

Signature

```
public java.lang.Throwable
getCause()
```

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

printStackTrace

Signature

```
public void
printStackTrace()
```

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

17.2.2.33 StaticSecurityException

---

public class StaticSecurityException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.SecurityException
          StaticSecurityException

Interfaces

javax.realtime.StaticThrowable

Description

A version of `SecurityException` to be thrown by RTSJ methods that does not require allocation.

Since RTSJ 2.0

17.2.2.33.1 Methods

get

Signature

```
public static javax.realtime.StaticSecurityException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns

the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns

the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters
`causingThrowable`—The reason why this `Throwable` gets thrown.
Throws
`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.
Returns
the reference to this `Throwable`.

getCause
Signature
```
public java.lang.Throwable
getCause()
```

Description

Returns
the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace
Signature
```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns
a reference to this `Throwable`.

setStackTrace(StackTraceElement)
Signature
```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

Parameters
`new_stackTrace`—the stack trace to be used as replace.
Throws
`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns

An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters

`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters

`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.StaticSecurityException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.34 StaticThrowableStorage

---

public class StaticThrowableStorage

Inheritance

java.lang.Object
  java.lang.Throwable
    StaticThrowableStorage

Description

Provides the methods for managing the thread local memory used for storing the data needed by preallocated throwables, i.e., exceptions and errors which implement `StaticThrowable`. This call is visible so that an application can extend an existing conventional Java throwable and still implement `StaticThrowable`; its methods can be implemented using the methods defined in this class. An application defined throwable that does not need to extend an existing conventional Java throwable should extend one of `StaticCheckedException`, `StaticRuntimeException`, or `StaticError` instead.

Since RTSJ 2.0

17.2.2.34.1 Fields

EMPTY_TRACE

```
public static final java.lang.StackTraceElement[] EMPTY_TRACE
```

Description

A single copy of an empty stack trace.

17.2.2.34.2 Methods

---

getCurrent

Signature

```
public static javax.realtime.StaticThrowableStorage
getCurrent()
```

Description

A means of obtaining the storage object for the current task and throwable.

Returns

the storage object for the current task.

initCurrent(StaticThrowable)

Signature

```
public static javax.realtime.StaticThrowableStorage
initCurrent(StaticThrowable<?> throwable)
```

Description

Obtaining the storage object for the current task and initialize it.

Returns

the storage object for the current task.

setLastThrown(StaticThrowable)

Signature

```
public javax.realtime.StaticThrowableStorage
setLastThrown(StaticThrowable<?> value)
```

Description

Capture the exception to be thrown, so as to provide a context for the data stored in this object.

Returns

the storage object for the current task.

getLastThrown

Signature

```
public javax.realtime.StaticThrowable<?>
getLastThrown()
```

Description

Determine for what throwable the data is valid;

Returns

the current context for the throwable data stored in this object.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Captures the current thread's stack trace and saves it in thread local storage. Only the part of the stack trace that fits in the preallocated buffer is stored. This method should be called by a preallocated exception to implement its method of the same name.

Returns

`this` NYI: UNDER DEVELOPMENT: JAM-5543 Implementation Under Construction — this should be done on the native side to avoid allocation.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Gets the message from thread local storage that was saved by the last preallocated exception thrown. This method should be called by a preallocated exception to implement its method of the same name.

Returns

the message.

initMessage(String)

Signature

```
public javax.realtime.StaticThrowableStorage
initMessage(String message)
```

Description

Saves the message in thread local storage for later retrieval. Only the part of the message that fits in the preallocated buffer is stored. This method should be called by a preallocated exception to implement its method of the same name.

Parameters

`message`—The description to save.

Returns

`this`

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Gets the cause from thread local storage that was saved by the last preallocated exception thrown. The actual exception of cause is not saved, but just a reference to its type. This returns a newly allocated exception without any valid content, i.e., no valid stack trace. This method should be called by a preallocated exception to implement its method of the same name.

Returns

the throwable that caused the condition or `null` when none was set.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable cause)
```

Description

Saves the message in thread local storage for later retrieval. Only a reference to the exception class is stored. The rest of its information is lost. This method should be called by a preallocated exception to implement its method of the same name.

Parameters

`cause`—In the case of cascading throwables, the exception or error that was the original cause.

Returns

`this`

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Gets the stack trace from thread local storage that was saved by the last preallocated exception thrown. This method should be called by a preallocated exception to implement its method of the same name.

Returns

an array of the elements of the stack trace.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] stackTrace)
```

printStackTrace

Signature

```
public void
printStackTrace()
```

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

17.2.2.35 StaticUnsupportedOperationException

---

public class StaticUnsupportedOperationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.UnsupportedOperationException
          StaticUnsupportedOperationException

Interfaces

javax.realtime.StaticThrowable

Description

A version of `UnsupportedOperationException` to be thown by RTSJ methods that does not require allocation.

Since RTSJ 2.0

17.2.2.35.1 Methods

---

get

Signature

```
public static javax.realtime.StaticUnsupportedOperationException
get()
```

Description

Gets the preallocated version of this `Throwable`. Allocation is done in memory that acts like `ImmortalMemory`. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception.

getMessage

Signature

```
public java.lang.String
getMessage()
```

Description

Returns

the message when this was the last method thrown and message was set for it or `null`.

getLocalizedMessage

Signature

```
public java.lang.String
getLocalizedMessage()
```

Description

Returns

the value of `getMessage()`.

initCause(Throwable)

Signature

```
public java.lang.Throwable
initCause(Throwable causingThrowable)
```

Description

Parameters

`causingThrowable`—The reason why this `Throwable` gets thrown.

Throws

`StaticIllegalArgumentException`—when the cause is this `Throwable` itself.

Returns

the reference to this `Throwable`.

getCause

Signature

```
public java.lang.Throwable
getCause()
```

Description

Returns

the cause when this was the last thrown exception and cause was set or `null`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Returns

a reference to this `Throwable`.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] trace)
throws NullPointerException
```

Description

Parameters
`new_stackTrace`—the stack trace to be used as replace.
Throws
`NullPointerException`—when new_stackTrace or any element of new_stackTrace is `null`.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

Returns
An array representing the stack trace when this was the last message thrown or `StaticThrowableStorage.EMPTY_TRACE`, but never `null`.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

Parameters
`stream`—The stream to print to.

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

Parameters
`s`—The PrintWriter to write to.

getSingleton

Signature

```
public javax.realtime.StaticUnsupportedOperationException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.36 ThrowBoundaryError

---

public class ThrowBoundaryError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      StaticError
        ThrowBoundaryError

Interfaces

javax.realtime.StaticThrowable

Description

The error thrown by `MemoryArea.enter(Runnable logic)` when a `Throwable` allocated from memory that is not usable in the surrounding scope tries to propagate out of the scope of the `enter`.

Since RTSJ 2.0 extends StaticError

17.2.2.36.1 Constructors

ThrowBoundaryError

Signature

```
public
ThrowBoundaryError()
```

Description

A constructor for `ThrowBoundaryError`, but application code should use `get()` instead.

17.2.2.36.2 Methods

get

Signature

```
public static javax.realtime.ThrowBoundaryError
get()
```

Description

Gets the preallocated instance of this exception.

Returns

the preallocated instance of this exception.

get(Throwable)

Signature

```
public static javax.realtime.ThrowBoundaryError
get(Throwable cause)
```

Description

Gets the preallocated instance of this exception and set the message and backtace from `cause` and set cause to `cause` as well.

Parameters

`cause`—The throwable that cause the scope boundary error.

Returns

the preallocated instance of this exception.

getSingleton

Signature

```
public javax.realtime.ThrowBoundaryError
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.37 UninitializedStateException

public class UninitializedStateException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          UninitializedStateException

Interfaces

javax.realtime.StaticThrowable

Description

Thrown when a resource is not yet initialized, such as a Clock which cannot be created yet because its data source is not yet available. This can happen when a Java process starts early in the system startup process.

Since RTSJ 2.0

17.2.2.37.1 Methods

---

get

Signature

```
public static javax.realtime.UninitializedStateException
get()
```

Description

Gets the static instance of this class and initializes its stack trace.

Returns

the static singleton of this class.

getSingleton

Signature

```
public javax.realtime.UninitializedStateException
getSingleton()
```

Description

Returns

the singleton version of this exception.

17.2.2.38 UnsupportedPhysicalMemoryException

---

public class UnsupportedPhysicalMemoryException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          UnsupportedPhysicalMemoryException

Interfaces

javax.realtime.StaticThrowable

Description

Thrown when the underlying hardware does not support the type of physical memory requested.

See Section PhysicalMemoryFactory
Since RTSJ 1.0.1 became unchecked
Since RTSJ 2.0 extends StaticRuntimeException

17.2.2.38.1 Constructors

UnsupportedPhysicalMemoryException

Signature

```
public
UnsupportedPhysicalMemoryException()
```

Description

A constructor for `UnsupportedPhysicalMemoryException`, but application code should use `get()` instead.

17.2.2.38.2 Methods

---

get

Signature

```
public static javax.realtime.UnsupportedPhysicalMemoryException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Since RTSJ 2.0

getSingleton

Signature

```
public javax.realtime.UnsupportedPhysicalMemoryException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.2.2.39 UnsupportedRawMemoryRegionException

---

public class UnsupportedRawMemoryRegionException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        StaticRuntimeException
          UnsupportedRawMemoryRegionException

Interfaces
javax.realtime.StaticThrowable

Description

Indicates an invalid raw memory region.

Since RTSJ 2.0

17.2.2.39.1 Methods

---

get

Signature

```
public static javax.realtime.UnsupportedRawMemoryRegionException
get()
```

Description

Obtains the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

getSingleton

Signature

```
public javax.realtime.UnsupportedRawMemoryRegionException
getSingleton()
```

Description

Returns
the singleton version of this exception.

17.3 Rationale

Given the new classes and semantics added to Java by this specification, the need for new exceptions is obvious; however, the need for static exceptions may be less clear. Exceptions, as defined in conventional Java, are heavy weight in that they cause a significant amount of memory to be allocated when created. Every throw requires the creation of an exception with a full backtrace. In scoped memory, this can dramatically increase the size of scopes necessary. Even with determinitic garbage collection, this is quite expensive in execution time. Ideally, one would not need to allocate some much memory and even be able to limit the amount of stack trace captured.

The concept of static exceptions was added to the specification to ameliorate this conflict. Conventional Java classes retain the "allocate on throw" paradigm, but exceptions thrown directly from classes in this specification use either their own exception or a subclass of an existing exception that implements the `StaticThrowable` interface, indicating that their exception information is stored in a preallocated thread local structure. This structure's size can be controlled via the `ConfigurationParameters` (Section 5.3.2.1) class. The stacktrace is captured from the deepest nesting up until there is no room left to store its elements.

This minimizes allocation and limits the amount of copying at throw time while maintaining a high degree of compatibility with conventional Java exception semantics. The difference being in how static exceptions are thrown and in what context their information is valid. Since the main use of the backtrace is for debugging, it seems reasonable to limit the validity of the information to the thread in which it was created.

There is one part of the specification that require special exception support: asynchronous transfer of control (ATC). This requires the addition of an asynchronous

exceptions: `AsynchronouslyInterruptedException`. Almost all conventional Java exceptions are thrown synchronously. The notable exception is the `ThreadDeath` error, which is thrown when `Thread.stop()` is called. The problem with `ThreadDeath` is cleaning up resources. `AsynchronouslyInterruptedException` addresses this by extending `InterruptedException`, so as to be able to break out of I/O exceptions and clean up resources. In addition, ATC only applies to well-defined code blocks giving further control over cleanup.

Appendix A

Bibliography

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Appendix B

Deprecated APIs

Since modules are new in RTSJ 2.0 and this version introduces new ways of handling happening, POSIX signals, and raw memory access, there is no need to include the old API in the RTSJ subsets. Therefore the old classes, including those that have copies in new subpackages, are deprecated and appear only here. Other deprecated methods, constructors, and fields, including those for feasibility analysis, are also here. The feasibility methods are the only ones without replacement, as they where insufficient for admission control, so where of little utility. Only full implementation of the RTSJ should implement them.

B.1 Semantics

Implementations of the deprecated interfaces, classes, constructors, methods, and field given below are optional. In some cases, classes have been moved to a new package. In this case, the class appears here in its old place and in the documentation above in its new place. The deprecated elements are only needed for backward compatibility. They should not be included in implementations that do not include all modules.

B.2 javax.realtime

B.2.1 Interfaces

B.2.1.1 Interruptible

---

public interface Interruptible

Description

`Interruptible` is an interface implemented by classes that will be used as arguments on the methods`doInterruptible()` of `AsynchronouslyInterruptedException` and its subclasses. `doInterruptible()` invokes the implementations of the methods in this interface.

Deprecated in RTSJ 2.0; moved to package `javax.realtime.control`

B.2.1.1.1 Methods

---

run(AsynchronouslyInterruptedException)

Signature

```
public void
run(AsynchronouslyInterruptedException exception)
throws AsynchronouslyInterruptedException
```

Description

The main piece of code that is executed when an implementation is given to `doInterruptible()`. When a class is created that implements this interface, for example through an anonymous inner class, it must include the `throws` clause to make the method interruptible.

Parameters

`exception`—The AIE object whose doInterruptible method is calling the `run` method. Used to invoke methods on `AsynchronouslyInterruptedException` from within the `run()` method.

interruptAction(AsynchronouslyInterruptedException)

Signature

```
public void
interruptAction(AsynchronouslyInterruptedException exception)
```

Description

This method is called by the system when the `run()` method is interrupted. By using this, the program logic can determine when the `run()` method completed normally or had its control asynchronously transferred to its caller.

Parameters

`exception`—The currently pending AIE. Used to invoke methods on `AsynchronouslyInterruptedException` from within the `interruptAction()` method.

run(AsynchronouslyInterruptedException)

Signature

```
public void
run(AsynchronouslyInterruptedException exception)
throws AsynchronouslyInterruptedException
```

interruptAction(AsynchronouslyInterruptedException)

Signature

```
public void
interruptAction(AsynchronouslyInterruptedException exception)
```

B.2.1.2 PhysicalMemoryTypeFilter

---

public interface PhysicalMemoryTypeFilter

Description

Implementation or device providers may include classes that implement `PhysicalMemoryTypeFilter` which allow additional characteristics of memory in devices to be specified. Implementations of `PhysicalMemoryTypeFilter` are intended to be used by the `PhysicalMemoryManager`, not directly from application code.

Deprecated as of RTSJ 2.0

B.2.1.2.1 Methods

---

contains(long, long)

Signature

```
public boolean
contains(long base,
         long size)
```

Description

Queries the system about whether the specified range of memory contains any of this type.

Parameters

`base`—The physical address of the beginning of the memory region.

`size`—The size of the memory region.

Throws

`IllegalArgumentException`—when `base` or `size` is negative.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when the specified range contains ANY of this type of memory.

See Section PhysicalMemoryManager.isRemovable

find(long, long)

Signature

```
public long
find(long base,
     long size)
```

Description

Search for physical memory of the right type.

Parameters

`base`—The physical address at which to start searching.

`size`—The amount of memory to be found.

Throws

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

`IllegalArgumentException`—when `base` or `size` is negative.

Returns

the address where memory was found or -1 when it was not found.

getVMAttributes

Signature

```
public int
getVMAttributes()
```

Description

Gets the virtual memory attributes of `this`. The value of this field is as defined for the POSIX `mmap` function's `prot` parameter for the platform. The meaning of the bits is platform-dependent. POSIX defines constants for PROT_READ, PROT_WRITE, PROT_EXEC, and PROT_NONE.

Returns

the virtual memory attributes as an integer.

getVMFlags

Signature

```
public int
getVMFlags()
```

Description

Gets the virtual memory flags of `this`. The value of this field is as defined for the POSIX `mmap` function's `flags` parameter for the platform. The meaning of the bits is platform-dependent. POSIX defines constants for MAP_SHARED, MAP_PRIVATE, and MAP_FIXED.

Returns

the virtual memory flags as an integer.

initialize(long, long, long)

Signature

```
public void
initialize(long base,
           long vBase,
           long size)
```

Description

When configuration is required for memory to fit the attribute of this object, do the configuration here.

Parameters

`base`—The address of the beginning of the physical memory region.

`vBase`—The address of the beginning of the virtual memory region.

`size`—The size of the memory region.

Throws

`IllegalArgumentException`—when `base` or `size` is negative.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor, or `vBase` plus `size` would exceed the virtual addressing range of the processor.

isPresent(long, long)

Signature

```
public boolean
isPresent(long base,
          long size)
```

Description

Queries the system about the existence of the specified range of physical memory.

Parameters

`base`—The address of the beginning of the memory region.

`size`—The size of the memory region.

Throws

`IllegalArgumentException`—when the base and size do not fall into this type of memory.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when all of the memory is present. `False`, when any of the memory has been removed.

See Section PhysicalMemoryManager.isRemoved

isRemovable

Signature

```
public boolean
isRemovable()
```

Description

Queries the system about the removability of this memory.

Returns

`true`, when this type of memory is removable.

onInsertion(long, long, AsyncEvent)

Signature

```
public void
onInsertion(long base,
            long size,
            AsyncEvent ae)
```

Description

Register the specified `AsyncEvent` to fire when any memory of this type in the range is added to the system.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`ae`—The async event to fire.

Throws

`IllegalArgumentException`—when `ae` is `null`, or when the specified range contains no removable memory of this type. `IllegalArgumentException` may also be thrown when `size` is less than zero.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Since RTSJ 1.0.1

onRemoval(long, long, AsyncEvent)

Signature

```
public void
onRemoval(long base,
          long size,
          AsyncEvent ae)
```

Description

Registers the specified AE to fire when any memory in the range is removed from the system.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`ae`—The async event to register.

Throws

`IllegalArgumentException`—when the specified range contains no removable memory of this type, when `ae` is `null`, or when `size` is less than zero.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Since RTSJ 1.0.1

unregisterInsertionEvent(long, long, AsyncEvent)

Signature

```
public boolean
unregisterInsertionEvent(long base,
                         long size,
                         AsyncEvent ae)
```

Description

Unregisters the specified insertion event. The event is only unregistered when all three arguments match the arguments used to register the event, except that `ae` of `null` matches all values of `ae` and will unregister every `ae` that matches the address range.

Note that this method has no effect on handlers registered directly as async event handlers.

Parameters

`base`—The starting address in physical memory associated with `ae`.

`size`—The size of the memory area associated with `ae`.

`ae`—The event to unregister.

Throws

`IllegalArgumentException`—when `size` is less than 0.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when at least one event matched the pattern, `false` when no such event was found.

Since RTSJ 1.0.1

unregisterRemovalEvent(long, long, AsyncEvent)

Signature

```
public boolean
unregisterRemovalEvent(long base,
                       long size,
                       AsyncEvent ae)
```

Description

Unregisters the specified removal event. The async event is only unregistered when all three arguments match the arguments used to register the event, except that `ae` of `null` matches all values of `ae` and will unregister every `ae` that matches the address range. Note that this method has no effect on handlers registered directly as async event handlers.

Parameters

`base`—The starting address in physical memory associated with `ae`.

`size`—The size of the memory area associated with `ae`.

`ae`—The async event to unregister.

Throws

`IllegalArgumentException`—when `size` is less than 0.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when at least one event matched the pattern, `false` when no such event was found.

Since RTSJ 1.0.1

vFind(long, long)

Signature

```
public long
vFind(long base,
      long size)
```

Description

Searches for virtual memory of the right type. This is important for systems where attributes are associated with particular ranges of virtual memory.

Parameters

`base`—The address at which to start searching.

`size`—The amount of memory to be found.

Throws

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

`IllegalArgumentException`—when `base` or `size` is negative. `IllegalArgumentException` may also be when `base` is an invalid virtual address.

Returns

the address where memory was found or -1 when it was not found.

B.2.1.3 *Schedulable*

---

public interface Schedulable

The following elements of Schedulable are deprecated. The required elements are documented in Section 6.3.1.2 above.

B.2.1.3.1 Methods

---

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public void
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
             MemoryParameters memoryParameters,
             ProcessingGroupParameters group)
```

Description

Sets the scheduler and associated parameter objects. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. See `PriorityScheduler`.

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`group`—A reference to the `ProcessingGroupParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`IllegalThreadStateException`—when `scheduler` prohibits the changing of the scheduler or a parameter at this time due to the state of the schedulable.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Deprecated since RTSJ 2.0

getProcessingGroupParameters

Signature

```
public javax.realtime.ProcessingGroupParameters
getProcessingGroupParameters()
```

Description

Gets a reference to the `ProcessingGroupParameters` object for this schedulable.

Returns

A reference to the current `ProcessingGroupParameters` object.

Deprecated since RTSJ 2.0

setProcessingGroupParameters(ProcessingGroupParameters)

Signature

```
public void
setProcessingGroupParameters(ProcessingGroupParameters group)
```

Description

Sets the `ProcessingGroupParameters` of `this`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

Parameters

`group`—A `ProcessingGroupParameters` object which will take effect as determined by the associated scheduler. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `group` is not compatible with the scheduler for this schedulable object. Also when this schedulable may not use the heap and `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `group` or `group` cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Deprecated since RTSJ 2.0; see `javax.realtime.enforce.ProcessingConstraint`.

setProcessingGroupParametersIfFeasible (ProcessingGroupParameters)

Signature

```
public boolean
setProcessingGroupParametersIfFeasible(ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

addIfFeasible

Signature

```
public boolean
addIfFeasible()
```

Description

This method first performs a feasibility analysis with `this` added to the system. When the resulting system is feasible, informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified. When the analysis shows that the system including `this` would not be feasible, this method does not admit `this` to the feasibility set.

When the object is already included in the feasibility set, does nothing.

Returns

`true` when inclusion of `this` in the feasibility set yields a feasible system, and false otherwise. When `true` is returned then `this` is known to be in the feasibility set. When false is returned, `this` was not added to the feasibility set, but it may already have been present.

Since RTSJ 1.0.1 Promoted to the Schedulable interface
Deprecated as of RTSJ 2.0, because the framework for feasibility analysis is inadequate.

addToFeasibility

Signature

```
public boolean
addToFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, does nothing.

Returns

`true`, when the resulting system is feasible. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate.

removeFromFeasibility

Signature

```
public boolean
removeFromFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should *not* be considered in feasibility analysis until it is further notified.

Returns

`true` when the removal was successful. `false` when the schedulable cannot be removed from the scheduler's feasibility set; e.g., the schedulable is not part of the scheduler's feasibility set.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              MemoryParameters memory)
throws StaticIllegalArgumentException,
       IllegalAssignmentError,
       IllegalThreadStateException
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it

may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Since RTSJ 1.0.1 Promoted to the `Schedulable` interface.
Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
throws StaticIllegalArgumentException,
       IllegalAssignmentError,
       IllegalThreadStateException
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Since RTSJ 1.0.1 Promoted to the `Schedulable` interface.
Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              ProcessingGroupParameters group)
throws StaticIllegalArgumentException,
       IllegalAssignmentError,
       IllegalThreadStateException
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Since RTSJ 1.0.1 Promoted to the `Schedulable` interface.
Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory)
throws StaticIllegalArgumentException,
       IllegalAssignmentError,
       IllegalThreadStateException
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Since RTSJ 1.0.1
Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory,
```

```
ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use . When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Since RTSJ 1.0.1
Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setMemoryParametersIfFeasible(MemoryParameters)

Signature

```
public boolean
setMemoryParametersIfFeasible(MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the memory parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

```
public boolean
setReleaseParametersIfFeasible(ReleaseParameters<?> release)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the release parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate.

setSchedulingParametersIfFeasible(SchedulingParameters)

Signature

```
public boolean
setSchedulingParametersIfFeasible(SchedulingParameters scheduling)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the scheduling parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

B.2.2 Classes

B.2.2.1 *AbsoluteTime*

---

public class AbsoluteTime

The following elements of AbsoluteTime are deprecated. The required elements are documented in Section 9.3.1.1 above.

B.2.2.1.1 Constructors

AbsoluteTime(long, int, Clock)

Signature

```
public
AbsoluteTime(long millis,
             int nanos,
             Clock clock)
throws StaticIllegalArgumentException
```

Description

Superceeded by and equivalent to `AbsoluteTime(long, int, Chronograph)`

Since RTSJ 1.0.1
Deprecated since version 2.0
Parameters

`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.

`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.

`clock`—The clock providing the association for the newly constructed object.

Throws

`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(AbsoluteTime, Clock)

Signature

```
public
AbsoluteTime(AbsoluteTime time,
             Clock clock)
throws StaticIllegalArgumentException
```

Description

Equivalent to `AbsoluteTime(long, int, Chronograph)` with the arguments `time.getMilliseconds(), time.getNanoseconds(), clock()`.

Since RTSJ 1.0.1
Deprecated since version 2.0

Parameters

`time`—The `AbsoluteTime` object which is the source for the copy.

`clock`—The clock providing the association for the newly constructed object.

Throws

`StaticIllegalArgumentException`—when the `time` parameter is `null`.

AbsoluteTime(Date, Clock)

Signature

```
public
AbsoluteTime(Date date,
             Clock clock)
throws StaticIllegalArgumentException
```

Description

Superceeded by and equivalent to `AbsoluteTime(Date, Chronograph)`

Since RTSJ 1.0.1
Deprecated since version 2.0

Parameters

`date`—The `java.util.Date` representation of the time past the Epoch.

`clock`—The clock providing the association for the newly constructed object.

Throws

`StaticIllegalArgumentException`—when the `date` parameter is `null`.

AbsoluteTime(Clock)

Signature

```
public
AbsoluteTime(Clock clock)
```

Description

Superceeded by and equivalent to `AbsoluteTime(Chronograph)`

Since RTSJ 1.0.1
Deprecated since version 2.0
Parameters
`clock`—The clock providing the association for the newly constructed object.

B.2.2.1.2 Methods

---

absolute(Clock)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Clock clock)
```

Description

Superceeded by and equivalent to `absolute(Chronograph)`.

Parameters
`clock`—The `clock` parameter is used only as the new clock association with the result, since no conversion is needed.
Returns
the copy of `this` in a newly allocated `AbsoluteTime` object, associated with the `clock` parameter.

Deprecated since version 2.0

absolute(Clock, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Clock clock,
         AbsoluteTime dest)
```

Description

Superceeded by and equivalent to `absolute(Chronograph, AbsoluteTime)`.

Parameters
`clock`—The `clock` parameter is used only as the new clock association with the result, since no conversion is needed.
`dest`—When `dest` is not `null`, the result is placed in it and returned.

Returns
the copy of `this` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. It is associated with the `clock` parameter.

Deprecated since version 2.0

relative(Clock)

Signature

```
public javax.realtime.RelativeTime
relative(Clock clock)
throws ArithmeticException
```

Description

Superceeded by and equivalent to `relative(Chronograph)`.

Parameters
`clock`—The instance of `Clock` used to convert the time of `this` into relative time, and the new clock association for the result.
Throws
`ArithmeticException`—when the result does not fit in the normalized format.

Returns
the `RelativeTime` conversion in a newly allocated object, associated with the `clock` parameter.

Deprecated since version 2.0

relative(Clock, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
relative(Clock clock,
         RelativeTime dest)
throws ArithmeticException
```

Description

Superceeded by and equivalent to `relative(Chronograph, RelativeTime)`.

Parameters
`clock`—The instance of `Clock` used to convert the time of `this` into relative time, and the new clock association for the result.
`dest`—When `dest` is not `null`, the result is placed in it and returned.
Throws
`ArithmeticException`—when the result does not fit in the normalized format.

Returns
the `RelativeTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. It is associated with the `clock` parameter.

Deprecated since version 2.0

B.2.2.2 *AperiodicParameters*

public class AperiodicParameters

The following elements of AperiodicParameters are deprecated. The required elements are documented in Section 6.3.3.2 above.

B.2.2.2.1 Fields

arrivalTimeQueueOverflowExcept
`public static final java.lang.String arrivalTimeQueueOverflowExcept`

Description

Represents the "EXCEPT" policy for dealing with arrival time queue overflow. Under this policy, when an arrival occurs and its time should be queued but the queue already holds a number of times equal to the initial queue length defined by `this` then the `fire()` method shall throw a `ArrivalTimeQueueOverflowException`. Any other associated semantics are governed by the schedulers for the schedulables using these aperiodic parameters. When the arrival is a result of a happening to which the instance of `AsyncEventHandler` is bound then the arrival time is ignored.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0

arrivalTimeQueueOverflowIgnore
`public static final java.lang.String arrivalTimeQueueOverflowIgnore`

Description

Represents the "IGNORE" policy for dealing with arrival time queue overflow. Under this policy, when an arrival occurs and its time should be queued, but the queue already holds a number of times equal to the initial queue length defined by `this` then the arrival is ignored. Any other associated semantics are governed by the schedulers for the schedulables using these aperiodic parameters.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0

arrivalTimeQueueOverflowReplace
`public static final java.lang.String arrivalTimeQueueOverflowReplace`

Description

Represents the "REPLACE" policy for dealing with arrival time queue overflow. Under this policy, when an arrival occurs and should be queued but the queue already holds a number of times equal to the initial queue length defined by `this` then the information for this arrival replaces a previous arrival. Any other associated semantics are governed by the schedulers for the schedulables using these aperiodic parameters.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0

arrivalTimeQueueOverflowSave
```
public static final java.lang.String arrivalTimeQueueOverflowSave
```

Description

Represents the "SAVE" policy for dealing with arrival time queue overflow. Under this policy, when an arrival occurs and should be queued but the queue is full, then the queue is lengthened and the arrival time is saved. Any other associated semantics are governed by the schedulers for the schedulables using these aperiodic parameters.

This policy does not update the "initial queue length;" it alters the actual queue length. Since the `SAVE` policy grows the arrival time queue as necessary for the `SAVE` policy, the initial queue length is only an optimization.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0

B.2.2.2.2 Methods

---

getInitialArrivalTimeQueueLength

Signature
```
public int
getInitialArrivalTimeQueueLength()
```

Description

Gets the initial number of elements the arrival time queue can hold. This returns the initial queue length currently associated with this parameter object. When the overflow policy is `SAVE` the initial queue length may not be related to the current queue lengths of schedulables associated with this parameter object.

Returns
The initial length of the queue.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0 replaced by `ReleaseParameters.getInitialQueueLength()`.

setInitialArrivalTimeQueueLength(int)

Signature

```
public void
setInitialArrivalTimeQueueLength(int initial)
```

Description

Sets the initial number of elements the arrival time queue can hold without lengthening the queue. The initial length of an arrival queue is set when the schedulable using the queue is constructed, after that time changes in the initial queue length are ignored.

Parameters

`initial`—The initial length of the queue.

Throws

`StaticIllegalArgumentException`—when `initial` is less than zero.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated since RTSJ 2.0 replaced by `ReleaseParameters.setInitialQueueLength(int initial)`.

getArrivalTimeQueueOverflowBehavior

Signature

```
public java.lang.String
getArrivalTimeQueueOverflowBehavior()
```

Description

Gets the behavior of the arrival time queue in the event of an overflow.

Returns

The behavior of the arrival time queue as a string.

Since RTSJ 1.0.1 Moved from `SporadicParameters`
Deprecated since RTSJ 2.0 and replaced by `ReleaseParameters.getEventQueueOverflowPolicy`

setArrivalTimeQueueOverflowBehavior(String)

Signature

```
public void
setArrivalTimeQueueOverflowBehavior(String behavior)
```

Description

Sets the behavior of the arrival time queue for the case where the insertion of a new element makes the queue size greater than the initial size given when `this` object was constructed.

Values of `behavior` are compared using reference equality (==) not value equality (`equals()`).

Parameters

`behavior`—A string representing the behavior.

Throws

`StaticIllegalArgumentException`—when `behavior` is not one of the `final` queue overflow behavior values defined in this class.

Since RTSJ 1.0.1 Moved here from `SporadicParameters`.
Deprecated Since RTSJ 2.0

setIfFeasible(RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime cost,
              RelativeTime deadline)
```

Description

This method first performs a feasibility analysis using the new cost and deadline as replacements for the matching attributes of this. When the resulting system is feasible, the method replaces the current scheduling characteristics of `this` with the new scheduling characteristics.

Parameters

`cost`—The proposed cost used to determine when any particular object exceeds cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The proposed deadline. When `null`, the default value is a new instance of `RelativeTime(Long.MAX_VALUE, 999999)`.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the time value of `deadline` is less than or equal to zero, or the values are incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

`IllegalAssignmentError`—when `cost` or `deadline` cannot be stored in `this`.

Returns

`false`. Aperiodic parameters never yield a feasible system. (Subclasses of `AperiodicParameters`, such as `SporadicParameters`, need not return false.)

Deprecated as of RTSJ 2.0

B.2.2.3 *ArrivalTimeQueueOverflowException*

---

public class ArrivalTimeQueueOverflowException

The following elements of ArrivalTimeQueueOverflowException are deprecated. The required elements are documented in Section 17.2.2.2 above.

B.2.2.3.1 Constructors

ArrivalTimeQueueOverflowException(String)

Signature

```
public
ArrivalTimeQueueOverflowException(String description)
```

Description

A descriptive constructor for `ArrivalTimeQueueOverflowException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—A description of the exception.

B.2.2.4 *AsyncEvent*

public class AsyncEvent

The following elements of AsyncEvent are deprecated. The required elements are documented in Section 8.3.2.4 above.

B.2.2.4.1 Methods

handledBy(AsyncEventHandler)

Signature

```
public boolean
handledBy(AsyncEventHandler handler)
```

Description

Determines whether or not the handler given as the parameter is associated with `this`.

Parameters

`handler`—The handler to be tested to determine its association with `this`.

Returns

`true` when the parameter is associated with `this`. `false` when `handler` is `null` or the parameters is not associated with `this`.

Deprecated since RTSJ 2.0, replaced by `AsyncBaseEvent.handledBy(AsyncBaseEventHandler)`

addHandler(AsyncEventHandler)

Signature

```
public void
addHandler(AsyncEventHandler handler)
```

Description

Adds a handler to the set of handlers associated with this event. An instance of `AsyncBaseEvent` may have more than one associated handler. However, adding a handler to an event has no effect when the handler is already attached to the event.

The execution of this method is atomic with respect to the execution of the `fire()` method.

Note that there is an implicit reference to the handler stored in `this`. The assignment must be valid under any applicable memory assignment rules.

Parameters

`handler`—The new handler to add to the list of handlers already associated with this. When `handler` is already associated with the event, the call has no effect.

Throws

`StaticIllegalArgumentException`—when `handler` is `null` or the handler has `PeriodicParameters`. Only the subclass `PeriodicTimer` is allowed to have handlers with `PeriodicParameters`.

`IllegalAssignmentError`—when this `AsyncEvent` cannot hold a reference to `handler`.

`StaticIllegalStateException`—when the configured `Scheduler` and `SchedulingParameters` for `handler` are not compatible with one another.

`ScopedCycleException`—when `handler` has an explicit initial scoped memory area that has already been entered from a memory area other than the area where `handler` was allocated.

Deprecated since RTSJ 2.0, replaced by `AsyncBaseEvent.addHandler(AsyncBaseEventHandler)`

setHandler(AsyncEventHandler)

Signature

```
public void
setHandler(AsyncEventHandler handler)
```

Description

Replaced by `AsyncBaseEvent.setHandler(AsyncBaseEventHandler)`

Parameters

`handler`—For becoming the sole handler for `this`.

Deprecated since RTSJ 2.0

removeHandler(AsyncEventHandler)

Signature

```
public void
removeHandler(AsyncEventHandler handler)
```

Description

Replaced by `AsyncBaseEvent.removeHandler(AsyncBaseEventHandler)`

Parameters

`handler`—For removal.

Deprecated since RTSJ 2.0

bindTo(String)

Signature

```
public void
bindTo(String happening)
```

Description

Binds this to an external event, a *happening*. The meaningful values of `happening` are implementation dependent. This instance of `AsyncEvent` is considered to have occurred whenever the happening is triggered. More than one happening can be bound to the same `AsyncEvent`. However, binding a happening to an event has no effect when the happening is already bound to the event.

When an event, which is declared in a scoped memory area, is bound to an external happening, the reference count of that scoped memory area is incremented (as if there is an external realtime thread accessing the area). The reference count is decremented when the event is unbound from the happening.

Parameters

`happening`—An implementation-dependent value that binds this instance of `AsyncEvent` to a happening.

Throws

`UnknownHappeningException`—when the String value is not supported by the implementation.

`StaticIllegalArgumentException`—when `happening` is `null`.

Deprecated since RTSJ 2.0

unbindTo(String)

Signature

```
public void
unbindTo(String happening)
```

Description

Removes a binding to an external event, a *happening*. The meaningful values of `happening` are implementation dependent. When the associated event is declared in a scoped memory area, the reference count for the memory area is decremented.

Parameters

`happening`—An implementation-dependent value representing some external event to which this instance of `AsyncEvent` is bound.

Throws

`UnknownHappeningException`—when this instance of `AsyncEvent` is not bound to the given `happening` or the given `happening` is not supported by the implementation.

`StaticIllegalArgumentException`—when `happening` is `null`.

Deprecated since RTSJ 2.0

B.2.2.5 *AsyncEventHandler*

---

public class AsyncEventHandler

The following elements of AsyncEventHandler are deprecated. The required elements are documented in Section 8.3.2.5 above.

B.2.2.5.1 Constructors

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  ProcessingGroupParameters pgp,
                  boolean nonheap,
                  Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)` with arguments `(scheduling, release, memory, area, pgp, nonheap, logic)`.

Deprecated in version 2.0.

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  ProcessingGroupParameters pgp,
                  Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)` with arguments `(scheduling, release, memory, area, pgp, false, logic)`.

Deprecated in version 2.0.

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  ProcessingGroupParameters pgp,
                  boolean nonheap)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean Runnable)` with arguments `(scheduling, release, memory, area, null, false, null)`.

Deprecated in version 2.0.

AsyncEventHandler(boolean, Runnable)

Signature

```
public
AsyncEventHandler(boolean nonheap,
                  Runnable logic)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)` with arguments `(null, null, null, null, null, nonheap, logic)`.

Deprecated in version 2.0.

AsyncEventHandler(boolean)

Signature

```
public
AsyncEventHandler(boolean nonheap)
```

Description

Calling this constructor is equivalent to calling `AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)` with arguments `(null, null, null, null, null, nonheap, null)`.

Deprecated in version 2.0.

B.2.2.5.2 Methods

---

getAndIncrementPendingFireCount

Signature

```
protected int
getAndIncrementPendingFireCount()
```

Description

This is an accessor method for `fireCount`. This method atomically increments, by one, the value of `fireCount` and returns the value from before the increment.

Calling this method is effectively the same as firing an event that is associated with this handler. When called from outside the handler's control flow, call it is effectively the same as firing an event that is associated with this handler, *except that it does not constitute a release event.*

Throws

`MITViolationException`—when this AEH is controlled by sporadic scheduling parameters under the base scheduler, the parameters specify the `mitViolationExcept` policy, and this method would introduce a release that would violate the specified minimum interarrival time.

`ArrivalTimeQueueOverflowException`—when this AEH is controlled by aperiodic scheduling parameters under the base scheduler, the release parameters specify the `arrivalTimeQueueOverflowExcept` policy, and this method would cause the arrival time queue to overflow.

Returns

the value held by `fireCount` prior to incrementing it by one.

Deprecated as of RTSJ 2.0 Use ae.fire()

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public void
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
             MemoryParameters memoryParameters,
             ProcessingGroupParameters pgp)
```

Description

Sets the scheduler and associated parameter objects. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. See `PriorityScheduler`.

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`pgp`—null

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Deprecated since RTSJ 2.0

getProcessingGroupParameters

Signature

```
public javax.realtime.ProcessingGroupParameters
getProcessingGroupParameters()
```

Description

Gets a reference to the `ProcessingGroupParameters` object for this schedulable.

Returns

A reference to the current `ProcessingGroupParameters` object.

Deprecated since RTSJ 2.0

setProcessingGroupParameters(ProcessingGroupParameters)

Signature

```
public void
setProcessingGroupParameters(ProcessingGroupParameters pgp)
```

Description

Sets the `ProcessingGroupParameters` of `this`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

Parameters

`pgp`—null

Throws

`StaticIllegalArgumentException`—when `group` is not compatible with the scheduler for this schedulable object. Also when this schedulable may not use the heap and `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `group` or `group` cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Deprecated since RTSJ 2.0

addToFeasibility

Signature

```
public boolean
addToFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, does nothing.

Returns

`true`, when the resulting system is feasible. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

addIfFeasible

Signature

```
public boolean
addIfFeasible()
```

Description

This method first performs a feasibility analysis with `this` added to the system. When the resulting system is feasible, informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified. When the analysis shows that the system including `this` would not be feasible, this method does not admit `this` to the feasibility set.

When the object is already included in the feasibility set, does nothing.

Returns

`true` when inclusion of `this` in the feasibility set yields a feasible system, and false otherwise. When `true` is returned then `this` is known to be in the feasibility set. When false is returned, `this` was not added to the feasibility set, but it may already have been present.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

removeFromFeasibility

Signature

```
public boolean
removeFromFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should *not* be considered in feasibility analysis until it is further notified.

Returns

`true` when the removal was successful. `false` when the schedulable cannot be removed from the scheduler's feasibility set; e.g., the schedulable is not part of the scheduler's feasibility set.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
```

```
ReleaseParameters<?> release,
MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
```

```
                MemoryParameters memory,
                ProcessingGroupParameters pgp)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`pgp`—null

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory,
```

```
ProcessingGroupParameters pgp)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use . When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`pgp`—null

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

```
public boolean
setReleaseParametersIfFeasible(ReleaseParameters<?> release)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the release parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setProcessingGroupParametersIfFeasible (ProcessingGroupParameters)

Signature

```
public boolean
setProcessingGroupParametersIfFeasible(ProcessingGroupParameters pgp)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`pgp`—null

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate.

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              ProcessingGroupParameters pgp)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`pgp`—null

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setMemoryParametersIfFeasible(MemoryParameters)

Signature

```
public boolean
setMemoryParametersIfFeasible(MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the memory parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setSchedulingParametersIfFeasible(SchedulingParameters)

Signature

```
public boolean
setSchedulingParametersIfFeasible(SchedulingParameters scheduling)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the scheduling parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

B.2.2.6 AsynchronouslyInterruptedException

---

public class AsynchronouslyInterruptedException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.InterruptedException
        control.AsynchronouslyInterruptedException
          AsynchronouslyInterruptedException

Description

A special exception that is thrown in response to an attempt to asynchronously transfer the locus of control of a schedulable.

A `Schedulable` that is executing a method or constructor, which is declared with an `AsynchronouslyInterruptedException` in its `throws` clause, can be asynchronously interrupted except when it is executing in the lexical scope of a synchronized statement within that method/constructor. As soon as the `Schedulable` object leaves the lexical scope of the method by calling another method/constructor it may be asynchronously interrupted when the called method/constructor is asynchronously interruptible. (See this chapter's introduction section for the detailed semantics).

The asynchronous interrupt is generated for a `Schedulable`, `s`, when the `s.interrupt()` method is called or the `fire` method is called of an AIE for which `s` has a `doInterruptible` method call in progress.

When an asynchronous interrupt is generated when the target `Schedulable` is executing within an ATC-deferred section, the asynchronous interrupt becomes pending. A pending asynchronous interrupt is delivered when the target `Schedulable` next attempts to enter asynchronously interruptible code.

Asynchronous transfers of control (ATCs) are intended to allow long-running computations to be terminated without the overhead or latency of polling with `java.lang.Thread.interrupted()`.

When `Schedulable.interrupt`, or `AsynchronouslyInterruptedException.fire()` is called, the `AsynchronouslyInterruptedException` is compared against any currently pending `AsynchronouslyInterruptedException` on the `Schedulable`. When there is none, or when the depth of the `AsynchronouslyInterruptedException` is less than the currently pending `AsynchronouslyInterruptedException`; (i.e., it is targeted at a less deeply nested method call), the new `AsynchronouslyInterruptedException` becomes the currently pending `AsynchronouslyInterruptedException` and the previously pending `AsynchronouslyInterruptedException` is discarded. Otherwise, the new `AsynchronouslyInterruptedException` is discarded.

When an `AsynchronouslyInterruptedException` is caught, the catch clause may invoke the `clear()` method on the `AsynchronouslyInterruptedException` in which it is interested to see if the exception matches the pending `AsynchronouslyInterruptedException`. When so, the pending `AsynchronouslyInterruptedException` is cleared for the `Schedulable` and `clear` returns true. Otherwise, the current AIE remains pending and `clear` returns `false`.

`Schedulable.interrupt()` generates the generic `AsynchronouslyInterruptedException` which will always propagate outward through interruptible methods until the generic `AsynchronouslyInterruptedException` is identified and

handled. The pending state of the generic AIE is per-instance of `Schedulable`.

Other sources (e.g., `AsynchronouslyInterruptedException.fire()` and `Timed`) will generate specific instances of `AsynchronouslyInterruptedException` which applications can identify and thus limit propagation.

Deprecated in RTSJ 2.0; moved to package `javax.realtime.control`

B.2.2.6.1 Constructors

AsynchronouslyInterruptedException

Signature

```
public
AsynchronouslyInterruptedException()
```

Description

Creates an instance of `AsynchronouslyInterruptedException`.

AsynchronouslyInterruptedException(String)

Signature

```
public
AsynchronouslyInterruptedException(String message)
```

Description

Creates an instance of `AsynchronouslyInterruptedException`.

Parameters

`message`—A message to identify this instance.

B.2.2.6.2 Methods

---

getGeneric

Signature

```
public static javax.realtime.AsynchronouslyInterruptedException
getGeneric()
throws IllegalTaskStateException
```

Description

Gets the singleton system generic `AsynchronouslyInterruptedException` that is generated when `Schedulable.interrupt()` is invoked.

Throws

`IllegalTaskStateException`—when the current thread context is not an instance of `Schedulable`.

Returns
the generic `AsynchronouslyInterruptedException`.

enable

Signature

```
public boolean
enable()
```

Description

Enables the throwing of this exception. This method is valid only when the caller has a call to `doInterruptible` in progress. When invoked when no call to `doInterruptible` is in progress, `enable` returns `false` and does nothing.

Returns
`true`, when `this` was disabled before the method was called and the call was invoked whilst the associated `doInterruptible` was in progress, and `false` otherwise.

disable

Signature

```
public synchronized boolean
disable()
```

Description

Disables the throwing of this exception. When the `fire` method is called on `this` AIE whilst it is disabled, the fire is held pending and delivered as soon as the AIE is enabled and the interruptible code is within an AI-method. When an AIE is pending when the associated disable method is called, the AIE remains pending, and is delivered as soon as the AIE is enabled and the interruptible code is within an AI-method.

This method is valid only when the caller has a call to `doInterruptible` in progress. If invoked when no call to `doInterruptible` is in progress, `disable` returns `false` and does nothing.

Returns
`true`, when `this` was enabled before the method was called and the call was invoked with the associated `doInterruptible` in progress, and `false` otherwise.

isEnabled

Signature

```
public boolean
isEnabled()
```

Description

Queries the enabled status of this exception.

This method is valid only when the caller has a call to `doInterruptible` in progress. If invoked when no call to `doInterruptible` is in progress, `enable` returns `false` and does nothing.

Returns

`true`, when this is enabled and the method call was invoked in the context of the associated `doInterruptible`, and `false` otherwise.

fire

Signature

```
public boolean
fire()
```

Description

Generates this exception when its `doInterruptible` has been invoked and not completed. When `this` is the only outstanding AIE on the `schedulable` object that invoked this AIE's `doInterruptible(Interruptible)` method, this AIE becomes that `schedulable`'s current AIE. Otherwise, it only becomes the current AIE when it is at a less deep level of nesting compared with the current outstanding AIE.

Behaves as if `Thread.interrupt()` were called on the task currently operating within this exception's `doInterruptible`.

Returns

`true`, when `this` is not disabled and it has an invocation of a `doInterruptible` in progress and there is no outstanding fire request, and `false` otherwise.

doInterruptible(Interruptible)

Signature

```
public boolean
doInterruptible(Interruptible logic)
```

Description

Executes the `run()` method of the given `Interruptible`. This method may be on the stack in exactly one `Schedulable` object. An attempt to invoke this method in a `schedulable` while it is on the stack of another or the same `schedulable` will cause an immediate return with a value of `false`.

The `run()` method of the given `Interruptible` is always entered with the exception in the enabled state, but that state can be modified with `enable()` and `disable()`, and the state can be observed with `isEnabled()`.

This AIE is cleared on return from `doInterruptible`.

Parameters

`logic`—An instance of an `Interruptible` whose `run()` method will be called.

Throws

`IllegalTaskStateException`—when called on the generic `AsynchronouslyInterruptedException`.

`StaticIllegalArgumentException`—when `logic` is `null`.

Returns

`true`, when the method call completed normally, and `false`, when another call to `doInterruptible` has not completed.

Since RTSJ 2.0 nolonger throws an exception when called from a Java thread.

clear

Signature

```
public boolean
clear()
```

Description

Atomically checks whether or not `this` is pending on the currently executing `schedulable`, and when so, makes it non-pending.

This method may be called at any time, and in particular need not be called in a `try` or `catch` block.

Returns

`true`, when `this` was pending, and `false`, when `this` was not pending.

Since RTSJ 1.0.1
Since RTSJ 2.0 no longer throws an exception when called from a task that is not an instance of `Schedulable`.

fillInStackTrace

Signature

```
public java.lang.Throwable
fillInStackTrace()
```

Description

Does nothing, since no stacktrace is kept.

Returns

`this` instance.

setStackTrace(StackTraceElement)

Signature

```
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException
```

Description

Does nothing, since no stacktrace is kept.

getStackTrace

Signature

```
public java.lang.StackTraceElement[]
getStackTrace()
```

Description

No stacktrace is kept, so none can be returned.

Returns

an empty array.

printStackTrace

Signature

```
public void
printStackTrace()
```

Description

No stacktrace is kept, so a message to that effect is printed.

printStackTrace(PrintStream)

Signature

```
public void
printStackTrace(PrintStream stream)
```

Description

No stacktrace is kept, so a message to that effect is printed.

Parameters

`stream`—A `PrintStream` for printing

printStackTrace(PrintWriter)

Signature

```
public void
printStackTrace(PrintWriter writer)
```

Description

No stacktrace is kept, so a message to that effect is printed.

Parameters

`writer`—A `PrintWriter` for printing

B.2.2.7 *BoundAsyncEventHandler*

public class BoundAsyncEventHandler

The following elements of BoundAsyncEventHandler are deprecated. The required elements are documented in Section 8.3.2.10 above.

B.2.2.7.1 Constructors

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       ReleaseParameters<?> release,
                       MemoryParameters memory,
                       MemoryArea area,
                       ProcessingGroupParameters group,
                       boolean nonheap,
                       Runnable logic)
```

Description

Creates an instance of `BoundAsyncEventHandler` with the specified parameters.

Deprecated since RTSJ 2.0, replaced by `BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, RealtimeThreadGroup, ConfigurationParameters, Runnable)`

Parameters

`scheduling`—A `SchedulingParameters` object which will be associated with the constructed instance. When `null`, and the creator is not an instance of `Schedulable`, a `SchedulingParameters` object is created which has the default `SchedulingParameters` for the scheduler associated with the current thread. When `null`, and the creator is an instance of `Schedulable`, the `SchedulingParameters` are inherited from the current schedulable (a new `SchedulingParameters` object is cloned). When `null` or when the affinity is not defined in this parameter, then this object will inherits from the creating task's Affinity at execution of the handler. However, this default Affinity will not appear when calling `AsyncBaseEventHandler.getSchedulingParameters()`, that will only return SchedulingParameters containing the affinity that was explicitly set.

`release`—A `ReleaseParameters` object which will be associated with the constructed instance. When `null`, `this` will have default `ReleaseParameters` for the BAEH's scheduler.

`memory`—A `MemoryParameters` object which will be associated with the constructed instance. When `null`, `this` will have no `MemoryParameters`.

`area`—The `MemoryArea` for `this`. When `null`, the memory area will be that of the current thread/schedulable.

`group`—A `ProcessingGroupParameters` object which will be associated with the constructed instance. When `null`, `this` will not be associated with any processing group.

`logic`—The `Runnable` object whose `run()` method is executed by `AsyncEventHandler.handleAsyncEvent()`. When `null`, the default `handleAsyncEvent()` method invokes nothing.

`nonheap`—When `true`, the code executed by this handler may not reference or store objects in `HeapMemory`; otherwise, that code may do so. When `true` and the current handler tries to reference or store objects in `HeapMemory` or enter the `HeapMemory` an `StaticIllegalArgumentException` is thrown.

Throws

`StaticIllegalArgumentException`—when `nonheap` is `false` and `logic`, any parameter object, or `this` is in heap memory. Also when `nonheap` is `true` and `area` is heap memory.

`IllegalAssignmentError`—when the new `AsyncEventHandler` instance cannot hold a reference to non-null values of `scheduling release memory` and `group`, or when those parameters cannot hold a reference to the new `AsyncEventHandler`. Also when the new `AsyncEventHandler` instance cannot hold a reference to non-null values of `area` and `logic`.

B.2.2.8 DuplicateFilterException

---

public class DuplicateFilterException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      DuplicateFilterException

Description

`PhysicalMemoryManager` can only accommodate one filter object for each type of memory. It throws this exception when an attempt is made to register more than one filter for a type of memory.

Deprecated since RTSJ 2.0

B.2.2.8.1 Constructors

DuplicateFilterException(String)

Signature

```
public
DuplicateFilterException(String description)
```

Description

A descriptive constructor for `DuplicateFilterException`.

Parameters

`description`—Description of the error.

DuplicateFilterException

Signature

```
public
DuplicateFilterException()
```

Description

A constructor for `DuplicateFilterException`.

B.2.2.9 *HighResolutionTime*

---

public abstract class HighResolutionTime<T extends HighResolutionTime<T>>

The following elements of HighResolutionTime are deprecated. The required elements are documented in Section 9.3.1.2 above.

B.2.2.9.1 Methods

---

absolute(Clock, AbsoluteTime)

Signature

```
public abstract javax.realtime.AbsoluteTime
absolute(Clock clock,
         AbsoluteTime dest)
```

Description

Equivalent to and superseded by `absolute(Chronograph, AbsoluteTime)`. When `dest` is not `null`, the result is placed in it and returned. Otherwise, a new object is allocated for the result. The clock association of the result is the `clock` passed as a parameter. See the subclass comments for more specific information.

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into absolute time, and the new clock association for the result.

`dest`—when `dest` is not `null`, the result is placed it and returned.

Returns

The `AbsoluteTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. It is associated with the `clock` parameter.

Deprecated since version 2.0

absolute(Clock)

Signature

```
public abstract javax.realtime.AbsoluteTime
absolute(Clock clock)
```

Description

Equivalent to and superseded by `absolute(Chronograph)`.

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into absolute time, and the new clock association for the result.

Returns

the `AbsoluteTime` conversion in a newly allocated object, associated with the `clock` parameter.

Deprecated since version 2.0

relative(Clock, RelativeTime)

Signature

```
public abstract javax.realtime.RelativeTime
relative(Clock clock,
         RelativeTime dest)
```

Description

Equivalent to and superseded by `relative(Chronograph, RelativeTime)`

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into relative time, and the new clock association for the result.

`dest`—When `dest` is not `null`, the result is placed in it and returned.

Returns

the `RelativeTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object.

Deprecated since version 2.0

relative(Clock)

Signature

```
public abstract javax.realtime.RelativeTime
relative(Clock clock)
```

Description

Equivalent to and superseded by `relative(Chronograph)`

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into relative time, and the new clock association for the result.

Returns

the `RelativeTime` conversion in a newly allocated object, associated with the `clock` parameter.

Deprecated since version 2.0

B.2.2.10 *IllegalAssignmentError*

---

public class IllegalAssignmentError

The following elements of IllegalAssignmentError are deprecated. The required elements are documented in Section 17.2.2.8 above.

B.2.2.10.1 Constructors

IllegalAssignmentError(String)

Signature

```
public
IllegalAssignmentError(String description)
```

Description

A descriptive constructor for `IllegalAssignmentError`.

Deprecated since RTSJ 2.0; application code should use `get()` instead, e.g., `IllegalAssignmentError.get().init(description)`.

Parameters

`description`—The reason for throwing the error.

B.2.2.11 ImmortalPhysicalMemory

---

public class ImmortalPhysicalMemory

Inheritance

java.lang.Object
  MemoryArea
    PerennialMemory
      ImmortalPhysicalMemory

Description

An instance of `ImmortalPhysicalMemory` allows objects to be allocated from a range of physical memory with particular attributes, determined by their memory type. This memory area has the same restrictive set of assignment rules as `ImmortalMemory` memory areas, and may be used in any execution context where `ImmortalMemory` is appropriate.

No provision is made for sharing object in `ImmortalPhysicalMemory` with entities outside the JVM that creates them, and, while the memory backing an instance of `ImmortalPhysicalMemory` could be shared by multiple JVMs, the class does not support such sharing.

Methods from `ImmortalPhysicalMemory` should be overridden only by methods that use `super`.

Since RTSJ 2.0 extends `PerennialMemory` instead of `MemoryArea` directly.
Deprecated since RTSJ 2.0

B.2.2.11.1 Constructors

ImmortalPhysicalMemory(Object, long, long, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       long size,
                       Runnable logic)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`SizeOutOfBoundsException`—when `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is negative. `IllegalArgumentException` may also be when `base` plus `size` would be greater than the maximum physical address supported by the processor.

`MemoryInUseException`—when the specified memory is already in use.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

ImmortalPhysicalMemory(Object, long, SizeEstimator, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       SizeEstimator size,
                       Runnable logic)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`SizeOutOfBoundsException`—when the size estimate from `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative. `IllegalArgumentException` may also be when `base` plus the size indicated by `size` would be greater than the maximum physical address supported by the processor.

`MemoryInUseException`—when the specified memory is already in use.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for the backing memory.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

ImmortalPhysicalMemory(Object, long, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long size,
                       Runnable logic)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`IllegalArgumentException`—when `size` is negative.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

ImmortalPhysicalMemory(Object, SizeEstimator, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       SizeEstimator size,
                       Runnable logic)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`MemoryTypeConflictException`—when `type` specifies incompatible memory attributes.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

ImmortalPhysicalMemory(Object, long, long)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       long size)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`SizeOutOfBoundsException`—when the `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is less than zero. `IllegalArgumentException` may also be when `base` plus `size` would be greater than the maximum physical address supported by the processor.

`MemoryInUseException`—when the specified memory is already in use.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or or for its allocation area in its backing store.

ImmortalPhysicalMemory(Object, long, SizeEstimator)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       SizeEstimator size)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`SizeOutOfBoundsException`—when the size estimate from `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative. `IllegalArgumentException` may also be when `base` plus the size indicated by `size` would be greater than the maximum physical address supported by the processor.

`MemoryInUseException`—when the specified memory is already in use.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

ImmortalPhysicalMemory(Object, long)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long size)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

`SizeOutOfBoundsException`—when the `size` extends into an invalid range of memory.

ImmortalPhysicalMemory(Object, SizeEstimator)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       SizeEstimator size)
```

Description

Creates an instance with the given parameters.

Parameters

`type`—An instance of `Object` or an array of objects representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the size estimate from `size` extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ImmortalPhysicalMemory` object or for its allocation area in its backing store.

B.2.2.12 ImportanceParameters

---

public class ImportanceParameters

Inheritance

java.lang.Object
  SchedulingParameters
    PriorityParameters
      ImportanceParameters

Description

Importance is an additional scheduling metric that may be used by some priority-based scheduling algorithms during overload conditions to differentiate execution order among threads of the same priority.

In some realtime systems an external physical process determines the period of many threads. When rate-monotonic priority assignment is used to assign priorities, many of the threads in the system may have the same priority because their periods are the same. However, it is conceivable that some threads may be more important than others and in an overload situation importance can help the scheduler decide which threads to execute first. The base scheduling algorithm represented by `PriorityScheduler` must not consider importance.

Deprecated since RTSJ 2.0

B.2.2.12.1 Constructors

ImportanceParameters(int, int)

Signature

```
public
ImportanceParameters(int priority,
                     int importance)
```

Description

Creates an instance of `ImportanceParameters`.

Parameters

`priority`—The priority value assigned to schedulables that use this parameter instance. This value is used in place of the value passed to `Thread.setPriority`.

`importance`—The importance value assigned to schedulable objects that use this parameter instance.

B.2.2.12.2 Methods

---

getImportance

Signature

```
public int
getImportance()
```

Description

Gets the importance value.

Returns

the value of importance for the associated instances of `Schedulable`.

setImportance(int)

Signature

```
public void
setImportance(int importance)
```

Description

Sets the importance value. When this parameter object is associated with any schedulable, either by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setSchedulingParameters(SchedulingParameters)`, the importance of those schedulables is altered at a moment controlled by the schedulers for the respective schedulables.

Parameters

`importance`—The value to which importance is set.

Throws

`StaticIllegalArgumentException`—when the given importance value is incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

toString

Signature

```
public java.lang.String
toString()
```

Description

Prints the value of the priority and importance values of the associated instance of `Schedulable`

B.2.2.13 LTMemory

---

public class LTMemory

Inheritance

java.lang.Object
  MemoryArea
    ScopedMemory
      LTMemory

Description

Equivalent to and superseded by `javax.realtime.memory.LTMemory`.

Deprecated since RTSJ 2.0; moved to package `javax.realtime.memory`.

B.2.2.13.1 Constructors

LTMemory(long, long, Runnable)

Signature

```
public
LTMemory(long initial,
         long maximum,
         Runnable logic)
```

Description

Creates an `LTMemory` of the given size.

Parameters

`initial`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

`maximum`—The size in bytes of the memory to allocate for this area.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(long initial, long maximum)`.

Throws

`IllegalArgumentException`—when `initial` is greater than `maximum`, or when `initial` or `maximum` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(SizeEstimator, SizeEstimator, Runnable)

Signature

```
public
LTMemory(SizeEstimator initial,
         SizeEstimator maximum,
         Runnable logic)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(initial.getEstimate(), maximum.getEstimate(), logic)`.

Parameters

`initial`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

`maximum`—An instance of `SizeEstimator` used to give an estimate for the maximum bytes to allocate for this area.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(SizeEstimator initial, SizeEstimator maximum)`.

Throws

`IllegalArgumentException`—when `initial` is `null`, `maximum` is `null`, `initial.getEstimate()` is greater than `maximum.getEstimate()`, or when `initial.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(long, long)

Signature

```
public
LTMemory(long initial,
```

```
            long maximum)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(initial, maximum, null)`.

Parameters

`initial`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

`maximum`—The size in bytes of the memory to allocate for this area.

Throws

`IllegalArgumentException`—when `initial` is greater than `maximum`, or when `initial` or `maximum` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

LTMemory(SizeEstimator, SizeEstimator)

Signature

```
public
LTMemory(SizeEstimator initial,
         SizeEstimator maximum)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(initial.getEstimate(), maximum.getEstimate(), null)`.

Parameters

`initial`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

`maximum`—An instance of `SizeEstimator` used to give an estimate for the maximum bytes to allocate for this area.

Throws

`IllegalArgumentException`—when `initial` is `null`, `maximum` is `null`, `initial.getEstimate()` is greater than `maximum.getEstimate()`, or when `initial.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

LTMemory(long, Runnable)

Signature

```
public
LTMemory(long size,
         Runnable logic)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(size, size, logic)`.

Since RTSJ 1.0.1

Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(long size)`.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(SizeEstimator, Runnable)

Signature

```
public
LTMemory(SizeEstimator size,
         Runnable logic)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(size.getEstimate(), size.getEstimate(), logic)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `LTMemory(SizeEstimator size)`.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTMemory(long)

Signature

```
public
LTMemory(long size)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(size, size, null)`.

Since RTSJ 1.0.1

Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

LTMemory(SizeEstimator)

Signature

```
public
LTMemory(SizeEstimator size)
```

Description

Equivalent to `LTMemory(long, long, Runnable)` with the argument list `(size.getEstimate(), size.getEstimate(), null)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `LTMemory` object or for its allocation area in its backing store.

B.2.2.13.2 Methods

---

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a string representation of this object. The string is of the form

{@code (LTMemory) ScopedMemory#<num>}

where <num> uniquely identifies the LTMemory area.

Returns
a string representing the value of this.

B.2.2.14 LTPhysicalMemory

---

public class LTPhysicalMemory

Inheritance
java.lang.Object
MemoryArea
ScopedMemory
LTPhysicalMemory

Description

An instance of LTPhysicalMemory allows objects to be allocated from a range of physical memory with particular attributes, determined by their memory type. This memory area has the same semantics as ScopedMemory memory areas, and the same performance restrictions as LTMemory.

No provision is made for sharing object in LTPhysicalMemory with entities outside the JVM that creates them, and, while the memory backing an instance of LTPhysicalMemory could be shared by multiple JVMs, the class does not support such sharing.

Methods from LTPhysicalMemory should be overridden only by methods that use super.

Deprecated since RTSJ 2.0

B.2.2.14.1 Constructors

LTPhysicalMemory(Object, long, long, Runnable)

Signature

```
public
LTPhysicalMemory(Object type,
                 long base,
                 long size,
                 Runnable logic)
```

Description

Creates an instance of `LTPhysicalMemory` with the given parameters.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`SizeOutOfBoundsException`—when the implementation detects that `base` plus `size` extends beyond physically addressable memory.

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`IllegalArgumentException`—when `size` is less than zero.

`OffsetOutOfBoundsException`—when the address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTPhysicalMemory(Object, long, SizeEstimator, Runnable)

Signature

```
public
LTPhysicalMemory(Object type,
                 long base,
                 SizeEstimator size,
                 Runnable logic)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, base, size.getEstimate(), logic)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the implementation detects that `base` plus the size estimate extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTPhysicalMemory(Object, long, long)

Signature

```
public
LTPhysicalMemory(Object type,
                 long base,
                 long size)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the the argument list `(type, base, size, null)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the size is less than zero, or the implementation detects that `base` plus `size` extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is less than zero.

`MemoryInUseException`—when the specified memory is already in use.

LTPhysicalMemory(Object, long, SizeEstimator)

Signature

```
public
LTPhysicalMemory(Object type,
                 long base,
                 SizeEstimator size)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, base, size.getEstimate(), null)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the implementation detects that `base` plus the size estimate extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

LTPhysicalMemory(Object, long, Runnable)

Signature

```
public
LTPhysicalMemory(Object type,
                 long size,
                 Runnable logic)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size, logic)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`IllegalArgumentException`—when `size` is less than zero.

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

LTPhysicalMemory(Object, SizeEstimator, Runnable)

Signature

```
public
LTPhysicalMemory(Object type,
                 SizeEstimator size,
                 Runnable logic)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size.getEstimate(), logic)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the implementation detects that `base` plus the size estimate extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the request type, or when `type` specifies attributes with a conflict.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`IllegalAssignmentError`—when storing `logic` in `this` violates the assignment rules.

LTPhysicalMemory(Object, long)

Signature

```
public
LTPhysicalMemory(Object type,
                 long size)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size, null)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`IllegalArgumentException`—when `size` is less than zero.

`SizeOutOfBoundsException`—when the implementation detects `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when `type` specifies incompatible memory attributes.

LTPhysicalMemory(Object, SizeEstimator)

Signature

```
public
LTPhysicalMemory(Object type,
```

```
                    SizeEstimator size)
```

Description

Equivalent to `LTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size.getEstimate(), null)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given type of memory.

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

B.2.2.14.2 Methods

---

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a string describing this object. The string is of the form

```
(LTPhysicalMemory) Scoped memory # num
```

where `num` is a number that uniquely identifies this `LTPhysicalMemory` memory area representing the value of `this`.

Returns
A string representing the value of `this`.

B.2.2.15 *MemoryAccessError*

---

public class MemoryAccessError

The following elements of MemoryAccessError are deprecated. The required elements are documented in Section 17.2.2.13 above.

B.2.2.15.1 Constructors

MemoryAccessError(String)

Signature

```
public
MemoryAccessError(String description)
```

Description

A descriptive constructor for `MemoryAccessError`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—The reason for throwing this error.

B.2.2.16 *MemoryParameters*

---

public class MemoryParameters

The following elements of MemoryParameters are deprecated. The required elements are documented in Section 11.3.2.4 above.

B.2.2.16.1 Fields

NO_MAX

```
public static final long NO_MAX
```

Description

Specifies no maximum limit.

Deprecated since RTSJ 2.0.

B.2.2.16.2 Methods

getMaxMemoryArea

Signature

```
public long
getMaxMemoryArea()
```

Description

Gets the limit on the amount of memory the schedulable may allocate in its initial memory area. Units are in bytes.

Returns

the allocation limit in the schedulable's initial memory area. When zero, no allocation is allowed in the initial memory area. When the returned value is `NO_MAX` then there is no limit for allocation in the initial memory area.

Deprecated since RTSJ 2.0, repleace by getMaxInitialArea.

setAllocationRate(long)

Signature

```
public void
setAllocationRate(long allocationRate)
```

Description

Sets the limit on the rate of allocation in the heap.

Changes to this parameter take place at the next object allocation for each associated schedulable, on an individual basis. Schedulables which are in current violation of the newly configured value will simply receive an `StaticOutOfMemoryError` on violating allocations. Because this `MemoryParameters` may be associated with more than one schedulable, on a multiprocessor system there may be some implementation-defined delay before executing schedulables detect the parameter changes.

Parameters

`allocationRate`—Units are in bytes per second of wall-clock time. When `allocationRate` is zero, no allocation is allowed in the heap. To specify no limit, use `NO_MAX`. Measurement starts when the schedulable starts; not when it is constructed. Enforcement of the allocation rate is an implementation option. When the implementation does not enforce allocation rate limits, it treats all non-zero allocation rate limits as `NO_MAX`.

Throws

`StaticIllegalArgumentException`—when any value other than positive, zero, or `NO_MAX` is passed as the value of `allocationRate`.

Deprecated RTSJ 2.0

setAllocationRateIfFeasible(long)

Signature

```
public boolean
setAllocationRateIfFeasible(long allocationRate)
```

Description

Sets the limit on the rate of allocation in the heap. When this `MemoryParameters` object is currently associated with one or more schedulables that have been passed admission control, this change in allocation rate will be submitted to admission control. The scheduler (in conjunction with the garbage collector) will either admit all the effected threads with the new allocation rate, or leave the allocation rate unchanged and cause `setAllocationRateIfFeasible` to return `false`.

Changes to this parameter take place at the next object allocation for each associated schedulable, on an individual basis. Schedulables which are in current violation of the newly configured value will simply receive an `StaticOutOfMemoryError` on violating allocations. Because this `MemoryParameters` may be associated with more than one schedulable, on a multiprocessor system there may be some implementation-defined delay before executing schedulables detect the parameter changes.

Parameters

`allocationRate`—Units in bytes per second of wall-clock time. When `allocationRate` is zero, no allocation is allowed in the heap. To specify no limit, use `NO_MAX`. Enforcement of the allocation rate is an implementation option. When the implementation does not enforce allocation rate limits, it treats all non-zero allocation rate limits as `NO_MAX`.

Throws

`StaticIllegalArgumentException`—when any value other than positive, zero, or `NO_MAX` is passed as the value of `allocationRate`.

Returns

`true` when the request was fulfilled.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate.

setMaxImmortalIfFeasible(long)

Signature

```
public boolean
setMaxImmortalIfFeasible(long maximum)
```

Description

Sets the limit on the amount of memory the schedulable may allocate in the immortal area.

Changes to this parameter take place at the next object allocation for each associated schedulable, on an individual basis. Schedulables which are in current violation of the newly configured value will simply receive an `StaticOutOfMemoryError` on violating allocations. Because this `MemoryParameters` may be

associated with more than one schedulable, on a multiprocessor system there may be some implementation-defined delay before executing schedulables detect the parameter changes.

Parameters

`maximum`—Units in bytes. When zero, no allocation allowed in immortal. To specify no limit, use `NO_MAX`.

Throws

`StaticIllegalArgumentException`—when any value other than positive, zero, or `NO_MAX` is passed as the value of `maximum`.

Returns

`true` when the value is set, false when any of the schedulables have already allocated more than the given value. In this case the call has no effect.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setMaxMemoryAreaIfFeasible(long)

Signature

```
public boolean
setMaxMemoryAreaIfFeasible(long maximum)
```

Description

Sets the limit on the amount of memory the schedulable may allocate in its initial memory area.

Changes to this parameter take place at the next object allocation for each associated schedulable, on an individual basis. Schedulables which are in current violation of the newly configured value will simply receive an `StaticOutOfMemoryError` on violating allocations. Because this `MemoryParameters` may be associated with more than one schedulable, on a multiprocessor system there may be some implementation-defined delay before executing schedulables detect the parameter changes.

Parameters

`maximum`—Units in bytes. When zero, no allocation allowed in the initial memory area. To specify no limit, use `UNLIMITED`.

Throws

`StaticIllegalArgumentException`—when any value other than positive, zero, or `NO_MAX` is passed as the value of `maximum`.

Returns

`true` when the value is set, false when any of the schedulables have already allocated more than the given value. In this case the call has no effect.

Deprecated as of RTSJ 2.0, since the framework for feasibility analysis is inadequate.

B.2.2.17 *MemoryScopeException*

public class MemoryScopeException

The following elements of MemoryScopeException are deprecated. The required elements are documented in Section 17.2.2.15 above.

B.2.2.17.1 Constructors

MemoryScopeException(String)

Signature

```
public
MemoryScopeException(String description)
```

Description

A descriptive constructor for `MemoryScopeException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—The reason for throwing this exception.

B.2.2.18 NoHeapRealtimeThread

public class NoHeapRealtimeThread

Inheritance

java.lang.Object
  java.lang.Thread
    RealtimeThread
      NoHeapRealtimeThread

Description

A `NoHeapRealtimeThread` is a specialized form of `RealtimeThread`. Because an instance of `NoHeapRealtimeThread` may immediately preempt any implemented garbage collector, logic contained in its `run()` is never allowed to allocate or reference any object allocated in the heap. At the byte-code level, it is illegal for a reference to an object allocated in heap to appear on a this realtime thread's operand stack.

Thus, it is always safe for a `NoHeapRealtimeThread` to interrupt the garbage collector at any time, without waiting for the end of the garbage collection cycle or a defined preemption point. Due to these restrictions, a `NoHeapRealtimeThread` object must be placed in a memory area such that thread logic may unexceptionally access instance variables and such that Java methods on `Thread`, e.g., enumerate

and join, complete normally, except where execution would cause access violations. The constructors of `NoHeapRealtimeThread` require a reference to `ScopedMemory` or `ImmortalMemory`.

When the thread is started, all execution occurs in the scope of the given memory area. Thus, all memory allocation performed with the *new* operator is taken from this given area.

Deprecated since RTSJ 2.0

B.2.2.18.1 Constructors

NoHeapRealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
NoHeapRealtimeThread(SchedulingParameters scheduling,
                     ReleaseParameters<?> release,
                     MemoryParameters memory,
                     MemoryArea area,
                     ProcessingGroupParameters group,
                     Runnable logic)
```

Description

Creates a realtime thread with the given characteristics and a Runnable. The thread group of the new thread is (effectively) null. The newly-created realtime thread which may not use the heap is associated with the scheduler in effect during execution of the constructor.

Parameters

`scheduling`—the SchedulingParameters associated with this (and possibly other instances of Schedulable). When scheduling is `null`, the default is a copy of the creator's scheduling parameters created in the same memory area as the new NoHeapRealtimeThread.

`release`—the ReleaseParameters associated with this (and possibly other instances of Schedulable). When release is null, the default is a copy of the creator's ReleaseParameters created in the same memory area as the new NoHeapRealtimeThread.

`memory`—the MemoryParameters associated with this (and possibly other instances of Schedulable). When memory is null, the new NoHeapRealtimeThread will have a null value for its MemoryParameters, and the amount or rate of memory allocation is unrestricted.

`area`—the MemoryArea associated with this. When area is null, an IllegalArgumentException is thrown.

`group`—the ProcessingGroupParameters associated with this (and possibly other instances of Schedulable). When null, the new NoHeapRealtimeThread will not be associated with any processing group.

`logic`—the Runnable object whose run() method will serve as the logic for the new NoHeapRealtimeThread. When logic is null, the run() method in the new object will serve as its logic.

Throws

`IllegalArgumentException`—when the parameters are not compatible with the associated scheduler, when area is null, when area is heap memory, when area, scheduling release, memory or group is allocated in heap memory. when `this` is in heap memory, or when logic is in heap memory.

`IllegalAssignmentError`—when the new NoHeapRealtimeThread instance cannot hold references to non-null values of the scheduling release, memory and group, or when those parameters cannot hold a reference to the new NoHeapRealtime-Thread.

NoHeapRealtimeThread(SchedulingParameters, ReleaseParameters, MemoryArea)

Signature

```
public
NoHeapRealtimeThread(SchedulingParameters scheduling,
                     ReleaseParameters<?> release,
                     MemoryArea area)
```

Description

Creates a realtime thread which may not use the heap with the given `SchedulingParameters`, `ReleaseParameters` and `MemoryArea`, and default values for all other parameters. This constructor is equivalent to `NoHeapRealtime-Thread(scheduling, release, null, area, null, null, null)`.

NoHeapRealtimeThread(SchedulingParameters, MemoryArea)

Signature

```
public
NoHeapRealtimeThread(SchedulingParameters scheduling,
                     MemoryArea area)
```

Description

Creates a realtime thread with the given `SchedulingParameters` and `MemoryArea` and default values for all other parameters.

This constructor is equivalent to `NoHeapRealtimeThread(scheduling, null, null, area, null, null, null)`.

B.2.2.18.2 Methods

start

Signature

```
public void
start()
```

Description

Throws

`StaticIllegalStateException`—when the configured `Scheduler` and `SchedulingParameters` for this `RealtimeThread` are not compatible.

`IllegalTaskStateException`—when the affinity of this RealtimeThread is not compatible with the affinity of the `RealtimeThreadGroup` it belongs.

`IllegalThreadStateException`—when the thread is already started.

Since RTSJ 2.0 adds new exceptions

startPeriodic(PhasingPolicy)

Signature

```
public void
startPeriodic(PhasingPolicy phasingPolicy)
throws LateStartException
```

Description

Starts the periodic thread with the specified phasing policy.

Since RTSJ 2.0

B.2.2.19 *OffsetOutOfBoundsException*

public class OffsetOutOfBoundsException

The following elements of OffsetOutOfBoundsException are deprecated. The required elements are documented in Section 17.2.2.17 above.

B.2.2.19.1 Constructors

OffsetOutOfBoundsException(String)

Signature

```
public
OffsetOutOfBoundsException(String description)
```

Description

A descriptive constructor for `OffsetOutOfBoundsException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—The reason for throwing the exception.

B.2.2.20 POSIXSignalHandler

---

public class POSIXSignalHandler

Inheritance

java.lang.Object
  POSIXSignalHandler

Description

This class enables the use of an AsyncEventHandler to react on the occurrence of POSIX signals.

On systems that support POSIX signals fully, the 13 signals required by POSIX will be supported. Any further signals defined in this class may be supported by the system. On systems that do not support POSIX signals, even the 13 standard signals may never be fired.

Deprecated since RTSJ 2.0

B.2.2.20.1 Fields

SIGHUP

```
public static final int SIGHUP
```

Description

Hangup (POSIX).

SIGINT

```
public static final int SIGINT
```

Description

interrupt (ANSI)

SIGQUIT
```
public static final int SIGQUIT
```
Description

quit (POSIX)

SIGILL
```
public static final int SIGILL
```
Description

illegal instruction (ANSI)

SIGTRAP
```
public static final int SIGTRAP
```
Description

trace trap (POSIX), optional signal.

SIGABRT
```
public static final int SIGABRT
```
Description

Abort (ANSI).

SIGBUS
```
public static final int SIGBUS
```
Description

BUS error (4.2 BSD), optional signal.

SIGFPE
```
public static final int SIGFPE
```
Description

floating point exception

SIGKILL
```
public static final int SIGKILL
```
Description

Kill, unblockable (POSIX).

SIGUSR1
```
public static final int SIGUSR1
```
Description

User-defined signal 1 (POSIX).

SIGSEGV
```
public static final int SIGSEGV
```
Description

Segmentation violation (ANSI).

SIGUSR2
```
public static final int SIGUSR2
```
Description

User-defined signal 2 (POSIX).

SIGPIPE
```
public static final int SIGPIPE
```
Description

Broken pipe (POSIX).

SIGALRM
```
public static final int SIGALRM
```
Description

Alarm clock (POSIX).

SIGTERM
```
public static final int SIGTERM
```
Description

Termination (ANSI).

SIGCHLD
```
public static final int SIGCHLD
```
Description

Child status has changed (POSIX).

SIGCONT

```
public static final int SIGCONT
```

Description

Continue (POSIX), optional signal.

SIGSTOP

```
public static final int SIGSTOP
```

Description

Stop, unblockable (POSIX), optional signal.

SIGTSTP

```
public static final int SIGTSTP
```

Description

Keyboard stop (POSIX), optional signal.

SIGTTIN

```
public static final int SIGTTIN
```

Description

Background read from tty (POSIX), optional signal.

SIGTTOU

```
public static final int SIGTTOU
```

Description

Background write to tty (POSIX), optional signal.

SIGSYS

```
public static final int SIGSYS
```

Description

Bad system call, optional signal.

SIGIOT

```
public static final int SIGIOT
```

Description

IOT instruction (4.2 BSD), optional signal.

SIGCLD
`public static final int SIGCLD`

Description

Same as SIGCHLD (System V), optional signal.

SIGEMT
`public static final int SIGEMT`

Description

EMT instruction, optional signal.

B.2.2.20.2 Methods

---

addHandler(int, AsyncEventHandler)

Signature

```
public static void
addHandler(int signal,
           AsyncEventHandler handler)
```

Description

Adds the handler provided to the set of handlers that will be released on the provided signal.

Parameters

`signal`—The POSIX signal as defined in the constants SIG*.

`handler`—The handler to be released on the given signal.

Throws

`IllegalArgumentException`—when signal is not defined by any of the constants in this class or handler is `null`.

removeHandler(int, AsyncEventHandler)

Signature

```
public static void
removeHandler(int signal,
              AsyncEventHandler handler)
```

Description

Removes a handler that was added for a given signal.

Parameters

`signal`—The POSIX signal as defined in the constants SIG*.

`handler`—The handler to be removed from the given signal. When this handler is `null` or has not been added to the signal, nothing will happen.

Throws

`IllegalArgumentException`—when signal is not defined by any of the constants in this class.

setHandler(int, AsyncEventHandler)

Signature

```
public static void
setHandler(int signal,
           AsyncEventHandler handler)
```

Description

Sets the set of handlers that will be released on the provided signal to the set with the provided handler being the single element.

Parameters

`signal`—The POSIX signal as defined in the constants SIG*.

`handler`—The handler to be released on the given signal, `null` to remove all handlers for the given signal.

Throws

`IllegalArgumentException`—when signal is not defined by any of the constants in this class.

B.2.2.21 *PeriodicParameters*

---

public class PeriodicParameters

The following elements of PeriodicParameters are deprecated. The required elements are documented in Section 6.3.3.6 above.

B.2.2.21.1 Methods

---

setIfFeasible(RelativeTime, RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime period,
              RelativeTime cost,
              RelativeTime deadline)
```

Description

This method first performs a feasibility analysis using the new period, cost and deadline attributes as replacements for the matching attributes of `this`. When the resulting system is feasible the method replaces the current attributes of `this`. When `this` parameter object is associated with any schedulable, either by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setReleaseParameters(ReleaseParameters)`, the parameters of those schedulables are altered as specified by each schedulable's respective scheduler.

Parameters

`period`—The proposed period. There is no default value. When `period` is `null` an exception is thrown.

`cost`—The proposed cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The proposed deadline. When `null`, the default value is new instance of `RelativeTime(period)`.

Throws

`StaticIllegalArgumentException`—when the `period` is `null` or its time value is not greater than zero, or when the time value of `cost` is less than zero, or when the time value of `deadline` is not greater than zero. Also when the values are incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

`IllegalAssignmentError`—when `period`, `cost`, or `deadline` cannot be stored in `this`.

Returns

`true`, when the resulting system is feasible and the changes are made. `False`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0; the framework for feasibility analysis is inadequate

B.2.2.22 PhysicalMemoryManager

---

public class PhysicalMemoryManager

Inheritance

java.lang.Object
  PhysicalMemoryManager

Description

The `PhysicalMemoryManager` is not ordinarily used by applications, except that the implementation may require the application to use the `registerFilter` method to make the physical memory manager aware of the memory types on their platform. The `PhysicalMemoryManager` class is primarily intended for use by the various physical memory accessor objects (`VTPhysicalMemory`, `LTPhysicalMemory`, and `ImmortalPhysicalMemory`) to create objects of the types requested by the application. The physical memory manager is responsible for

finding areas of physical memory with the appropriate characteristics and access rights, and moderating any required combination of physical and virtual memory characteristics.

The Physical Memory Manager assumes that the physical adresss space is linear but not necessarily contiguous. That is, addresses range from 0 .. `MAX_LONG`, but there may be gaps in the memory space. Some intervals in the range may be filled with removable memory as well.

The physical memory is partitioned into chunks (pages, segments, etc.). Each chunk of memory has a base address and a length.

Each chunk of memory has certain properties. Some of these properties may require actions to be performed by the Physical Memory Manager when the memory is accessed. For example, access to `IO_PAGE` may require the use of special instructions to even reach the devices, or it may require special code sequences to ensure proper handling of processor write queues and caches.

Filters tell the Physical Memory Manager about the properties of the memory that are available on the machine by registering with the Physical Memory Manager.

When the program requests a physical memory area with particular properties, the constructor communicates with the Physical Memory Manager through a private interface. The Physical Memory Manager asks the filter whether or not the address specified has the required properties and whether it is free, or asks for a chunk of memory with the requested size.

The Physical Memory Manager then maps the physical memory chunk into virtual memory and locks the virtual memory to the memory chunk, on systems that support virtual memory.

Examples of characteristics that might be specified are DMA memory, hardware byte swapping, and non-cached access to memory. Standard "names" for some memory characteristics are included in this class: DMA, SHARED, ALIGNED, BYTESWAP, and IO_PAGE. Support for these characteristics is optional, but when they are supported they must use these names. Additional characteristics may be supported, but only names defined in this specification may be visible in the `PhysicalMemoryManager` API.

The base implementation will provide a `PhysicalMemoryManager`.

Original Equipment Manufacturers (OEMs) or other interested parties may provide `PhysicalMemoryTypeFilter` classes that allow additional characteristics of memory devices to be specified.

Deprecated as of RTSJ 2.0

B.2.2.22.1 Fields

ALIGNED

```
public static final java.lang.Object ALIGNED
```

Description

When aligned memory is supported by the implementation, specify `ALIGNED` to identify aligned memory. This type of memory ignores low-order bits in load and store accesses to force accesses to fall on natural boundaries for the access type even when the processor uses a poorly aligned address.

See Section javax.realtime.device.RawMemory

BYTESWAP

```
public static final java.lang.Object BYTESWAP
```

Description

When automatic byte swapping is supported by the implementation, specify `BYTESWAP` when byte swapping should be used. Byte-swapping memory re-orders the bytes in accesses for 16 bits or more such that little-endian data in memory is accessed as big-endian, and vice-versa. Such memory would typically be available in swapped mode in one physical address range and in un-swapped mode in another address range.

See Section javax.realtime.device.RawMemory

DMA

```
public static final java.lang.Object DMA
```

Description

When DMA (Direct Memory Access) memory is supported by the implementation, specify `DMA` to identify DMA memory. This memory is visible to devices that use DMA. In some systems, only a portion of the physical address space is available to DMA devices. On such systems, memory that will be used for DMA must be allocated from the range of addresses that DMA can reach.

See Section javax.realtime.device.RawMemory

IO_PAGE

```
public static final java.lang.Object IO_PAGE
```

Description

When access to the system I/O space is supported by the implementation, specify `IO_PAGE` when I/O space should be used. Addresses tagged with the name `IO_PAGE` are used for memory mapped I/O devices. Such addresses are almost certainly not suitable for physical memory, but only for raw memory access.

Since RTSJ 1.0.1

SHARED

```
public static final java.lang.Object SHARED
```

Description

When shared memory is supported by the implementation, specify `SHARED` to identify shared memory. In a NUMA (Non-Uniform Memory Access) architecture, processors may make some part of their local memory available to other processors. This memory would be tagged with `SHARED`, as would memory that is shared and non-local.

A fully built-out NUMA system might well need sub-classifications of `SHARED` to reflect different paths to memory. Note that, as with other physical memory names, a single byte of memory may be visible at several physical addresses with different access properties at each address. For instance, a byte of shared memory accesses at address x might be shared with high-performance access, but without the support of coherent caches. The same byte accessed at address y might be shared with coherent cache support, but substantially longer access times.

B.2.2.22.2 Methods

isRemovable(long, long)

Signature

```
public static boolean
isRemovable(long base,
            long size)
```

Description

Queries the system about the removability of the specified range of memory.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

`OffsetOutOfBoundsException`—when `base` is less than zero.

Returns

`true`, when any part of the specified range can be removed.

isRemoved(long, long)

Signature

```
public static boolean
isRemoved(long base,
          long size)
```

Description

Queries the system about the removed state of the specified range of memory. This method is used for devices that lie in the memory address space and can be removed while the system is running. (Such as PC cards).

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when any part of the specified range is currently not usable.

onInsertion(long, long, AsyncEvent)

Signature

```
public static void
onInsertion(long base,
            long size,
            AsyncEvent ae)
```

Description

Registers the specified `AsyncEvent` to fire when any memory in the range is added to the system. When the specified range of physical memory contains multiple different types of removable memory, the AE will be registered with each of them.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`ae`—The async event to fire.

Throws

`IllegalArgumentException`—when `ae` is `null`, or when the specified range contains no removable memory, or when `size` is less than zero.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Since RTSJ 1.0.1

onInsertion(long, long, AsyncEventHandler)

Signature

```
public static void
onInsertion(long base,
            long size,
```

```
                AsyncEventHandler aeh)
```

Description

Registers the specified `AsyncEventHandler` to run when any memory in the range is added to the system. When the specified range of physical memory contains multiple different types of removable memory, the AEH will be registered with each of them. When the size or the base is less than 0, unregisters all "onInsertion" references to the handler.

Note that this method only removes handlers that were registered with the same method. It has no effect on handlers that were registered using an associated async event.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`aeh`—The handler to register.

Throws

`IllegalArgumentException`—when `aeh` is `null`, or when the specified range contains no removable memory, or when `aeh` is `null` and `size` and `base` are both greater than or equal to zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

onRemoval(long, long, AsyncEvent)

Signature

```
public static void
onRemoval(long base,
          long size,
          AsyncEvent ae)
```

Description

Registers the specified AE to fire when any memory in the range is removed from the system. When the specified range of physical memory contains multiple different types of removable memory, the AE will be registered with each of them.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`ae`—The async event to register.

Throws

`IllegalArgumentException`—when the specified range contains no removable memory, when `ae` is `null`, or when `size` is less than zero.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

onRemoval(long, long, AsyncEventHandler)

Signature

```
public static void
onRemoval(long base,
          long size,
          AsyncEventHandler aeh)
```

Description

Registers the specified AEH to run when any memory in the range is removed from the system. When the specified range of physical memory contains multiple different types of removable memory, the AEH will be registered with each of them. When `size` or `base` is less than 0, unregisters all "onRemoval" references to the handler parameter.

Note that this method only removes handlers that were registered with the same method. It has no effect on handlers that were registered using an associated async event.

Parameters

`base`—The starting address in physical memory.

`size`—The size of the memory area.

`aeh`—The handler to register.

Throws

`IllegalArgumentException`—when the specified range contains no removable memory, or when `aeh` is `null` and `size` and `base` are both greater than or equal to zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

registerFilter(Object, PhysicalMemoryTypeFilter)

Signature

```
public static final void
registerFilter(Object name,
               PhysicalMemoryTypeFilter filter)
throws DuplicateFilterException
```

Description

Registers a memory type filter with the physical memory manager.

Values of `name` are compared using reference equality (==) not value equality (`equals()`).

Parameters

`name`—The type of memory handled by this filter.

`filter`—The filter object.

Throws

`DuplicateFilterException`—when a filter for this type of memory already exists.

`ResourceLimitError`—when the system is configured for a bounded number of filters. This filter exceeds the bound.

`IllegalArgumentException`—when the name parameter is an array of objects, when the name and filter are not both in immortal memory, or when either `name` or `filter` is `null`.

`StaticSecurityException`—when this operation is not permitted.

removeFilter(Object)

Signature

```
public static final void
removeFilter(Object name)
```

Description

Removes the identified filter from the set of registered filters. When the filter is not registered, silently does nothing.

Values of `name` are compared using reference equality (==) not value equality (`equals()`).

Parameters

`name`—The identifying object for this memory attribute.

Throws

`IllegalArgumentException`—when `name` is `null`.

`StaticSecurityException`—when this operation is not permitted.

unregisterInsertionEvent(long, long, AsyncEvent)

Signature

```
public static boolean
unregisterInsertionEvent(long base,
                         long size,
                         AsyncEvent ae)
```

Description

Unregisters the specified insertion event. The event is only unregistered when all three arguments match the arguments used to register the event, except that `ae` of `null` matches all values of `ae` and will unregister every `ae` that matches the address range.

Note that this method has no effect on handlers registered directly as async event handlers.

Parameters

`base`—The starting address in physical memory associated with `ae`.

`size`—The size of the memory area associated with `ae`.

`ae`—The event to unregister.

Throws

`IllegalArgumentException`—when `size` is less than 0.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when at least one event matched the pattern, `false`, when no such event was found.

Since RTSJ 1.0.1

unregisterRemovalEvent(long, long, AsyncEvent)

Signature

```
public static boolean
unregisterRemovalEvent(long base,
                       long size,
                       AsyncEvent ae)
```

Description

Unregisters the specified removal event. The async event is only unregistered when all three arguments match the arguments used to register the event, except that `ae` of `null` matches all values of `ae` and will unregister every `ae` that matches the address range.

Note that this method has no effect on handlers registered directly as async event handlers.

Parameters

`base`—The starting address in physical memory associated with `ae`.

`size`—The size of the memory area associated with `ae`.

`ae`—The async event to unregister.

Throws

`IllegalArgumentException`—when `size` is less than 0.

`OffsetOutOfBoundsException`—when `base` is less than zero.

`SizeOutOfBoundsException`—when `base` plus `size` would be greater than the physical addressing range of the processor.

Returns

`true`, when at least one event matched the pattern, `false`, when no such event was found.

Since RTSJ 1.0.1

B.2.2.23 *PriorityParameters*

---

public class PriorityParameters

The following elements of PriorityParameters are deprecated. The required elements are documented in Section 6.3.3.7 above.

B.2.2.23.1 Methods

setPriority(int)

Signature

```
public javax.realtime.PriorityParameters
setPriority(int priority)
```

Description

Sets the priority value. When this parameter object is associated with any schedulable (by being passed through the schedulable's constructor or set with a method such as `RealtimeThread.setSchedulingParameters(SchedulingParameters)`) the base priority of those schedulables is altered as specified by each schedulable's scheduler.

Parameters

`priority`—The value to which priority is set.

Throws

`StaticIllegalArgumentException`—when the given priority value is incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

Returns

`this`

Deprecated since RTSJ 2.0

B.2.2.24 *PriorityScheduler*

public abstract class PriorityScheduler

The following elements of PriorityScheduler are deprecated. The required elements are documented in Section 6.3.3.8 above.

B.2.2.24.1 Methods

getMaxPriority(Thread)

Signature

```
public static int
getMaxPriority(Thread thread)
```

Description

Gets the maximum priority for the given thread. When the given thread is a realtime thread that is scheduled by an instance of `PriorityScheduler`, then the maximum priority for that scheduler is returned. When the given thread is not an instance of `Schedulable`, the maximum priority of its thread group is returned. Otherwise an exception is thrown.

Parameters

`thread`—An instance of `Thread`. When `null`, the maximum priority of this scheduler is returned.

Throws

`StaticIllegalArgumentException`—when `thread` is a realtime thread that is not scheduled by an instance of `PriorityScheduler`.

Returns

the maximum priority for `thread`

Deprecated since RTSJ 2.0

getMinPriority(Thread)

Signature

```
public static int
getMinPriority(Thread thread)
```

Description

Gets the minimum priority for the given thread. When the given thread is a realtime thread that is scheduled by an instance of `PriorityScheduler`, then the minimum priority for that scheduler is returned. When the given thread is not an instance of `Schedulable`, `Thread.MIN_PRIORITY` is returned. Otherwise an exception is thrown.

Parameters

`thread`—An instance of `Thread`. When `null`, the minimum priority of this scheduler is returned.

Throws

`StaticIllegalArgumentException`—when `thread` is a realtime thread that is not scheduled by an instance of `PriorityScheduler`.

Returns

the minimum priority for `thread`

Deprecated since RTSJ 2.0

getNormPriority(Thread)

Signature

```
public static int
getNormPriority(Thread thread)
```

Description

Gets the "norm" priority for the given thread. When the given thread is a realtime thread that is scheduled by an instance of `PriorityScheduler`, then the norm priority for that scheduler is returned. When the given thread is not an instance of `Schedulable`, `Thread.NORM_PRIORITY` is returned. Otherwise an exception is thrown.

Parameters

`thread`—An instance of `Thread`. When `null`, the norm priority for this scheduler is returned.

Throws

`StaticIllegalArgumentException`—when `thread` is a realtime thread that is not scheduled by an instance3 of `PriorityScheduler`.

Returns

The norm priority for `thread`

Deprecated since RTSJ 2.0

instance

Signature

```
public static javax.realtime.PriorityScheduler
instance()
```

Description

Obtains a reference to the distinguished instance of `PriorityScheduler`, which is the system's base scheduler.

Returns

A reference to the distinguished instance `PriorityScheduler`.

Deprecated since RTSJ 2.0

isFeasible

Signature

```
public boolean
isFeasible()
```

Description

Queries this `Scheduler` about the feasibility of the set of schedulables currently in the feasibility set.

Implementation Notes

The default feasibility test for the `PriorityScheduler` considers a set of schedulables with bounded resource requirements, to always be feasible. This covers all schedulable objects with release parameters of types `PeriodicParameters` and `SporadicParameters`.

When any schedulable within the feasibility set has release parameters of the exact type `AperiodicParameters` (not a subclass thereof), then the feasibility set is not feasible, as aperiodic release characteristics require unbounded

resources. In that case, this method will return `false` and all methods in the `setIfFeasible` family of methods will also return `false`. Consequently, any call to a `setIfFeasible` method that passes a schedulable which has release parameters of type `AperiodicParameters`, or passes proposed release parameters of type `AperiodicParameters`, will return `false`. The only time a `setIfFeasible` method can return `true`, when there exists in the feasibility set a schedulable with release parameters of type `AperiodicParameters`, is when the method will change those release parameters to not be `AperiodicParameters`.

Implementations may provide a feasibility test other than the default test just described. In which case the details of that test should be documented here in place of this description of the default implementation.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(Schedulable schedulable,
              ReleaseParameters<?> release,
              MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones. This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new release parameters change `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made. `False`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(Schedulable schedulable,
              ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The proposed processing group parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new release parameters change `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made. `False`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(Schedulable schedulable,
              SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`scheduling`—The proposed scheduling parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The proposed processing group parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new release parameters change `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made. `False`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

addToFeasibility(Schedulable)

Signature

```
protected boolean
addToFeasibility(Schedulable schedulable)
```

Description

Informs this scheduler and cooperating facilities that the resource demands of the given instance of `Schedulable` will be considered in the feasibility analysis of the associated `Scheduler` until further notice. Whether the resulting system is feasible or not, the addition is completed. When the object is already included in the feasibility set, does nothing.

Parameters

`schedulable`—A reference to the given instance of `Schedulable`

Throws

`StaticIllegalArgumentException`—when `schedulable` is `null`, or when `schedulable` is not associated with `this`; that is `schedulable.getScheduler() != this`.

Returns

`true`, when the system is feasible after the addition, otherwise `False`.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

removeFromFeasibility(Schedulable)

Signature

```
protected boolean
removeFromFeasibility(Schedulable schedulable)
```

Description

Informs this scheduler and cooperating facilities that the resource demands of the given instance of `Schedulable` should no longer be considered in the feasibility analysis of the associated `Scheduler`. Whether the resulting system is feasible or not, the removal is completed.

Parameters

`schedulable`—A reference to the given instance of `Schedulable`

Throws

`StaticIllegalArgumentException`—when `schedulable` is `null`.

Returns

`true`, when the removal was successful. `false`, when the schedulable cannot be removed from the scheduler's feasibility set; e.g., the schedulable is not part of the scheduler's feasibility set.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

fireSchedulable(Schedulable)

Signature

```
public void
fireSchedulable(Schedulable schedulable)
```

Description

Triggers the execution of a schedulable (like an `AsyncEventHandler`).

Parameters

`schedulable`—The schedulable to make active. When `null`, nothing happens.

Throws

`StaticUnsupportedOperationException`—Thrown in all cases by instance of `PriorityScheduler`.

Deprecated RTSJ 2.0

B.2.2.25 ProcessingGroupParameters

---

public class ProcessingGroupParameters

Inheritance

java.lang.Object
  ProcessingGroupParameters

Interfaces

`Cloneable`
`Serializable`

Description

This is associated with one or more schedulables for which the system guarantees that the associated objects will not be given more time per period than indicated by `cost` (budget). The motivation for this class is to allow the execution demands of one or more aperiodic schedulables to be bound. However, periodic or sporadic schedulables can also be associated with a processing group.

Processing groups have an associated affinity set that must contain only a single processor.

For all schedulables with a reference to an instance of `ProcessingGroupParameters p` no more than `p.cost` will be allocated to the execution of these schedulables on the processor associated with its processing group in each interval of time given by `p.period` after the time indicated by `p.start`. No execution of the schedulables will be allowed on any processor other than this processor. When there is no intersection between the a schedulable object's affinity set and its processing group's affinity set, then the schedulable execution is constrained by the default processing group's affinit set.

Logically a virtual server is associated with each instance of `ProcessingGroupParameters`. This server has a start time, a period, a cost (budget) and a deadline. The server can only logically execute when (a) it has not consumed more execution time in its current release than the cost parameter, and (b) one of its associated schedulables is executable and is the most eligible of the executable schedulables. When the server is logically executable, the associated schedulable is executed. When the cost has been consumed, any `overrunHandler` is released, and the server is not eligible for logical execution until its next period is due. At this point, its allocated cost is replenished. When the server is logically executing when its deadline expires, any associated `missHandler` is released. The deadline and cost parameters of all the associated schedulable objects have the same impact as they would if the objects were not bound to a processing group.

Processing group parameters use `HighResolutionTime` values for cost, deadline, period and start time. Since those times are expressed as a `HighResolutionTime`, the values use accurate timers with nanosecond granularity. The actual resolution available and even the quantity it measures depends on the clock associated with each time value.

When a reference to a `ProcessingGroupParameters` object is given as a parameter to a schedulable's constructor or passed as an argument to one of the schedulable's setter methods, the `ProcessingGroupParameters` object becomes the processing group parameters object bound to that schedulable object. Changes to the values in the `ProcessingGroupParameters` object affect that schedulable object. When bound to more than one schedulable then changes to the values in the `ProcessingGroupParameters` object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

The implementation must use modified copy semantics for each `HighResolutionTime` parameter value. The value of each time object should be treated as if it were copied at the time it is passed to the parameter object, but the object reference must also be retained.

Only changes to a `ProcessingGroupParameters` object caused by methods on that object are immediately visible to the scheduler. For instance, invoking

`setPeriod()` on a `ProcessingGroupParameters` object will make the change, then notify the scheduler that the parameter object has changed. At that point the scheduler's view of the processing group parameters object is updated. Invoking a method on the `RelativeTime` object that is the period for this object may change the period but it does not pass the change to the scheduler at that time. That new value for period must not change the behavior of the SOs that use the parameter object until a setter method on the `ProcessingGroupParameters` object is invoked, or the parameter object is used in `setProcessingGroupParameters()` or a constructor for an SO.

The implementation may use copy semantics for each `HighResolutionTime` parameter value. For instance the value returned by `getCost()` must be `equal` to the value passed in by `setCost`, but it need not be the same object.

The following table gives the default parameter values for the constructors.

Table B.1: ProcessingGroupParameter Default Values

Attribute	Default Value
start	new RelativeTime(0,0)
period	No default. A value must be supplied
cost	No default. A value must be supplied
deadline	new RelativeTime(period)
overrunHandler	None
missHandler	None

Caution: This class is explicitly unsafe in multithreaded situations when it is being changed. No synchronization is done. It is assumed that users of this class who are mutating instances will be doing their own synchronization at a higher level.

Caution: The `cost` parameter time should be considered to be measured against the target platform.

Deprecated as of RTSJ 2.0; replaced by `javax.realtime.enforce.ProcessingConstraint`.

B.2.2.25.1 Constructors

ProcessingGroupParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
ProcessingGroupParameters(HighResolutionTime<?> start,
                          RelativeTime period,
                          RelativeTime cost,
                          RelativeTime deadline,
                          AsyncEventHandler overrunHandler,
                          AsyncEventHandler missHandler)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Creates a `ProcessingGroupParameters` object.

Parameters

`start`—Time at which the first period begins. When a `RelativeTime`, this time is relative to the creation of `this`. When an `AbsoluteTime`, then the first release of the logical server is at the start time (or immediately when the absolute time is in the past). When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`period`—The period is the interval between successive replenishment of the logical server's associated cost budget. There is no default value. When `period` is `null` an exception is thrown.

`cost`—Processing time per period. The budget CPU time that the logical server can consume each period. When `null`, an exception is thrown.

`deadline`—The latest permissible completion time measured from the start of the current period. Changing the deadline might not take effect after the expiration of the current deadline. Specifying a deadline less than the period constrains execution of all the members of the group to the beginning of each period. When `null`, the default value is new instance of `RelativeTime(period)`.

`overrunHandler`—This handler is invoked when any schedulable object member of this processing group attempts to use processor time beyond the group's budget. When `null`, no application async event handler is fired on the overrun condition.

`missHandler`—This handler is invoked when the logical server is still executing after the deadline has passed. When `null`, no application async event handler is fired on the deadline miss condition.

Throws

`IllegalArgumentException`—when the `period` is `null` or its time value is not greater than zero, when `cost` is `null`, or when the time value of `cost` is less than zero, when `start` is an instance of `RelativeTime` and its value is negative, or when the time value of `deadline` is not greater than zero and less than or equal to the `period`. When the implementation does not support processing group deadline less than period, `deadline` less than `period` will cause `IllegalArgumentException` to be thrown.

`IllegalAssignmentError`—when `start`, `period`, `cost`, `deadline`, `overrunHandler` or `missHandler` cannot be stored in `this`.

B.2.2.25.2 Methods

clone

Signature

```
public java.lang.Object
clone()
```

Description

Creates a clone of `this`. This method should behave effectively as if it constructed a new object with clones of the high-resolution time values of `this`.

- The new object is in the current allocation context.
- `clone` does not copy any associations from `this` and it does not implicitly bind the new object to a SO.
- The new object has clones of all high-resolution time values (deep copy).
- References to event handlers are copied (shallow copy.)

Returns

the clone of `this`

Since RTSJ 1.0.1

getCost

Signature

```
public javax.realtime.RelativeTime
getCost()
```

Description

Gets the value of `cost`.

Returns

a reference to the value of `cost`.

getCostOverrunHandler

Signature

```
public javax.realtime.AsyncEventHandler
getCostOverrunHandler()
```

Description

Gets the cost overrun handler.

Returns

a reference to an instance of `AsyncEventHandler` that is cost overrun handler of `this`.

getDeadline

Signature

```
public javax.realtime.RelativeTime
getDeadline()
```

Description

Gets the value of `deadline`.

Returns

a reference to an instance of `RelativeTime` that is the deadline of `this`.

getDeadlineMissHandler

Signature

```
public javax.realtime.AsyncEventHandler
getDeadlineMissHandler()
```

Description

Gets the deadline miss handler.

Returns

a reference to an instance of `AsyncEventHandler`that is deadline miss handler of `this`.

getPeriod

Signature

```
public javax.realtime.RelativeTime
getPeriod()
```

Description

Gets the value of `period`.

Returns

a reference to an instance of `RelativeTime` that represents the value of `period`.

getStart

Signature

```
public javax.realtime.HighResolutionTime<?>
getStart()
```

Description

Gets the value of `start`. This is the value that was specified in the constructor or by `setStart()`, not the actual absolute time the corresponding to the start of the processing group.

Returns

a reference to an instance of `HighResolutionTime` that represents the value of `start`.

setCost(RelativeTime)

Signature

```
public void
setCost(RelativeTime cost)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `cost`.

Parameters

`cost`—The new value for `cost`. When `null`, an exception is thrown.

Throws

`IllegalArgumentException`—when `cost` is `null` or its time value is less than zero.

`IllegalAssignmentError`—when `cost` cannot be stored in `this`.

setCostOverrunHandler(AsyncEventHandler)

Signature

```
public void
setCostOverrunHandler(AsyncEventHandler handler)
throws IllegalAssignmentError
```

Description

Sets the cost overrun handler.

Parameters

`handler`—This handler is invoked when the `run()` method of and of the the schedulables attempt to execute for more than `cost` time units in any period. When `null`, no handler is attached, and any previous handler is removed.

Throws

`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

setDeadline(RelativeTime)

Signature

```
public void
setDeadline(RelativeTime deadline)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `deadline`.

Parameters

`deadline`—The new value for `deadline`. When `null`, the default value is new instance of `RelativeTime(period)`.

Throws

`IllegalArgumentException`—when `deadline` has a value less than zero or greater than the period. Unless the implementation supports deadline less than period in processing groups, `IllegalArgumentException` is also when `deadline` is less than the period.

`IllegalAssignmentError`—when `deadline` cannot be stored in `this`.

setDeadlineMissHandler(AsyncEventHandler)

Signature

```
public void
setDeadlineMissHandler(AsyncEventHandler handler)
throws IllegalAssignmentError
```

Description

Sets the deadline miss handler.

Parameters

`handler`—This handler is invoked when the `run()` method of any of the schedulables still expect to execute after the deadline has passed. When `null`, no handler is attached, and any previous handler is removed.

Throws

`IllegalAssignmentError`—when `handler` cannot be stored in `this`.

setIfFeasible(RelativeTime, RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime period,
              RelativeTime cost,
              RelativeTime deadline)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

This method first performs a feasibility analysis using the period, cost and deadline attributes as replacements for the matching attributes `this`. When the resulting system is feasible the method replaces the current attributes of this with the new attributes.

Parameters

`period`—The proposed period. There is no default value. When `period` is `null` an exception is thrown.

`cost`—The proposed cost. When `null`, an exception is thrown.

`deadline`—The proposed deadline. When `null`, the default value is new instance of `RelativeTime(period)`.

Throws

`IllegalArgumentException`—when the `period` is `null` or its time value is not greater than zero, or when the time value of `cost` is less than zero, or when the time value of `deadline` is not greater than zero.

`IllegalAssignmentError`—when `period`, `cost`, or `deadline` cannot be stored in `this`.

Returns

`true`, when the resulting system is feasible and the changes are made. `False`, when the resulting system is not feasible and no changes are made.

setPeriod(RelativeTime)

Signature

```
public void
setPeriod(RelativeTime period)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `period`.

Parameters

`period`—The new value for `period`. There is no default value. When `period` is `null` an exception is thrown.

Throws

`IllegalArgumentException`—when `period` is `null`, or its time value is not greater than zero. When the implementation does not support processing group deadline less than period, and `period` is not equal to the current value of the processing group's deadline, the deadline is set to a clone of `period` created in the same memory area as `period`.

`IllegalAssignmentError`—when `period` cannot be stored in `this`.

setStart(HighResolutionTime)

Signature

```
public void
setStart(HighResolutionTime<?> start)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Sets the value of `start`. When the processing group is already started this method alters the value of this object's start time property, but has no other effect.

Parameters

`start`—The new value for `start`. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

Throws

`IllegalAssignmentError`—when `start` cannot be stored in `this`.

`IllegalArgumentException`—when `start` is a relative time value and less than zero.

B.2.2.26 RationalTime

---

public class RationalTime

Inheritance

java.lang.Object
  HighResolutionTime<RelativeTime>
    RelativeTime
      RationalTime

Description

An object that represents a time interval milliseconds/10^3 + nanoseconds/10^9 seconds long that is divided into subintervals by some frequency. This is generally used in periodic events, threads, and feasibility analysis to specify periods where there is a basic period that must be adhered to strictly (the interval), but within that interval the periodic events are supposed to happen frequency times, as uniformly spaced as possible, but clock and scheduling jitter is moderately acceptable.

Caution: This class is explicitly unsafe for multithreading when being changed. Code that mutates instances of this class should synchronize at a higher level. **Deprecated** as of RTSJ 1.0.1

B.2.2.26.1 Constructors

RationalTime(int, long, int)

Signature

```
public
RationalTime(int frequency,
             long millis,
             int nanos)
```

Description

Constructs an instance of `RationalTime`. All arguments must be greater than or equal to zero.

Parameters

`frequency`—The frequency value.

`millis`—The milliseconds value.

`nanos`—The nanoseconds value.

Throws

`IllegalArgumentException`—when any of the argument values are less than zero, or when `frequency` is equal to zero.

RationalTime(int, RelativeTime)

Signature

```
public
RationalTime(int frequency,
             RelativeTime interval)
```

Description

Constructs an instance of `RationalTime` from the given `RelativeTime`.

Parameters

`frequency`—The frequency value.

`interval`—The given instance of `RelativeTime`.

Throws

`IllegalArgumentException`—when either of the argument values are less than zero, or when `frequency` is equal to zero.

RationalTime(int)

Signature

```
public
RationalTime(int frequency)
```

Description

Constructs an instance of `RationalTime`. Equivalent to new `RationalTime(1000, 0, frequency)`—essentially a cycles-per-second value.

Throws

`IllegalArgumentException`—when `frequency` is less than or equal to zero.

B.2.2.26.2 Methods

---

absolute(Clock, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Clock clock,
         AbsoluteTime destination)
```

Description

Converts time of `this` to an absolute time.

Parameters
`clock`—The reference clock. When `null`, `Clock.getRealTimeClock()` is used.
`destination`—A reference to the destination instance.

getFrequency

Signature

```
public int
getFrequency()
```

Description

Gets the value of `frequency`.

Returns
The value of `frequency` as an integer.

getInterarrivalTime

Signature

```
public javax.realtime.RelativeTime
getInterarrivalTime()
```

Description

Gets the interarrival time. This time is `(milliseconds/10`^{3} `+ nanoseconds/10`^{9}`)/frequency` rounded down to the nearest expressible value of the fields and their types of `RelativeTime`.

getInterarrivalTime(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getInterarrivalTime(RelativeTime dest)
```

Description

Gets the interarrival time. This time is `(milliseconds / 10<sup>3</sup> + nanoseconds / 10<sup>9</sup>) / frequency` rounded down to the nearest expressible value of the fields and their types of `RelativeTime`.

Parameters
`dest`—Result is stored in dest and returned, when `null`, a new object is returned.

set(long, int)

Signature

```
public javax.realtime.RationalTime
set(long millis,
    int nanos)
```

Description

Sets the indicated fields to the given values.

Parameters
`millis`—The new value for the millisecond field.
`nanos`—The new value for the nanosecond field.
Returns
`this`

Since RTSJ 2.0 returns itself

setFrequency(int)

Signature

```
public void
setFrequency(int frequency)
```

Description

Sets the value of the `frequency` field.

Parameters
`frequency`—The new value for the `frequency`.
Throws
`IllegalArgumentException`—when `frequency` is less than or equal to zero.

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a printable string of the time given by `this`.

The string shall be a decimal representation of the frequency, milliseconds and nanosecond values; formatted as follows "(100, 2251 ms, 750000 ns)"

Returns
a string object converted from the time given by `this`.

B.2.2.27 RawMemoryAccess

---

public class RawMemoryAccess

Inheritance
java.lang.Object
RawMemoryAccess

Description

An instance of `RawMemoryAccess` models a range of physical memory as a fixed sequence of bytes. A complement of accessor methods enable the contents of the physical area to be accessed through offsets from the base, interpreted as byte, short, int, or long data values or as arrays of these types.

Whether an offset addresses the high-order or low-order byte is normally based on the value of the `RealtimeSystem.BYTE_ORDER` static byte variable in class `RealtimeSystem`. When the type of memory used for this `RawMemoryAccess` region implements non-standard byte ordering, accessor methods in this class continue to select bytes starting at `offset` from the base address and continuing toward greater addresses. The memory type may control the mapping of these bytes into the primitive data type. The memory type could even select bytes that are not contiguous. In each case the documentation for the `PhysicalMemoryTypeFilter` must document any mapping other than the "normal" one specified above.

The `RawMemoryAccess` class allows a realtime program to implement device drivers, memory-mapped I/O, flash memory, battery-backed RAM, and similar low-level software.

A raw memory area cannot contain references to Java objects. Such a capability would be unsafe (since it could be used to defeat Java's type checking) and error-prone (since it is sensitive to the specific representational choices made by the Java compiler).

Many of the constructors and methods in this class throw `OffsetOutOfBoundsException`. This exception means that the value given in the offset parameter is either negative or outside the memory area.

Many of the constructors and methods in this class throw `SizeOutOfBoundsException`. This exception means that the value given in the size parameter is either negative, larger than an allowable range, or would cause an accessor method to access an address outside of the memory area.

Unlike other integral parameters in this chapter, negative values are valid for `byte, short, int,` and `long` values that are copied in and out of memory by the `set` and `get` methods of this class.

All offset values used in this class are measured in bytes.

Atomic loads and stores on raw memory are defined in terms of physical memory. This memory may be accessible to threads outside the JVM and to non-programmed access (e.g., DMA), consequently atomic access must be supported by hardware. This specification is written with the assumption that all suitable hardware platforms support atomic loads for aligned bytes, shorts, and ints. Atomic access beyond the specified minimum may be supported by the implementation.

Storing values into raw memory is more hardware-dependent than loading values. Many processor architectures do not support atomic stores of variables except for aligned stores of the processor's word size. For instance, storing a byte into memory might require reading a 32-bit quantity into a processor register, updating the register to reflect the new byte value, then re-storing the whole 32-bit quantity. Changes to other bytes in the 32-bit quantity that take place between the load and the store will be lost.

Some processors have mechanisms that can be used to implement an atomic store of a byte, but those mechanisms are often slow and not universally supported.

This class supports unaligned access to data, but it does not require the implementation to make such access atomic. Accesses to data aligned on its natural boundary will be atomic when the processor implements atomic loads and stores of that data size.

Except where noted, accesses to raw memory are not atomic with respect to the memory or with respect to schedulables. A raw memory area could be updated by another schedulable, or even unmapped in the middle of a method.

The characteristics of raw-memory access are necessarily platform dependent. This specification provides a minimum requirement for the RTSJ platform, but it also supports optional system properties that identify a platform's level of support for atomic raw put and get. The properties represent a four-dimensional sparse array with boolean values indicating whether that combination of access attributes is atomic. The default value for array entries is false. The dimension are

Table B.3: Properties Array

Attribute	**Values**	**Comment**
Access type	read, write	
Data type	byte, short, int, long, float, double	
Alignment	0	aligned
	1 to one less than data type size	the first byte of the data is *alignment* bytes away from natural alignment.
Atomicity	processor	means access is atomic with respect to other taska on processor.
	smp	means access is *processor* atomic, and atomic with respect to all processors in an SMP.
	memory	means that access is *smp* atomic, and atomic with respect to all access to the memory including DMA.

The true values in the table are represented by properties of the following form. javax.realtime.atomicaccess_<access>_<type>_<alignment>_atomicity=true for example:

```
javax.realtime.atomicaccess_read_byte_0_memory=true
```

Table entries with a value of false may be explicitly represented, but since false is the default value, such properties are redundant.

All raw memory access is treated as volatile, and *serialized*. The run-time must be forced to re-read memory or write to memory on each call to a raw memory `get<type>` or `put<type>` method, where `type` is defined in the table above, and to complete the reads and writes in the order they appear in the program order.

Deprecated as of RTSJ 2.0. Use `javax.realtime.device.RawMemoryFactory` to create the appropriate `javax.realtime.device.RawMemory` object.

B.2.2.27.1 Constructors

RawMemoryAccess(Object, long, long)

Signature

```
public
RawMemoryAccess(Object type,
                long base,
                long size)
```

Description

Constructs an instance of `RawMemoryAccess` with the given parameters, and sets the object to the mapped state. When the platform supports virtual memory, maps the raw memory into virtual memory.

The run time environment is allowed to choose the virtual address where the raw memory area corresponding to this object will be mapped. The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

Parameters

`type`—An instance of `Object` representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the region.

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when application doesn't have permissions to access physical memory, the specified range of addresses, or the given type of memory.

`OffsetOutOfBoundsException`—when the address is invalid.

`SizeOutOfBoundsException`—when the size is negative or extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the request type, or when `type` specifies incompatible memory attributes.

`OutOfMemoryError`—when the requested type of memory exists, but there is not enough of it free to satisfy the request.

RawMemoryAccess(Object, long)

Signature

```
public
RawMemoryAccess(Object type,
                long size)
```

Description

Constructs an instance of `RawMemoryAccess` with the given parameters, and sets the object to the mapped state. When the platform supports virtual memory, maps the raw memory into virtual memory.

The run time environment is allowed to choose the virtual address where the raw memory area corresponding to this object will be mapped. The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

Parameters

`type`—An instance of `Object` representing the type of memory required (e.g., *dma, shared*) - used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory, the specified range of addresses, or the given type of memory.

`SizeOutOfBoundsException`—when the size is negative or extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the request type, or when `type` specifies incompatible memory

attributes.

`OutOfMemoryError`—when the requested type of memory exists, but there is not enough of it free to satisfy the request.

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

B.2.2.27.2 Methods

---

getByte(long)

Signature

```
public byte
getByte(long offset)
```

Description

Gets the `byte` at the given offset in the memory area associated with this object. The byte is always loaded from memory in a single atomic operation.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory from which to load the byte.

Throws

`SizeOutOfBoundsException`—when the object is not mapped, or when the byte falls in an invalid address range.

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the byte from raw memory.

See Section RawMemoryAccess.map(long,long)

getBytes(long, byte, int, int)

Signature

```
public void
getBytes(long offset,
         byte[] bytes,
         int low,
         int number)
```

Description

Gets `number` bytes starting at the given offset in the memory area associated with this object and assigns them to the byte array passed starting at position `low`. Each byte is loaded from memory in a single atomic operation. Groups of bytes may be loaded together, but this is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory from which to start loading.

`bytes`—The array into which the loaded items are placed.

`low`—The offset which is the starting point in the given array for the loaded items to be placed.

`number`—The number of items to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a byte falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `byte` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

getInt(long)

Signature

```
public int
getInt(long offset)
```

Description

Gets the `int` at the given offset in the memory area associated with this object. When the integer is aligned on a "natural" boundary it is always loaded from memory in a single atomic operation. When it is not on a natural boundary it may not be loaded atomically, and the number and order of the load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to load the integer.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the integer falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the integer from raw memory.

See Section RawMemoryAccess.map(long,long)

getInts(long, int, int, int)

Signature

```
public void
getInts(long offset,
        int[] ints,
        int low,
        int number)
```

Description

Gets `number` integers starting at the given offset in the memory area associated with this object and assign them to the `int` array passed starting at position `low`.

When the integers are aligned on natural boundaries each integer is loaded from memory in a single atomic operation. Groups of integers may be loaded together, but this is unspecified. When the integers are not aligned on natural boundaries they may not be loaded atomically and the number and order of load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start loading.

`ints`—The array into which the integers read from the raw memory are placed.

`low`—The offset which is the starting point in the given array for the loaded items to be placed.

`number`—The number of integers to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when an integer falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `int` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

getLong(long)

Signature

```
public long
getLong(long offset)
```

Description

Gets the `long` at the given offset in the memory area associated with this object. The load is not required to be atomic even it is located on a natural boundary.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to load the long.

Throws

`OffsetOutOfBoundsException`—when the offset is invalid.

`SizeOutOfBoundsException`—when the object is not mapped, or when the long falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the long from raw memory.

getLongs(long, long, int, int)

Signature

```
public void
getLongs(long offset,
         long[] longs,
         int low,
         int number)
```

Description

Gets `number` longs starting at the given offset in the memory area associated with this object and assign them to the `longs` array passed starting at position `low`.

The loads are not required to be atomic even when they are located on natural boundaries.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start loading.

`longs`—The array into which the loaded items are placed.

`low`—The offset which is the starting point in the given array for the loaded items to be placed.

`number`—The number of longs to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a long falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped.

The `long` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

getMappedAddress

Signature

```
public long
getMappedAddress()
```

Description

Gets the virtual memory location at which the memory region is mapped.

Throws

`IllegalStateException`—when the raw memory object is not in the mapped state.

Returns

the virtual address to which `this` is mapped, for reference purposes. When virtual memory is not supported, this is the same as the physical base address.

getShort(long)

Signature

```
public short
getShort(long offset)
```

Description

Gets the `short` at the given offset in the memory area associated with this object. When the short is aligned on a natural boundary it is always loaded from memory in a single atomic operation. When it is not on a natural boundary it may not be loaded atomically, and the number and order of the load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to load the short.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the short falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the short loaded from raw memory.

See Section RawMemoryAccess.map(long,long)

getShorts(long, short, int, int)

Signature

```
public void
getShorts(long offset,
          short[] shorts,
          int low,
          int number)
```

Description

Gets `number` shorts starting at the given offset in the memory area associated with this object and assign them to the `short` array passed starting at position `low`.

When the shorts are located on natural boundaries each short is loaded from memory in a single atomic operation. Groups of shorts may be loaded together, but this is unspecified.

When the shorts are not located on natural boundaries the load may not be atomic, and the number and order of load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to start loading.

`shorts`—The array into which the loaded items are placed.

`low`—The offset which is the starting point in the given array for the loaded shorts to be placed.

`number`—The number of shorts to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException`

somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a short falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `short` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

map

Signature

```
public long
map()
```

Description

Maps the physical memory range into virtual memory. No-op when the system doesn't support virtual memory.

The run time environment is allowed to choose the virtual address where the raw memory area corresponding to this object will be mapped. The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

When the object is already mapped into virtual memory, this method does not change anything.

Throws

`OutOfMemoryError`—when there is insufficient free virtual address space to map the object.

Returns

the starting point of the virtual memory range.

map(long)

Signature

```
public long
map(long base)
```

Description

Maps the physical memory range into virtual memory at the specified location. No-op when the system doesn't support virtual memory.

The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

When the object is already mapped into virtual memory at a different address, this method remaps it to `base`.

When a remap is requested while another schedulable is accessing the raw memory, the map will block until one load or store completes. It can interrupt an array operation between entries.

Parameters

`base`—The location to map at the virtual memory space.

Throws

`OutOfMemoryError`—when there is insufficient free virtual memory at the specified address.

`IllegalArgumentException`—when `base` is not a legal value for a virtual address, or the memory-mapping hardware cannot place the physical memory at the designated address.

Returns

the starting point of the virtual memory.

map(long, long)

Signature

```
public long
map(long base,
    long size)
```

Description

Maps the physical memory range into virtual memory. No-op when the system doesn't support virtual memory.

The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

When the object is already mapped into virtual memory at a different address, this method remaps it to `base`.

When a remap is requested while another schedulable is accessing the raw memory, the map will block until one load or store completes. It can interrupt an array operation between entries.

Parameters

`base`—The location to map at the virtual memory space.

`size`—The size of the block to map in. When the size of the raw memory area is greater than `size`, the object is unchanged but accesses beyond the mapped region will throw `SizeOutOfBoundsException`. When the size of the raw memory area is smaller than the mapped region, access to the raw memory will behave as if the mapped region matched the raw memory area, but additional virtual address space will be consumed after the end of the raw memory area.

Throws

`IllegalArgumentException`—when size is not greater than zero, `base` is not a legal value for a virtual address, or the memory-mapping hardware cannot place the physical memory at the designated address.

Returns

the starting point of the virtual memory.

setByte(long, byte)

Signature

```
public void
setByte(long offset,
        byte value)
```

Description

Sets the `byte` at the given offset in the memory area associated with this object.

This memory access may involve a load and a store, and it may have unspecified effects on surrounding bytes in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area to which to write the byte.

`value`—The byte to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the byte falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setBytes(long, byte, int, int)

Signature

```
public void
setBytes(long offset,
         byte[] bytes,
         int low,
         int number)
```

Description

Sets `number` bytes starting at the given offset in the memory area associated with this object from the `byte` array passed starting at position `low`.

This memory access may involve multiple load and a store operations, and it may have unspecified effects on surrounding bytes (even bytes in the range being stored) in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area to which to start writing.

`bytes`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of items to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a byte falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The store of the array into memory could, therefore, be only partially complete when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setInt(long, int)

Signature

```
public void
setInt(long offset,
       int value)
```

Description

Sets the `int` at the given offset in the memory area associated with this object. On most processor architectures an aligned integer can be stored in an atomic operation, but this is not required.

This memory access may involve multiple load and a store operations, and it may have unspecified effects on surrounding bytes (even bytes in the range being stored) in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to write the integer.

`value`—The integer to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the integer falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setInts(long, int, int, int)

Signature

```
public void
setInts(long offset,
        int[] ints,
        int low,
        int number)
```

Description

Sets `number` ints starting at the given offset in the memory area associated with this object from the `int` array passed starting at position `low`. On most processor architectures each aligned integer can be stored in an atomic operation, but this is not required.

This memory access may involve multiple load and a store operations, and it may have unspecified effects on surrounding bytes (even bytes in the range being stored) in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start writing.

`ints`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of items to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when an integer falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The store of the array into memory could, therefore, be only partially complete when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setLong(long, long)

Signature

```
public void
setLong(long offset,
        long value)
```

Description

Sets the `long` at the given offset in the memory area associated with this object. Even when it is aligned, the long value may not be updated atomically. It is unspecified how many load and store operations will be used or in what order.

This memory access may involve multiple load and a store operations, and it may have unspecified effects on surrounding bytes (even bytes in the range being

stored) in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to write the long.

`value`—The long to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the long falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setLongs(long, long, int, int)

Signature

```
public void
setLongs(long offset,
         long[] longs,
         int low,
         int number)
```

Description

Sets `number` longs starting at the given offset in the memory area associated with this object from the `long` array passed starting at position `low`. Even when they are aligned, the long values may not be updated atomically. It is unspecified how many load and store operations will be used or in what order.

This memory access may involve multiple load and a store operations, and it may have unspecified effects on surrounding bytes (even bytes in the range being stored) in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start writing.

`longs`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of items to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a long falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The store of the array into memory could, therefore, be only partially complete when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setShort(long, short)

Signature

```
public void
setShort(long offset,
         short value)
```

Description

Sets the `short` at the given offset in the memory area associated with this object.

This memory access may involve a load and a store, and it may have unspecified effects on surrounding shorts in the presence of concurrent access.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to write the short.

`value`—The short to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when the short falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

setShorts(long, short, int, int)

Signature

```
public void
setShorts(long offset,
          short[] shorts,
          int low,
          int number)
```

Description

Sets `number` shorts starting at the given offset in the memory area associated with this object from the `short` array passed starting at position `low`.

Each write of a short value may involve a load and a store, and it may have unspecified effects on surrounding shorts in the presence of concurrent access - even on other shorts in the array.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start writing.

`shorts`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of items to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

`SizeOutOfBoundsException`—when the object is not mapped, or when a short falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The

store of the array into memory could, therefore, be only partially complete when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

unmap

Signature

```
public void
unmap()
```

Description

Unmaps the physical memory range from virtual memory. This changes the raw memory from the mapped state to the unmapped state. When the platform supports virtual memory, this operation frees the virtual addresses used for the raw memory region.

When the object is already in the unmapped state, this method has no effect.

While a raw memory object is unmapped all attempts to set or get values in the raw memory will throw `SizeOutOfBoundsException`.

An unmapped raw memory object can be returned to mapped state with any of the object's `map` methods.

When an unmap is requested while another schedulable is accessing the raw memory, the `unmap` will throw an `IllegalStateException`. The `unmap` method can interrupt an array operation between entries.

B.2.2.28 RawMemoryFloatAccess

---

public class RawMemoryFloatAccess

Inheritance

java.lang.Object
  RawMemoryAccess
    RawMemoryFloatAccess

Description

This class holds the accessor methods for accessing a raw memory area by float and double types. Implementations are required to implement this class when and only when the underlying Java Virtual Machine supports floating point data types.

See `RawMemoryAccess` for commentary on changes in the preferred use of this class following RTSJ 2.0.

By default, the byte addressed by `offset` is the byte at the lowest address of the floating point processor's floating point representation. When the type of memory used for this `RawMemoryFloatAccess` region implements a non-standard floating point format, accessor methods in this class continue to select bytes starting at `offset` from the base address and continuing toward greater addresses. The memory type may control the mapping of these bytes into the primitive data type. The memory type could even select bytes that are not contiguous. In each case the documentation for the `PhysicalMemoryTypeFilter` must document any mapping other than the "normal" one specified above.

All offset values used in this class are measured in bytes.

Atomic loads and stores on raw memory are defined in terms of physical memory. This memory may be accessible to threads outside the JVM and to non-programmed access, e.g., DMA, consequently atomic access must be supported by hardware. This specification is written with the assumption that all suitable hardware platforms support atomic loads for aligned floats. Atomic access beyond the specified minimum may be supported by the implementation.

Storing values into raw memory is more hardware-dependent than loading values. Many processor architectures do not support atomic stores of variables except for aligned stores of the processor's word size.

This class supports unaligned access to data, but it does not require the implementation to make such access atomic. Accesses to data aligned on its natural boundary will be atomic when the processor implements atomic loads and stores of that data size.

Except where noted, accesses to raw memory are not atomic with respect to the memory or with respect to threads. A raw memory area could be updated by another thread, or even unmapped in the middle of a method.

The characteristics of raw-memory access are necessarily platform dependent. This specification provides a minimum requirement for the RTSJ platform, but it also supports optional system properties that identify a platform's level of support for atomic raw put and get. (See `RawMemoryAccess`.) The properties represent a four-dimensional sparse array with boolean values, indicating whether that combination of access attributes is atomic. The default value for array entries is false.

Many of the constructors and methods in this class throw `OffsetOutOfBoundsException`. This exception means that the value given in the offset parameter is either negative or outside the memory area.

Many of the constructors and methods in this class throw `SizeOutOfBoundsException`. This exception means that the value given in the size parameter is either negative, larger than an allowable range, or would cause an accessor method to access an address outside of the memory area.

Deprecated as of RTSJ 2.0. Use `javax.realtime.device.RawMemory`.

B.2.2.28.1 Constructors

RawMemoryFloatAccess(Object, long, long)

Signature

```
public
RawMemoryFloatAccess(Object type,
                     long base,
                     long size)
```

Description

Constructs an instance of `RawMemoryFloatAccess` with the given parameters, and sets the object to the mapped state. When the platform supports virtual memory, maps the raw memory into virtual memory.

The run time environment is allowed to choose the virtual address where the raw memory area corresponding to this object will be mapped. The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, for defining the base address and controlling the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the region.

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory, the specified range of addresses, or the given type of memory.

`OffsetOutOfBoundsException`—when the address is invalid.

`SizeOutOfBoundsException`—when the size is negative or extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the request type, or when `type` specifies incompatible memory attributes.

`OutOfMemoryError`—when the requested type of memory exists, but there is not enough of it free to satisfy the request.

RawMemoryFloatAccess(Object, long)

Signature

```
public
RawMemoryFloatAccess(Object type,
                     long size)
```

Description

Constructs an instance of `RawMemoryFloatAccess` with the given parameters, and sets the object to the mapped state. When the platform supports virtual memory, maps the raw memory into virtual memory.

The run time environment is allowed to choose the virtual address where the raw memory area corresponding to this object will be mapped. The attributes of the mapping operation are controlled by the vMFlags and vMAttributes of the `PhysicalMemoryTypeFilter` objects that matched this object's `type` parameter. (See `PhysicalMemoryTypeFilter.getVMAttributes` and `PhysicalMemoryTypeFilter.getVMFlags`.

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*), for defining the base address and controlling the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory, the specified range of addresses, or the given type of memory.

`SizeOutOfBoundsException`—when the size is negative or extends into an invalid range of memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the request type, or when `type` specifies incompatible memory attributes.

`OutOfMemoryError`—when the requested type of memory exists, but there is not enough of it free to satisfy the request.

B.2.2.28.2 Methods

---

getDouble(long)

Signature

```
public double
getDouble(long offset)
```

Description

Gets the `double` at the given offset in the memory area associated with this object.

The load is not required to be atomic even it is located on a natural boundary.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to load the double.

Throws

`OffsetOutOfBoundsException`—when the offset is invalid.

`SizeOutOfBoundsException`—when the object is not mapped, or when the double falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the double from raw memory.

getDoubles(long, double, int, int)

Signature

```
public void
getDoubles(long offset,
           double[] doubles,
           int low,
           int number)
```

Description

Gets `number` doubles starting at the given offset in the memory area associated with this object and assigns them to the `double` array passed starting at position `low`.

The loads are not required to be atomic even when they are located on natural boundaries.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start loading.

`doubles`—The array into which the loaded items are placed.

`low`—The offset which is the starting point in the given array for the loaded items to be placed.

`number`—The number of doubles to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when a double falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `double` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

getFloat(long)

Signature

```
public float
getFloat(long offset)
```

Description

Gets the `float` at the given offset in the memory area associated with this object. When the float is aligned on a "natural" boundary it is always loaded from memory in a single atomic operation. When it is not on a natural boundary it may not be loaded atomically, and the number and order of the load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area from which to load the float.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException`

somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when the float falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

Returns

the float from raw memory.

getFloats(long, float, int, int)

Signature

```
public void
getFloats(long offset,
          float[] floats,
          int low,
          int number)
```

Description

Gets `number` floats starting at the given offset in the memory area associated with this object and assign them to the `floats` array passed starting at position `low`.

When the floats are aligned on natural boundaries each float is loaded from memory in a single atomic operation. Groups of floats may be loaded together, but this is unspecified.

When the floats are not aligned on natural boundaries they may not be loaded atomically and the number and order of load operations is unspecified.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start loading.

`floats`—The array into which the floats loaded from the raw memory are placed.

`low`—The offset which is the starting point in the given array for the loaded items to be placed.

`number`—The number of floats to load.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when a float falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `float` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

setDouble(long, double)

Signature

```
public void
setDouble(long offset,
          double value)
```

Description

Sets the `double` at the given offset in the memory area associated with this object. Even when it is aligned, the double value may not be updated atomically. It is unspecified how many load and store operations will be used or in what order.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to write the double.

`value`—The double to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when the double falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

setDoubles(long, double, int, int)

Signature

```
public void
setDoubles(long offset,
           double[] doubles,
           int low,
           int number)
```

Description

Sets `number` doubles starting at the given offset in the memory area associated with this object from the `doubles` array passed starting at position `low`. Even when they are aligned, the double values may not be updated atomically. It is unspecified how many load and store operations will be used or in what order.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start writing.

`doubles`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of items to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when a double falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The `doubles` array could, therefore, be partially updated when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

setFloat(long, float)

Signature

```
public void
setFloat(long offset,
         float value)
```

Description

Sets the `float` at the given offset in the memory area associated with this object. On most processor architectures an aligned float can be stored in an atomic operation, but this is not required.

Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to write the float.

`value`—The float to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long,long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when the float falls in an invalid address range.

`StaticSecurityException`—when this access is not permitted by the security manager.

setFloats(long, float, int, int)

Signature

```
public void
setFloats(long offset,
          float[] floats,
          int low,
          int number)
```

Description

Sets `number` floats starting at the given offset in the memory area associated with this object from the `float` array passed starting at position `low`. On most processor architectures each aligned float can be stored in an atomic operation, but this is not required. Caching of the memory access is controlled by the memory `type` requested when the `RawMemoryAccess` instance was created. When the memory is not cached, this method guarantees serialized access (that is, the memory access at the memory occurs in the same order as in the program. Multiple writes to the same location may not be coalesced.)

Parameters

`offset`—The offset in bytes from the beginning of the raw memory area at which to start writing.

`floats`—The array from which the items are obtained.

`low`—The offset which is the starting point in the given array for the items to be obtained.

`number`—The number of floats to write.

Throws

`OffsetOutOfBoundsException`—when the offset is negative or greater than the size of the raw memory area. The role of the `SizeOutOfBoundsException` somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area. (See `RawMemoryAccess.map(long, long)`).

`SizeOutOfBoundsException`—when the object is not mapped, or when a float falls in an invalid address range. This is checked at every entry in the array to allow for the possibility that the memory area could be unmapped or remapped. The store of the array into memory could, therefore, be only partially complete when the raw memory is unmapped or remapped mid-method.

`ArrayIndexOutOfBoundsException`—when `low` is less than 0 or greater than `bytes.length - 1`, or when `low + number` is greater than or equal to `bytes.length`.

`StaticSecurityException`—when this access is not permitted by the security manager.

B.2.2.29 RealtimeSecurity

---

public class RealtimeSecurity

Inheritance

java.lang.Object
  RealtimeSecurity

Description

Security policy object for realtime specific issues. Primarily used to control access to physical memory.

Security requirements are generally application-specific. Every implementation shall have a default `RealtimeSecurity` instance, and a way to install a replacement at run-time, `RealtimeSystem.setSecurityManager`. The default security is minimal. All security managers should prevent access to JVM internal data and the Java heap; additional protection is implementation-specific and must be documented.

Deprecated since RTSJ 2.0

B.2.2.29.1 Constructors

RealtimeSecurity

Signature

```
public
RealtimeSecurity()
```

Description

Create an `RealtimeSecurity` object.

B.2.2.29.2 Methods

---

checkAccessPhysical

Signature

```
public void
checkAccessPhysical()
throws StaticSecurityException
```

Description

Check whether the application is allowed to access physical memory.

Throws

`StaticSecurityException`—The application doesn't have permission to access physical memory.

checkAccessPhysicalRange(long, long)

Signature

```
public void
checkAccessPhysicalRange(long base,
                         long size)
throws StaticSecurityException
```

Description

Checks whether the application is allowed to access physical memory within the specified range.

Parameters

`base`—The beginning of the address range.

`size`—The size of the address range.

Throws

`StaticSecurityException`—The application doesn't have permission to access the memory in the given range.

checkSetFilter

Signature

```
public void
checkSetFilter()
throws StaticSecurityException
```

Description

Checks whether the application is allowed to register `PhysicalMemoryTypeFilter` objects with the `PhysicalMemoryManager`.

Throws

`StaticSecurityException`—The application doesn't have permission to register filter objects.

checkSetMonitorControl(MonitorControl)

Signature

```
public void
checkSetMonitorControl(MonitorControl policy)
throws StaticSecurityException
```

Description

Checks whether the application is allowed to set the default monitor control policy.

Parameters

`policy`—The new policy

Throws

`StaticSecurityException`—when the application doesn't have permission to change the default monitor control policy to `policy`.

Since RTSJ 1.0.1

checkAEHSetDaemon

Signature

```
public void
checkAEHSetDaemon()
throws StaticSecurityException
```

Description

Checks whether the application is allowed to set the daemon status of an AEH.

Throws

`StaticSecurityException`—when the application is not permitted to alter the daemon status.

Since RTSJ 1.0.1

checkSetScheduler

Signature

```
public void
checkSetScheduler()
throws StaticSecurityException
```

Description

Checks whether the application is allowed to set the scheduler.

Throws

`StaticSecurityException`—The application doesn't have permission to set the scheduler.

B.2.2.30 *RealtimeSystem*

---

public class RealtimeSystem

The following elements of RealtimeSystem are deprecated. The required elements are documented in Section 16.2.2.5 above.

B.2.2.30.1 Methods

---

getSecurityManager

Signature

```
public static javax.realtime.RealtimeSecurity
getSecurityManager()
```

Description

Gets a reference to the security manager used to control access to realtime system features such as access to physical memory.

Returns

a `RealtimeSecurity` object representing the default realtime security manager.

Deprecated since RTSJ 2.0

B.2.2.31 *RealtimeThread*

---

public class RealtimeThread

The following elements of RealtimeThread are deprecated. The required elements are documented in Section 5.3.2.2 above.

B.2.2.31.1 Constructors

RealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               ReleaseParameters<?> release,
               MemoryParameters memory,
               MemoryArea area,
               ProcessingGroupParameters group,
               Runnable logic)
```

Description

Creates a realtime thread with the given characteristics and a Runnable. This is equivalent to `RealtimeThread(scheduling, release, memory, area, null, group, null, null, logic)`.

Deprecated since RTSJ 2.0

Throws

`StaticIllegalStateException`—when the `ThreadGroup` of the calling thread is not an instance of `RealtimeThreadGroup`.

B.2.2.31.2 Methods

getInitialMemoryAreaIndex

Signature

```
public static int
getInitialMemoryAreaIndex()
throws StaticIllegalStateException,
       ClassCastException
```

Description

Gets the position of the initial memory area for the current `Schedulable` in the memory area stack. Memory area stacks may include inherited stacks from parent threads. The initial memory area of a `RealtimeThread` or an `AsyncBaseEventHandler` is the memory area specified in its constructor. The index of the initial memory area in the initial memory area stack is a fixed property of a `Schedulable`.

Throws

`StaticIllegalStateException`—when the memory area stack of the current `Schedulable` has changed from its initial configuration and the memory area at the originally specified initial memory area index is not the initial memory area, thus the index is invalid.
This can only happen when the application uses the alternate memory module and the initial memory area is a scoped memory area. The following is an example of an event handler that will throw this exception when its initial memory area is a scoped memory area.

```
public void handleAsyncEvent()
{
  MemoryArea current = RealtimeThread.getCurrentMemoryArea();
  if (current instanceof ScopedMemory)
    {
      MemoryArea parent =
        ((ScopedMemory) current).getParent();
      parent.executeInArea(() ->
      {
        ScopedMemory scope = new LTMemory(1000);
        scope.enter(() ->
        {
          System.out.println("Initial Memory Area Index = " +
          RealtimeThread.getInitialMemoryAreaIndex());
         });
      });
    }
}
```

`ClassCastException`—when the current execution context is not an instance of `Schedulable`. An exception will be thrown on line 12, where the first opening bracket is line one, of the handler above.

Returns
the index into the initial memory area stack of the initial memory area of the current `Schedulable`.

Deprecated as of RTSJ 2.0.

getMemoryAreaStackDepth

Signature

```
public static int
getMemoryAreaStackDepth()
throws ClassCastException
```

Description

Gets the size of the memory area stack of `MemoryArea` instances to which the current schedulable has access. For a realtime thread started with immortal or heap as its explicit initial memory area, the initial size is one. The current memory area (`getCurrentMemoryArea()`) is found at memory area stack index of `getMemoryAreaStackDepth() - 1`.

Throws

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

Returns

the size of the stack of `MemoryArea` instances.

Deprecated as of RTSJ 2.0

getOuterMemoryArea(int)

Signature

```
public static javax.realtime.MemoryArea
getOuterMemoryArea(int index)
throws ClassCastException,
       MemoryAccessError
```

Description

Gets the instance of `MemoryArea` in the memory area stack at the index given. When the given index does not exist in the memory area stack, then `null` is returned. For a thread started with immortal or heap as its explicit initial memory area, the index of that area is zero. The current memory area (`getCurrentMemoryArea()`) is found at memory area stack index `getMemoryAreaStackDepth() - 1`, so `getCurrentMemoryArea() == getOutMemoryArea(getMemoryAreaStackDepth() - 1)`.

Note that accessing the stack should have a maximum complexity of `O(n`, where `n` is the stack depth. This means the memory stack need not be backed by an array.

Parameters

`index`—The offset into the memory area stack.

Throws

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`MemoryAccessError`—when the memory area is allocated in heap memory and the caller is a schedulable that may not use the heap.

Returns

the instance of `MemoryArea` at index or `null` when the given index does not correspond to a position in the stack.

sleep(Clock, HighResolutionTime)

Signature

```
public static void
sleep(Clock clock,
      HighResolutionTime<?> time)
throws InterruptedException,
       ClassCastException,
       StaticUnsupportedOperationException,
       StaticIllegalArgumentException
```

Description

A sleep method that is controlled by a generalized clock. Since the time is expressed as a `HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution available for the clock and even the quantity it measures depends on `clock` associated with `time`. The time base is the given `Clock` associated with `time`. The sleep time may be relative or absolute. When relative, then the calling thread is blocked for the amount of time given by `time`, and measured by `clock`. When absolute, then the calling thread is blocked until the indicated value is reached by `clock`. When the given absolute time is less than or equal to the current value of `clock`, the call to sleep returns immediately.

Calling `sleep` is permissible when control is in an `AsyncEventHandler`. The method causes the handler to sleep.

This method must not throw `IllegalAssignmentError`. It must tolerate `time` instances that may not be stored in `this`.

Parameters

`clock`—The instance of `Clock` used as the base. When `clock` is `null` the realtime clock (see `Clock.getRealtimeClock`) is used. When `time` uses a time-base other than `clock`, `time` is reassociated with `clock` for purposes of this method.

`time`—The amount of time to sleep or the point in time at which to awaken.

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.

`ClassCastException`—when the current execution context is not an instance of `Schedulable`.

`StaticUnsupportedOperationException`—when the sleep operation is not supported by `clock`.

`StaticIllegalArgumentException`—when `time` is `null`, or when `time` is a relative time less than zero.

Deprecated in RTSJ 2.0

waitForNextPeriod

Signature

```
public static boolean
waitForNextPeriod()
throws ClassCastException,
       IllegalThreadStateException
```

Description

Causes the current realtime thread to delay until the beginning of the next period. Used by threads that have a reference to a `ReleaseParameters` type of `PeriodicParameters` to block until the start of each period. The first period starts when `this` thread is first released. Each time it is called this method will block until the start of the next period unless the thread is in a deadline miss condition. In that case the operation of `waitForNextPeriod()` is controlled by this thread's scheduler. (See `PriorityScheduler`.)

Throws

`IllegalThreadStateException`—when `this` does not have a reference to a `ReleaseParameters` type of `PeriodicParameters`.

`ClassCastException`—when the current thread is not an instance of `RealtimeThread`.

Returns

either `false` when the thread is in a deadline miss condition or `true` otherwise. When a deadline miss condition occurs is defined by its thread's scheduler.

Since RTSJ 1.0.1 Changed from an instance method to a static method.
Deprecated RTSJ 2.0 Replaced by `waitForNextRelease()`

waitForNextPeriodInterruptible

Signature

```
public static boolean
waitForNextPeriodInterruptible()
throws InterruptedException,
       ClassCastException,
       IllegalThreadStateException
```

Description

The `waitForNextPeriodInterruptible()` method is a duplicate of `waitForNextPeriod()` except that `waitForNextPeriodInterruptible()` is able to throw `InterruptedException`.

Used by threads that have a reference to a `ReleaseParameters` type of `PeriodicParameters` to block until the start of each period. The first period starts when `this` thread is first released. Each time it is called, this method will block until the start of the next period unless the thread is in a deadline miss condition. In that case the operation of `waitForNextPeriodInterruptible()` is controlled by this thread's scheduler. (See `PriorityScheduler`)

Throws

`InterruptedException`—when the thread is interrupted by `interrupt()` or `AsynchronouslyInterruptedException.fire()` during the time between calling this method and returning from it.
An interrupt during `waitForNextPeriodInterruptible()` is treated as a release for purposes of scheduling. This is likely to disrupt proper operation of the periodic thread. The periodic behavior of the thread is unspecified until the state is reset by altering the thread's periodic parameters.

`ClassCastException`—when the current thread is not an instance of `RealtimeThread`.

`IllegalThreadStateException`—when `this` does not have a reference to a `ReleaseParameters` type of `PeriodicParameters`.

Returns

either `false`, when the thread is in a deadline miss condition, or `true`, otherwise. The time at which a deadline miss condition occurs is defined by its thread's scheduler.

Since RTSJ 1.0.1
Deprecated RTSJ 2.0 Replaced by `waitForNextReleaseInterruptible`

addIfFeasible

Signature

```
public boolean
addIfFeasible()
```

Description

This method first performs a feasibility analysis with `this` added to the system. When the resulting system is feasible, informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified. When the analysis shows that the system including `this` would not be feasible, this method does not admit `this` to the feasibility set.

When the object is already included in the feasibility set, does nothing.

Returns

`true` when inclusion of `this` in the feasibility set yields a feasible system, and false otherwise. When `true` is returned then `this` is known to be in the feasibility set. When false is returned, `this` was not added to the feasibility set, but it may already have been present.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

addToFeasibility

Signature

```
public boolean
addToFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, does nothing.

Returns

`true`, when the resulting system is feasible. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

deschedulePeriodic

Signature

```
public void
deschedulePeriodic()
```

Description

When the `ReleaseParameters` object associated with `this RealtimeThread` is an instance of `PeriodicParameters`, performs any `deschedulePeriodic` actions specified by this thread's scheduler. When the type of the associated instance of `ReleaseParameters` is not `PeriodicParameters` nothing happens.

Deprecated since RTSJ 2.0

getProcessingGroupParameters

Signature

```
public javax.realtime.ProcessingGroupParameters
getProcessingGroupParameters()
```

Description

Gets a reference to the `ProcessingGroupParameters` object for this schedulable.

Returns

A reference to the current `ProcessingGroupParameters` object.

Deprecated since RTSJ 2.0

removeFromFeasibility

Signature

```
public boolean
removeFromFeasibility()
```

Description

Informs the scheduler and cooperating facilities that this instance of `Schedulable` should *not* be considered in feasibility analysis until it is further notified.

Returns

`true` when the removal was successful. `false` when the schedulable cannot be removed from the scheduler's feasibility set; e.g., the schedulable is not part of the scheduler's feasibility set.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

schedulePeriodic

Signature

```
public void
schedulePeriodic()
```

Description

Begins unblocking `RealtimeThread.waitForNextPeriod()` for a periodic thread. When deadline miss detection is disabled, enables it. Typically used when a periodic schedulable is in a deadline miss condition. The details of the interaction of this method with `deschedulePeriodic()` and `waitForNextPeriod()` are dictated by this thread's scheduler.

When this `RealtimeThread` does not have a type of `PeriodicParameters` as its `ReleaseParameters` nothing happens.

Deprecated since RTSJ 2.0

setIfFeasible(ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(ReleaseParameters<?> release,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `this`. When the resulting system is feasible, this method replaces the current parameters of `this` with the proposed ones.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The release parameters to use . When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter values are not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and any of the specified parameter objects are located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold references to the specified parameter objects, or the parameter objects cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setMemoryParametersIfFeasible(MemoryParameters)

Signature

```
public boolean
setMemoryParametersIfFeasible(MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`memory`—The memory parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the memory parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setProcessingGroupParameters(ProcessingGroupParameters)

Signature

```
public void
setProcessingGroupParameters(ProcessingGroupParameters group)
```

Description

Sets the `ProcessingGroupParameters` of `this`.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

Parameters

`group`—A `ProcessingGroupParameters` object which will take effect as determined by the associated scheduler. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `group` is not compatible with the scheduler for this schedulable object. Also when this schedulable may not use the heap and `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold a reference to `group` or `group` cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Deprecated

setProcessingGroupParametersIfFeasible (ProcessingGroupParameters)

Signature

```
public boolean
setProcessingGroupParametersIfFeasible(ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`group`—The processing group parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the processing group parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

```
public boolean
setReleaseParametersIfFeasible(ReleaseParameters<?> release)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`release`—The release parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the release parameter at this time due to the state of the schedulable.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public void
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             ReleaseParameters<?> release,
             MemoryParameters memoryParameters,
             ProcessingGroupParameters group)
```

Description

Sets the scheduler and associated parameter objects. The timing of the change must be agreed between the scheduler currently associated with this schedulable, and `scheduler`.

Parameters

`scheduler`—A reference to the scheduler that will manage the execution of this schedulable. `Null` is not a permissible value.

`scheduling`—A reference to the `SchedulingParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. See `PriorityScheduler`.

`release`—A reference to the `ReleaseParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`memoryParameters`—A reference to the `MemoryParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

`group`—A reference to the `ProcessingGroupParameters` which will be associated with `this`. When `null`, the default value is governed by `scheduler`; a new object is created when the default value is not `null`. (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `scheduler` is `null` or the parameter values are not compatible with `scheduler`. Also thrown when this schedulable may not use the heap and `scheduler`, `scheduling` `release`, `memoryParameters`, or `group` is located in heap memory.

`IllegalAssignmentError`—when `this` object cannot hold references to all the parameter objects or the parameters cannot hold references to `this`.

`IllegalThreadStateException`—when `scheduler` prohibits the changing of the scheduler or a parameter at this time due to the state of the schedulable.

`StaticSecurityException`—when the caller is not permitted to set the scheduler for this schedulable.

Deprecated since RTSJ 2.0

setSchedulingParametersIfFeasible(SchedulingParameters)

Signature

```
public boolean
setSchedulingParametersIfFeasible(SchedulingParameters scheduling)
```

Description

This method first performs a feasibility analysis using the proposed parameter object as replacement for the current parameter of `this`. When the resulting system is feasible, this method replaces the current parameter of `this` with the proposed one.

This change becomes effective under conditions determined by the scheduler controlling the schedulable. For instance, the change may be immediate or it may be delayed until the next release of the schedulable. See the documentation for the scheduler for details.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`scheduling`—The scheduling parameters to use. When `null`, the default value is governed by the associated scheduler (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the specified parameter object is located in heap memory.

`IllegalAssignmentError`—when `this` cannot hold a reference to the specified parameter object, or the parameter object cannot hold a reference to `this`.

`IllegalThreadStateException`—when the schedulable's scheduler prohibits the changing of the scheduling parameter at this time due to the state of the schedulable object.

Returns

`true`, when the resulting system is feasible and the changes are made. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

B.2.2.32 *RelativeTime*

---

public class RelativeTime

The following elements of RelativeTime are deprecated. The required elements are documented in Section 9.3.1.3 above.

B.2.2.32.1 Constructors

RelativeTime(long, int, Clock)

Signature

```
public
RelativeTime(long millis,
             int nanos,
             Clock clock)
throws StaticIllegalArgumentException
```

Description

Constructs a `RelativeTime` object representing an interval based on the parameter `millis` plus the parameter `nanos`. The construction is subject to `millis` and `nanos` parameter normalization. When there is an overflow in the millisecond component when normalizing then an `StaticIllegalArgumentException` will be thrown.

The clock association is made with the `clock` parameter. When `clock` is `null` the association is made with the default realtime clock.

Since RTSJ 1.0.1
Deprecated since version 2.0
Parameters
`millis`—The desired value for the millisecond component of `this`. The actual value is the result of parameter normalization.
`nanos`—The desired value for the nanosecond component of `this`. The actual value is the result of parameter normalization.
`clock`—The clock providing the association for the newly constructed object.
Throws
`StaticIllegalArgumentException`—when there is an overflow in the millisecond component when normalizing.

RelativeTime(RelativeTime, Clock)

Signature

```
public
RelativeTime(RelativeTime time,
             Clock clock)
throws StaticIllegalArgumentException
```

Description

Makes a new `RelativeTime` object from the given `RelativeTime` object.

The clock association is made with the `clock` parameter. When `clock` is `null` the association is made with the default realtime clock.

Since RTSJ 1.0.1
Deprecated since version 2.0
Parameters
`time`—The `RelativeTime` object which is the source for the copy.
`clock`—The clock providing the association for the newly constructed object.
Throws
`StaticIllegalArgumentException`—when the `time` parameter is `null`.

RelativeTime(Clock)

Signature

```
public
RelativeTime(Clock clock)
```

Description

Equivalent to `new RelativeTime(0,0,clock)`.

The clock association is made with the `clock` parameter. When `clock` is `null` the association is made with the default realtime clock.

Since RTSJ 1.0.1
Deprecated since version 2.0
Parameters
`clock`—The clock providing the association for the newly constructed object.

B.2.2.32.2 Methods

---

absolute(Clock)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Clock clock)
throws ArithmeticException
```

Description

Converts the time of `this` to an absolute time, using the given instance of `Clock` to determine the current time. The calculation is the current time indicated by the given instance of `Clock` plus the interval given by `this`. When `clock` is `null` the realtime clock is assumed. A destination object is allocated for the result. The clock association of the result is with the `clock` passed as a parameter.

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into absolute time, and the new clock association for the result.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

The `AbsoluteTime` conversion in a newly allocated object, associated with the `clock` parameter.

Deprecated since version 2.0

absolute(Clock, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Clock clock,
         AbsoluteTime dest)
throws ArithmeticException
```

Description

Converts the time of `this` to an absolute time, using the given instance of `Clock` to determine the current time. The calculation is the current time indicated by the given instance of `Clock` plus the interval given by `this`. When clock is `null` the default realtime clock is assumed. When `dest` is `null`, a destination object is allocated for the result. The clock association of the result is with the `clock` passed as a parameter.

Parameters

`clock`—The instance of `Clock` used to convert the time of `this` into absolute time, and the new clock association for the result.

`dest`—When `dest` is not `null`, the result is placed there and returned.

Throws

`ArithmeticException`—when the result does not fit in the normalized format.

Returns

the `AbsoluteTime` conversion in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. The result is associated with the `clock` parameter.

Deprecated since version 2.0

relative(Clock)

Signature

```
public javax.realtime.RelativeTime
relative(Clock clock)
```

Description

Returns a copy of `this`. A new object is allocated for the result. This method is the implementation of the `abstract` method of the `HighResolutionTime` base class. No conversion into `RelativeTime` is needed in this case. The clock association of the result is with the `clock` passed as a parameter. When `clock` is `null` the association is made with the realtime clock.

Parameters

`clock`—The `clock` parameter is used only as the new clock association with the result, since no conversion is needed.

Returns

the copy of `this` in a newly allocated `RelativeTime` object, associated with the `clock` parameter.

Deprecated since version 2.0

relative(Clock, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
relative(Clock clock,
         RelativeTime dest)
```

Description

Returns a copy of `this`. When `dest` is not `null`, the result is placed there and returned. Otherwise, a new object is allocated for the result. This method is the implementation of the `abstract` method of the `HighResolutionTime` base class. No conversion into `RelativeTime` is needed in this case. The clock association of the result is with the `clock` passed as a parameter. When `clock` is `null` the association is made with the realtime clock.

Parameters

`clock`—The `clock` parameter is used only as the new clock association with the result, since no conversion is needed.

`dest`—When `dest` is not `null`, the result is placed there and returned.

Returns

the copy of `this` in `dest` when `dest` is not `null`, otherwise the result is returned in a newly allocated object. It is associated with the `clock` parameter.

Deprecated since version 2.0

getInterarrivalTime

Signature

```
public javax.realtime.RelativeTime
getInterarrivalTime()
```

getInterarrivalTime(RelativeTime)

Signature

```
public javax.realtime.RelativeTime
getInterarrivalTime(RelativeTime destination)
```

B.2.2.33 *ReleaseParameters*

---

public abstract class ReleaseParameters<T extends ReleaseParameters<T>>

The following elements of ReleaseParameters are deprecated. The required elements are documented in Section 6.3.3.10 above.

B.2.2.33.1 Methods

---

setIfFeasible(RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime cost,
              RelativeTime deadline)
```

Description

This method first performs a feasibility analysis using the new cost, and deadline as replacements for the matching attributes of all schedulables associated with this release parameters object. When the resulting system is feasible, the method replaces the current scheduling characteristics of `this` release parameters object with the new scheduling characteristics. The change in the release characteristics, including the timing of the change, of any associated schedulables will take place under the control of their schedulers.

Parameters

`cost`—The proposed cost. Equivalent to `RelativeTime(0,0)` when `null`. (A new instance of `RelativeTime` is created in the memory area containing this `ReleaseParameters` instance). When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The proposed deadline. There is no default for `deadline` in this class. The default must be determined by the subclasses.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the time value of `deadline` is less than or equal to zero.

`IllegalAssignmentError`—when `cost` or `deadline` cannot be stored in `this`.

Returns

`true`, when the resulting system is feasible and the changes are made, and `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0

B.2.2.34 *Scheduler*

---

public abstract class Scheduler

The following elements of Scheduler are deprecated. The required elements are documented in Section 6.3.3.13 above.

B.2.2.34.1 Methods

---

addToFeasibility(Schedulable)

Signature

```
protected abstract boolean
addToFeasibility(Schedulable schedulable)
```

Description

Informs this scheduler and cooperating facilities that the resource demands of the given instance of `Schedulable` will be considered in the feasibility analysis of the associated `Scheduler` until further notice. Whether the resulting system is feasible or not, the addition is completed. When the object is already included in the feasibility set, does nothing.

Parameters

`schedulable`—A reference to the given instance of `Schedulable`

Throws

`StaticIllegalArgumentException`—when `schedulable` is `null`, or when `schedulable` is not associated with `this`; that is `schedulable.getScheduler() != this`.

Returns

`true`, when the system is feasible after the addition, and `false`, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

isFeasible

Signature

```
public abstract boolean
isFeasible()
```

Description

Queries the system about the feasibility of the system currently being considered. The definitions of "feasible" and "system" are the responsibility of the feasibility algorithm of the actual `Scheduler` subclass.

Returns

`true`, when the system is feasible; `false`, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters)

Signature

```
public abstract boolean
setIfFeasible(Schedulable schedulable,
              ReleaseParameters<?> release,
              MemoryParameters memory)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones. This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new ReleaseParameters changes `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made; `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public abstract boolean
setIfFeasible(Schedulable schedulable,
              ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The proposed processing group parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new release parameters change `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made; `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(Schedulable, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public abstract boolean
setIfFeasible(Schedulable schedulable,
              SchedulingParameters scheduling,
              ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
```

Description

This method first performs a feasibility analysis using the proposed parameter objects as replacements for the current parameters of `Schedulable`. When the resulting system is feasible, this method replaces the current parameters of `Schedulable` with the proposed ones.

This method does not require that the schedulable be in the feasibility set before it is called. When it is not initially a member of the feasibility set it will be added when the resulting system is feasible.

Parameters

`schedulable`—The schedulable for which the changes are proposed.

`scheduling`—The proposed scheduling parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`release`—The proposed release parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`memory`—The proposed memory parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

`group`—The proposed processing group parameters. When `null`, the default value of this scheduler is used (a new object is created when the default value is not `null`). (See `PriorityScheduler`.)

Throws

`StaticIllegalArgumentException`—when `Schedulable` is `null`, or `Schedulable` is not associated with `this` scheduler, or the proposed parameters are not compatible with `this` scheduler.

`IllegalAssignmentError`—when `Schedulable` cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to `Schedulable`.

`IllegalThreadStateException`—when the new release parameters change `Schedulable` from periodic scheduling to some other protocol and `Schedulable` is currently waiting for the next release in `RealtimeThread.waitForNextPeriod()` or `RealtimeThread.waitForNextPeriodInterruptible()`.

Returns

`true`, when the resulting system is feasible and the changes are made; `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

removeFromFeasibility(Schedulable)

Signature

```
protected abstract boolean
removeFromFeasibility(Schedulable schedulable)
```

Description

Informs this scheduler and cooperating facilities that the resource demands of the given instance of `Schedulable` should no longer be considered in the feasibility analysis of the associated `Scheduler`. Whether the resulting system is feasible or not, the removal is completed.

Parameters

`schedulable`—A reference to the given instance of `Schedulable`

Throws

`StaticIllegalArgumentException`—when `schedulable` is `null`.

Returns

`true`, when the removal was successful, and `false`, when the schedulable cannot be removed from the scheduler's feasibility set; e.g., the schedulable is not part of the scheduler's feasibility set.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

fireSchedulable(Schedulable)

Signature

```
public abstract void
fireSchedulable(Schedulable schedulable)
```

Description

Triggers the execution of a schedulable (like an `AsyncEventHandler`).

Parameters

`schedulable`—The schedulable to make active. When `null`, nothing happens.

Throws

`StaticUnsupportedOperationException`—when the scheduler cannot release `schedulable` for execution.

Deprecated RTSJ 2.0

B.2.2.35 ScopedMemory

---

public abstract class ScopedMemory

Inheritance

java.lang.Object
  MemoryArea
    ScopedMemory

Description

Equivalent to and superseded by `javax.realtime.memory.ScopedMemory`.

Deprecated in RTSJ 2.0; moved to package `javax.realtime.memory`

B.2.2.35.1 Constructors

ScopedMemory(long, Runnable)

Signature

```
public
ScopedMemory(long size,
             Runnable logic)
```

Description

Creates a new `ScopedMemory` area with the given parameters.

Parameters

`size`—The size of the new `ScopedMemory` area in bytes.

`logic`—The `Runnable` to execute when this `ScopedMemory` is entered. When `logic` is `null`, this constructor is equivalent to constructing the memory area without a logic value.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ScopedMemory` object or for its allocation area in its backing store.

ScopedMemory(SizeEstimator, Runnable)

Signature

```
public
ScopedMemory(SizeEstimator size,
             Runnable logic)
```

Description

Equivalent to `ScopedMemory(long, Runnable)` with the argument list `(size.getEstimate(), logic)`.

Parameters

`size`—The size of the new `ScopedMemory` area estimated by an instance of `SizeEstimator`.

`logic`—The logic which will use the memory represented by `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to constructing the memory area without a logic value.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ScopedMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

ScopedMemory(long)

Signature

```
public
ScopedMemory(long size)
```

Description

Equivalent to `ScopedMemory(long, Runnable)` with the argument list `(size, null)`.

Parameters

`size`—of the new `ScopedMemory` area in bytes.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ScopedMemory` object or for its allocation area in its backing store.

ScopedMemory(SizeEstimator)

Signature

```
public
ScopedMemory(SizeEstimator size)
```

Description

Equivalent to `ScopedMemory(long, Runnable)` with the argument list `(size.getEstimate(), null)`.

Parameters

`size`—The size of the new `ScopedMemory` area estimated by an instance of `SizeEstimator`.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is negative.

`StaticOutOfMemoryError`—when there is insufficient memory for the `ScopedMemory` object or for its allocation area in its backing store.

B.2.2.35.2 Methods

---

enter

Signature

```
public void
enter()
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the instance of `Runnable` given in the constructor. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Throws

`ScopedCycleException`—when this invocation would break the single parent rule.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`IllegalThreadStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the SO that triggered finalization. This would include the scope containing the SO, and the scope (if any) containing the scope containing the SO.

`IllegalArgumentException`—null

`MemoryAccessError`—when caller is a schedulable that may not use the heap and this memory area's logic value is allocated in heap memory.

enter(Runnable)

Signature

```
public void
enter(Runnable logic)
```

Description

Associates this memory area with the current schedulable for the duration of the execution of the `run()` method of the given `Runnable`. During this period of execution, this memory area becomes the default allocation context until another default allocation context is selected (using `enter`, or `executeInArea`) or the `enter` method exits.

Parameters

`logic`—The Runnable object whose `run()` method should be invoked.

Throws

`ScopedCycleException`—when this invocation would break the single parent rule.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`IllegalThreadStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the SO that triggered finalization. This would include the scope containing the SO, and the scope (if any) containing the scope containing the SO.

`IllegalArgumentException`—null

executeInArea(Runnable)

Signature

```
public void
executeInArea(Runnable logic)
```

Description

Executes the run method from the `logic` parameter using this memory area as the current allocation context. This method behaves as if it moves the allocation context down the scope stack to the occurrence of `this`.

Parameters

`logic`—The runnable object whose `run()` method should be executed.

Throws

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

`IllegalArgumentException`—when the caller is a schedulable and `logic` is `null`.

getMaximumSize

Signature

```
public long
getMaximumSize()
```

Description

Gets the maximum size this memory area can attain. If this is a fixed size memory area, the returned value will be equal to the initial size.

Returns

the maximum size attainable.

getPortal

Signature

```
public java.lang.Object
getPortal()
```

Description

Obtains a reference to the portal object in this instance of `ScopedMemory`.

Assignment rules are enforced on the value returned by `getPortal` as if the return value were first stored in an object allocated in the current allocation context, then moved to its final destination.

Throws

`IllegalAssignmentError`—when a reference to the portal object cannot be stored in the caller's allocation context; that is, when `this` is "inner" relative to the current allocation context or not on the caller's scope stack.

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

Returns

a reference to the portal object or `null` when there is no portal object. The portal value is always set to `null` when the contents of the memory are deleted.

getReferenceCount

Signature

```
public int
getReferenceCount()
```

Description

Returns the reference count of this `ScopedMemory`.

Note that a reference count of 0 reliably means that the scope is not referenced, but other reference counts are subject to artifacts of lazy/eager maintenance by the implementation.

Returns
the reference count of this `ScopedMemory`.

join

Signature

```
public void
join()
throws InterruptedException
```

Description

Waits until the reference count of this `ScopedMemory` goes down to zero. Returns immediately when the memory is unreferenced.

Throws

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

join(HighResolutionTime)

Signature

```
public void
join(HighResolutionTime<?> time)
throws InterruptedException
```

Description

Waits at most until the time designated by the `time` parameter for the reference count of this `ScopedMemory` to drop to zero. Returns immediately when the memory area is unreferenced.

Since the time is expressed as a `HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then the delay is the amount of time given by `time`, and measured by its associated clock. When absolute, then the delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `join` returns immediately.

Parameters

`time`—When this time is an absolute time, the wait is bounded by that point in time. When the time is a relative time, the wait is bounded by a the specified interval from some time between the time `join` is called and the time it starts waiting for the reference count to reach zero.

Throws

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

`IllegalArgumentException`—when the caller is a schedulable and `time` is `null`.

`UnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

joinAndEnter

Signature

```
public void
joinAndEnter()
throws InterruptedException
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, then enter the `ScopedMemory` and execute the `run` method from `logic` passed in the constructor. When no instance of `Runnable` was passed to the memory area's constructor, the method throws `IllegalArgumentException` immediately.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that although `joinAndEnter` guarantees that the reference count is zero when the schedulable is released for entry, it does not guarantee that the reference count will remain one for any length of time. A subsequent `enter` could raise the reference count to two.

Throws

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the SO that triggered finalization. This would include the scope containing the SO, and the scope (if any) containing the scope containing the SO.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`ScopedCycleException`—when this invocation would break the single parent rule.

`IllegalArgumentException`—when the caller is a schedulable and no non-null `logic` value was supplied to the memory area's constructor.

`MemoryAccessError`—when caller is a non-heap schedulable and this memory area's logic value is allocated in heap memory.

joinAndEnter(HighResolutionTime)

Signature

```
public void
joinAndEnter(HighResolutionTime<?> time)
throws InterruptedException
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, or for the current time to reach the designated time, then enter the `ScopedMemory` and execute the `run` method from `Runnable` object passed to the constructor. When no instance of `Runnable` was passed to the memory area's constructor, the method throws `IllegalArgumentException` immediately. *

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Since the time is expressed as a `HighResolutionTime`, this method has an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then the calling thread is blocked for at most the amount of time given by `time`, and measured by its associated clock. When absolute, then the time delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `joinAndEnter` behaves effectively like `enter`.

Note that expiration of `time` may cause control to enter the memory area before its reference count has gone to zero.

Parameters

`time`—The time that bounds the wait.

Throws

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the caller context is not an instance of `Schedulable`, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the instance that triggered finalization. This would include the scope containing the instance, and the scope (if any) containing the scope containing the instance.

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`IllegalArgumentException`—when the caller is a schedulable, and `time` is `null` or `null` was supplied as `logic` value to the memory area's constructor.

`UnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

`MemoryAccessError`—when the calling schedulable may not use the heap and this memory area's logic value is allocated in heap memory.

joinAndEnter(Runnable)

Signature

```
public void
joinAndEnter(Runnable logic)
throws InterruptedException
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, then enter the `ScopedMemory` and execute the `run` method from `logic`

When `logic` is `null`, throw `IllegalArgumentException` immediately.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that although `joinAndEnter` guarantees that the reference count is zero when the schedulable is released for entry, it does not guarantee that the reference count will remain one for any length of time. A subsequent `enter` could raise the reference count to two.

Parameters

`logic`—The `Runnable` object which contains the code to execute.

Throws

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the SO that triggered finalization. This would include the scope containing the SO, and the scope (if any) containing the scope containing the SO.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`ScopedCycleException`—when this invocation would break the single parent rule.

`IllegalArgumentException`—when the caller is a schedulable and `logic` is `null`.

joinAndEnter(Runnable, HighResolutionTime)

Signature

```
public void
joinAndEnter(Runnable logic,
             HighResolutionTime<?> time)
throws InterruptedException
```

Description

In the error-free case, `joinAndEnter` combines `join();enter();` such that no `enter()` from another schedulable can intervene between the two method invocations. The resulting method will wait for the reference count on this `ScopedMemory` to reach zero, or for the current time to reach the designated time, then enter the `ScopedMemory` and execute the `run` method from `logic`.

Since the time is expressed as a `HighResolutionTime`, this method is an accurate timer with nanosecond granularity. The actual resolution of the timer and even the quantity it measures depends on the clock associated with `time`. The delay time may be relative or absolute. When relative, then the delay is the amount of time given by `time`, and measured by its associated clock. When absolute, then the delay is until the indicated value is reached by the clock. When the given absolute time is less than or equal to the current value of the clock, the call to `joinAndEnter` behaves effectively like `enter(Runnable)`.

Throws `IllegalArgumentException` immediately when `logic` is `null`.

When multiple threads are waiting in `joinAndEnter` family methods for a memory area, at most *one* of them will be released each time the reference count goes to zero.

Note that expiration of `time` may cause control to enter the memory area before its reference count has gone to zero.

Parameters

`logic`—The `Runnable` object which contains the code to execute.

`time`—The time that bounds the wait.

Throws

`InterruptedException`—When this schedulable is interrupted by `RealtimeThread.interrupt()` or `AsynchronouslyInterruptedException.fire()` while waiting for the reference count to go to zero.

`IllegalThreadStateException`—when the execution context in not an instance of `Schedulable`, or when this method is invoked during finalization of objects in scoped memory and entering this scoped memory area would force deletion of the task that triggered finalization. This would include the scope containing the task, and the scope (if any) containing the scope containing the task.

`ThrowBoundaryError`—when the JVM needs to propagate an exception allocated in `this` scope to (or through) the memory area of the caller. Storing a reference to that exception would cause an `IllegalAssignmentError`, so the JVM cannot be permitted to deliver the exception. The `ThrowBoundaryError` is allocated in the current allocation context and contains information about the exception it replaces.

`ScopedCycleException`—when the caller is a schedulable and this invocation would break the single parent rule.

`IllegalArgumentException`—when the caller is a schedulable and `time` or `logic` is `null`.

`UnsupportedOperationException`—when the wait operation is not supported using the clock associated with `time`.

newArray(Class, int)

Signature

```
public java.lang.Object
newArray(java.lang.Class<?> type,
         int number)
```

Description

Allocates an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

`type`—The class of the elements of the new array. To create an array of a primitive type use a `type` such as `Integer.TYPE` (which would call for an array of the primitive int type.)

`number`—The number of elements in the new array.

Throws

`IllegalArgumentException`—null

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns
a new array of class type, of number elements.

newInstance(Class)

Signature

```
public T
newInstance(java.lang.Class<T> type)
throws IllegalAccessException,
       InstantiationException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters
`type`—The class of which to create a new instance.
Throws
`IllegalAccessException`—The class or initializer is inaccessible.
`IllegalArgumentException`—null
`ExceptionInInitializerError`—when an unexpected exception has occurred in a static initializer.
`StaticOutOfMemoryError`—when space in the memory area is exhausted.
`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, or it is an array.
`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.
`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns
a new instance of class `type`.

newInstance(Constructor, Object)

Signature

```
public T
newInstance(java.lang.reflect.Constructor<T> c,
            java.lang.Object[] args)
throws IllegalAccessException,
       InstantiationException,
       InvocationTargetException
```

Description

Allocates an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

`c`—TThe constructor for the new instance.

`args`—An array of arguments to pass to the constructor.

Throws

`IllegalAccessException`—when the class or initializer is inaccessible under Java access control.

`InstantiationException`—when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

`StaticOutOfMemoryError`—when space in the memory area is exhausted.

`IllegalArgumentException`—null

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

`InvocationTargetException`—when the underlying constructor throws an exception.

`InaccessibleAreaException`—when the memory area is not in the schedulable's scope stack.

Returns

a new instance of the object constructed by `c`.

setPortal(Object)

Signature

```
public void
setPortal(Object object)
```

Description

Sets the *portal* object of the memory area represented by this instance of `ScopedMemory` to the given object. The object must have been allocated in this `ScopedMemory` instance.

Parameters

`object`—The object which will become the portal for this. When `null` the previous portal object remains the portal object for this or when there was no previous portal object then there is still no portal object for `this`.

Throws

`IllegalThreadStateException`—when the caller context in not an instance of `Schedulable`.

`IllegalAssignmentError`—when the caller is a schedulable, and `object` is not allocated in this scoped memory instance and not `null`.

`InaccessibleAreaException`—when the caller is a schedulable, `this` memory area is not in the caller's scope stack and `object` is not `null`.

toString

Signature

```
public java.lang.String
toString()
```

Description

Returns a user-friendly representation of this `ScopedMemory` of the form `ScopedMemory#<num>` where `<num>` is a number that uniquely identifies this scoped memory area.

Returns

The string representation

B.2.2.36 *SporadicParameters*

---

public class SporadicParameters

The following elements of SporadicParameters are deprecated. The required elements are documented in Section 6.3.3.15 above.

B.2.2.36.1 Fields

---

mitViolationExcept

```
public static final java.lang.String mitViolationExcept
```

Description

Represents the "EXCEPT" policy for dealing with minimum interarrival time violations. Under this policy, when an arrival time for any instance of `Schedulable` which has `this` as its instance of `ReleaseParameters` occurs at a time less then the minimum interarrival time defined here then the `fire()` method shall throw `MITViolationException`. Any other associated semantics are governed by the schedulers for the schedulables using these sporadic parameters. When the arrival time is a result of a happening to which the instance of `AsyncEventHandler` is bound then the arrival time is ignored.

Deprecated since RTSJ 2.0

mitViolationIgnore

```
public static final java.lang.String mitViolationIgnore
```

Description

Represents the "IGNORE" policy for dealing with minimum interarrival time violations. Under this policy, when an arrival time for any instance of `Schedulable` which has `this` as its instance of `ReleaseParameters` occurs at a time less then the minimum interarrival time defined here then the new arrival time is ignored. Any other associated semantics are governed by the schedulers for the schedulables using these sporadic parameters.

Deprecated since RTSJ 2.0

mitViolationSave

```
public static final java.lang.String mitViolationSave
```

Description

Represents the "SAVE" policy for dealing with minimum interarrival time violations. Under this policy the arrival time for any instance of `Schedulable` which has `this` as its instance of `ReleaseParameters` is not compared to the specified minimum interarrival time. Any other associated semantics are governed by the schedulers for the schedulable objects using these sporadic parameters.

Deprecated since RTSJ 2.0

mitViolationReplace

```
public static final java.lang.String mitViolationReplace
```

Description

Represents the "REPLACE" policy for dealing with minimum interarrival time violations. Under this policy when an arrival time for any instance of `Schedulable` which has `this` as its instance of `ReleaseParameters` occurs at a time less then the minimum interarrival time defined here then the information for this arrival replaces a previous arrival. Any other associated semantics are governed by the schedulers for the schedulables using these sporadic parameters.

Deprecated since RTSJ 2.0

B.2.2.36.2 Methods

---

setMitViolationBehavior(String)

Signature

```
public void
setMitViolationBehavior(String behavior)
```

Description

Sets the behavior of the arrival time queue for the case where the new arrival time is closer to the previous arrival time than the minimum interarrival time given in this.

Values of `behavior` are compared using reference equality (==) not value equality (`equals()`).

Parameters

`behavior`—A string representing the behavior.

Throws

`StaticIllegalArgumentException`—when `behavior` is not one of the `final` MIT violation behavior values defined in this class.

Deprecated since RTSJ 2.0 and replaced by `setMinimumInterarrivalPolicy`.

getMitViolationBehavior

Signature

```
public java.lang.String
getMitViolationBehavior()
```

Description

Gets the arrival time queue behavior in the event of a minimum interarrival time violation.

Returns

the minimum interarrival time violation behavior as a string.

Deprecated since RTSJ 2.0 and replaced by `getMinimumInterarrivalPolicy`.

setIfFeasible(RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime cost,
              RelativeTime deadline)
```

Description

This method first performs a feasibility analysis using the new cost, and deadline as replacements for the matching attributes of this. When the resulting system is feasible, the method replaces the current scheduling characteristics, of `this` with the new scheduling characteristics.

Parameters

`cost`—The proposed cost used to determine when any particular object exceeds cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The proposed deadline. When `null`, the default value is a new instance of `RelativeTime(mit)`.

Throws

`StaticIllegalArgumentException`—when the time value of `cost` is less than zero, or the time value of `deadline` is less than or equal to zero, or the values are incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

`IllegalAssignmentError`—when `cost` or `deadline` cannot be stored in `this`.

Returns

`true`, when the resulting system is feasible and the changes are made; `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

setIfFeasible(RelativeTime, RelativeTime, RelativeTime)

Signature

```
public boolean
setIfFeasible(RelativeTime interarrival,
              RelativeTime cost,
              RelativeTime deadline)
```

Description

This method first performs a feasibility analysis using the new interarrival, cost and deadline attributes as replacements for the matching attributes of this. When the resulting system is feasible the method replaces the current attributes with the new ones.

Changes to a `SporadicParameters` instance effect subsequent arrivals.

Parameters

`interarrival`—The proposed interarrival time. There is no default value. When `minInterarrival` is `null` an illegal argument exception is thrown.

`cost`—The proposed cost. When `null`, the default value is a new instance of `RelativeTime(0,0)`.

`deadline`—The proposed deadline. When `null`, the default value is a new instance of `RelativeTime(mit)`.

Throws

`StaticIllegalArgumentException`—when `minInterarrival` is `null` or its time value is not greater than zero, or the time value of `cost` is less than zero, or the time value of `deadline` is not greater than zero.

`IllegalAssignmentError`—when `interarrival`, `cost` or `deadline` cannot be stored in `this`.

Returns

`true`, when the resulting system is feasible and the changes are made; `false`, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0 The framework for feasibility analysis is inadequate

B.2.2.37 *ThrowBoundaryError*

---

public class ThrowBoundaryError

The following elements of ThrowBoundaryError are deprecated. The required elements are documented in Section 17.2.2.36 above.

B.2.2.37.1 Constructors

ThrowBoundaryError(String)

Signature

```
public
ThrowBoundaryError(String description)
```

Description

A descriptive constructor for `ThrowBoundaryError`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.
Parameters
`description`—The reason for throwing this error.

B.2.2.38 Timed

---

public class Timed

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.InterruptedException
        control.AsynchronouslyInterruptedException
          AsynchronouslyInterruptedException
            Timed

Description

Creates a scope in a `Schedulable` object which will be asynchronously interrupted at the expiration of a timer. This timer will begin measuring time at some point between the time `doInterruptible` is invoked and the time when the `run()` method of the `Interruptible` object is invoked. Each call of `doInterruptible` on an instance of `Timed` will restart the timer for the amount of time given in the constructor or the most recent invocation of `resetTime()`. The timer is cancelled when it has not expired before the `doInterruptible` method has finished.

All memory use of an instance of `Timed` occurs during construction or the first invocation of `doInterruptible`. Subsequent invocations of `doInterruptible` do not allocate memory.

When the timer fires, the resulting AIE will be generated for the schedulable within a bounded execution time of the targeted schedulable.

Typical usage: `new Timed(T).doInterruptible(interruptible);`

Deprecated in RTSJ 2.0; moved to package `javax.realtime.control`

B.2.2.38.1 Constructors

Timed(HighResolutionTime)

Signature

```
public
Timed(HighResolutionTime<?> time)
throws StaticIllegalArgumentException,
       StaticUnsupportedOperationException
```

Description

Creates an instance of `Timed` with a timer set to `time`. When the `time` is in the past the `AsynchronouslyInterruptedException` mechanism is activated immediately after or when the `doInterruptible` method is called.

Parameters

`time`—When `time` is a `RelativeTime` value, it is the interval of time between the invocation of `doInterruptible` and the time when the schedulable is asynchronously interrupted. When `time` is an `AbsoluteTime` value, the timer asynchronously interrupts at this time (assuming the timer has not been cancelled).

Throws

`StaticIllegalArgumentException`—when `time` is `null`.

`StaticUnsupportedOperationException`—when `time` is not based on a `Clock`.

B.2.2.38.2 Methods

---

doInterruptible(Interruptible)

Signature

```
public boolean
doInterruptible(Interruptible logic)
```

Description

Executes a timeout method by starting the timer and executing the `run()` method of the given `Interruptible` object.

Parameters

`logic`—An instance of an `Interruptible` whose `run()` method will be called.

Throws

`StaticIllegalArgumentException`—when `logic` is `null`.

`IllegalThreadStateException`—null

Returns

`true`, when the method call completed normally, and `false`, when another call to `doInterruptible` has not completed.

resetTime(HighResolutionTime)

Signature

```
public void
resetTime(HighResolutionTime<?> time)
```

Description

Sets the timeout for the next invocation of `doInterruptible`.

Parameters

`time`—This can be an absolute time or a relative time. When `null` or not based on a `Clock`, the timeout is not changed.

restart(HighResolutionTime)

Signature

```
public void
restart(HighResolutionTime<?> time)
```

Description

Resets the timeout. When this `Timed` instance is executing, it adjusts the timeout to `time` and restarts the timer. When the instance is not executing, it adjusts the timeout for the next invocation.

Parameters

`time`—The new timeout.

Throws

`StaticIllegalArgumentException`—when `time` is `null` or a relative time less than zero.

`StaticUnsupportedOperationException`—when `time` is not based on a `Clock`

Since RTSJ 2.0

B.2.2.39 UnknownHappeningException

---

public class UnknownHappeningException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        UnknownHappeningException

Description

This exception is used to indicate a situation where an instance of `AsyncEvent` attempts to bind to a happening that does not exist.

Deprecated since RTSJ 2.0

B.2.2.39.1 Constructors

UnknownHappeningException

Signature

```
public
UnknownHappeningException()
```

Description

A constructor for `UnknownHappeningException`.

UnknownHappeningException(String)

Signature

```
public
UnknownHappeningException(String description)
```

Description

A descriptive constructor for `UnknownHappeningException`.

Parameters

`description`—The reason for throwing the exception.

B.2.2.40 *UnsupportedPhysicalMemoryException*

public class UnsupportedPhysicalMemoryException

The following elements of UnsupportedPhysicalMemoryException are deprecated. The required elements are documented in Section 17.2.2.38 above.

B.2.2.40.1 Constructors

UnsupportedPhysicalMemoryException(String)

Signature

```
public
UnsupportedPhysicalMemoryException(String description)
```

Description

A descriptive constructor for `UnsupportedPhysicalMemoryException`.

Deprecated since RTSJ 2.0; application code should use `get()` instead.

Parameters

`description`—The reason for throwing the exception.

B.2.2.41 VTMemory

public class VTMemory

Inheritance

java.lang.Object
  MemoryArea
    ScopedMemory
      VTMemory

Description

`VTMemory` is similar to `LTMemory` except that the execution time of an allocation from a `VTMemory` area need not complete in linear time.

Methods from `VTMemory` should be overridden only by methods that use `super`.

Deprecated as of RTSJ 2.0

B.2.2.41.1 Constructors

VTMemory(long, long, Runnable)

Signature

```
public
VTMemory(long initial,
         long maximum,
         Runnable logic)
```

Description

Creates a `VTMemory` with the given parameters.

Parameters

`initial`—The size in bytes of the memory to initially allocate for this area.

`maximum`—The maximum size in bytes to which this memory area's size may grow.

`logic`—An instance of `Runnable` whose `run()` method will use `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `VTMemory(long initial, long maximum)`.

Throws

`IllegalArgumentException`—when `initial` is greater than `maximum`, or when `initial` or `maximum` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTMemory(SizeEstimator, SizeEstimator, Runnable)

Signature

```
public
VTMemory(SizeEstimator initial,
         SizeEstimator maximum,
         Runnable logic)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(initial.getEstimate(), maximum.getEstimate(), logic)`.

Parameters

`initial`—The size in bytes of the memory to initially allocate for this area estimated by an instance of `SizeEstimator`.

`maximum`—The maximum size in bytes to which this memory area's size may grow estimated by an instance of `SizeEstimator`.

`logic`—An instance of `Runnable` whose `run()` method will use `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `VTMemory(SizeEstimator initial, SizeEstimator maximum)`.

Throws

`IllegalArgumentException`—when `initial` is `null`, `maximum` is `null`, `initial.getEstimate()` is greater than `maximum.getEstimate()`, or when `initial.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTMemory(long, long)

Signature

```
public
VTMemory(long initial,
         long maximum)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(initial, maximum, null)`.

Parameters

`initial`—The size in bytes of the memory to initially allocate for this area.

`maximum`—The maximum size in bytes to which this memory area's size may grow.

Throws

`IllegalArgumentException`—when `initial` is greater than `maximum` or when `initial` or `maximum` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

VTMemory(SizeEstimator, SizeEstimator)

Signature

```
public
VTMemory(SizeEstimator initial,
         SizeEstimator maximum)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(initial.getEstimate(), maximum.getEstimate(), null)`.

Parameters

`initial`—The size in bytes of the memory to initially allocate for this area estimated by an instance of `SizeEstimator`.

`maximum`—The maximum size in bytes to which this memory area's size may grow estimated by an instance of `SizeEstimator`.

Throws

`IllegalArgumentException`—when `initial` is `null`, `maximum` is `null`, `initial.getEstimate()` is greater than `maximum.getEstimate()`, or when `initial.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

VTMemory(long, Runnable)

Signature

```
public
VTMemory(long size,
         Runnable logic)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(size, size, logic)`.

Since RTSJ 1.0.1

Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `VTMemory(long size)`.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTMemory(SizeEstimator, Runnable)

Signature

```
public
VTMemory(SizeEstimator size,
         Runnable logic)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(size.getEstimate(), size.getEstimate(), logic)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

`logic`—The `run()` of the given `Runnable` will be executed using `this` as its initial memory area. When `logic` is `null`, this constructor is equivalent to `VTMemory(SizeEstimator size)`.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTMemory(long)

Signature

```
public
VTMemory(long size)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(size, size, null)`.

Since RTSJ 1.0.1

Parameters

`size`—The size in bytes of the memory to allocate for this area. This memory must be committed before the completion of the constructor.

Throws

`IllegalArgumentException`—when `size` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

VTMemory(SizeEstimator)

Signature

```
public
VTMemory(SizeEstimator size)
```

Description

Equivalent to `VTMemory(long, long, Runnable)` with the argument list `(size.getEstimate(), size.getEstimate(), null)`.

Since RTSJ 1.0.1

Parameters

`size`—An instance of `SizeEstimator` used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

Throws

`IllegalArgumentException`—when `size` is `null`, or `size.getEstimate()` is less than zero.

`StaticOutOfMemoryError`—when there is insufficient memory for the `VTMemory` object or for its allocation area in its backing store.

B.2.2.41.2 Methods

---

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a string representing this object. The string is of the form

{@code (VTMemory) ScopedMemory#<num>}

where `<num>` uniquely identifies the `VTMemory` area.

Returns

a string representing the value of `this`.

B.2.2.42 VTPhysicalMemory

public class VTPhysicalMemory

Inheritance

java.lang.Object
  MemoryArea
    ScopedMemory
      VTPhysicalMemory

Description

An instance of `VTPhysicalMemory` allows objects to be allocated from a range of physical memory with particular attributes, determined by their memory type. This memory area has the same semantics as `ScopedMemory` memory areas, and the same performance restrictions as `VTMemory`.

No provision is made for sharing object in `VTPhysicalMemory` with entities outside the JVM that creates them, and, while the memory backing an instance of `VTPhysicalMemory` could be shared by multiple JVMs, the class does not support such sharing.

Methods from `VTPhysicalMemory` should be overridden only by methods that use `super`.

See Section MemoryArea
See Section ScopedMemory
See Section VTMemory
See Section LTMemory
See Section LTPhysicalMemory
See Section ImmortalPhysicalMemory
See Section RealtimeThread
See Section NoHeapRealtimeThread
Deprecated since RTSJ 2.0

B.2.2.42.1 Constructors

VTPhysicalMemory(Object, long, long, Runnable)

Signature

```
public
VTPhysicalMemory(Object type,
                 long base,
                 long size,
                 Runnable logic)
```

Description

Creates an instance of `VTPhysicalMemory` with the given parameters.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`StaticSecurityException`—when the application does not have permissions to access physical memory or the given range of memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTPhysicalMemory(Object, long, SizeEstimator, Runnable)

Signature

```
public
VTPhysicalMemory(Object type,
                 long base,
                 SizeEstimator size,
                 Runnable logic)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, base, size.getEstimate(), logic)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that the size estimate from `size` extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalArgumentException`—when `size` is `null`.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTPhysicalMemory(Object, long, long)

Signature

```
public
VTPhysicalMemory(Object type,
                 long base,
                 long size)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, base, size, null)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects.

When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

VTPhysicalMemory(Object, long, SizeEstimator)

Signature

```
public
VTPhysicalMemory(Object type,
                 long base,
                 SizeEstimator size)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, base, size.getEstimate(), null)`.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`base`—The physical memory address of the area.

`size`—A size estimator for this memory area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that the size estimate from `size` extends beyond physically addressable memory.

`OffsetOutOfBoundsException`—when the `base` address is invalid.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`MemoryInUseException`—when the specified memory is already in use.

`IllegalArgumentException`—when `size` is `null`.

VTPhysicalMemory(Object, long, Runnable)

Signature

```
public
VTPhysicalMemory(Object type,
                 long size,
                 Runnable logic)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size, logic)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required (e.g., *dma, shared*), used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application does not have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTPhysicalMemory(Object, SizeEstimator, Runnable)

Signature

```
public
VTPhysicalMemory(Object type,
                 SizeEstimator size,
                 Runnable logic)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size.getEstimate(), logic)`. where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

`logic`—The `run()` method of this object will be called whenever `MemoryArea.enter()` is called. When `logic` is `null`, `logic` must be supplied when the memory area is entered.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that the size estimate from `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`.

`IllegalAssignmentError`—when storing `logic` in `this` would violate the assignment rules.

VTPhysicalMemory(Object, long)

Signature

```
public
VTPhysicalMemory(Object type,
                 long size)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size, null)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—The size of the area in bytes.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is less than zero.

VTPhysicalMemory(Object, SizeEstimator)

Signature

```
public
VTPhysicalMemory(Object type,
                 SizeEstimator size)
```

Description

Equivalent to `VTPhysicalMemory(Object, long, long, Runnable)` with the argument list `(type, next, size.getEstimate(), null)`, where `next` is the beginning of the next best fit in the physical memory range.

See Section PhysicalMemoryManager

Parameters

`type`—An instance of `Object` representing the type of memory required, e.g., *dma, shared*, used to define the base address and control the mapping. When the required memory has more than one attribute, `type` may be an array of objects. When `type` is `null` or a reference to an array with no entries, any type of memory is acceptable. Note that `type` values are compared by reference (==), not by value (`equals`).

`size`—A size estimator for this area.

Throws

`StaticSecurityException`—when the application doesn't have permissions to access physical memory or the given range of memory.

`SizeOutOfBoundsException`—when the implementation detects that the size estimate from `size` extends beyond physically addressable memory.

`UnsupportedPhysicalMemoryException`—when the underlying hardware does not support the given type, or when no matching `PhysicalMemoryTypeFilter` has been registered with the `PhysicalMemoryManager`.

`MemoryTypeConflictException`—when the specified base does not point to memory that matches the requested type, or when `type` specifies incompatible memory attributes.

`IllegalArgumentException`—when `size` is `null`.

B.2.2.42.2 Methods

---

toString

Signature

```
public java.lang.String
toString()
```

Description

Creates a string representing this object. The string is of the form

```
(VTPhysicalMemory) Scoped memory # num
```

where `num` is a number that uniquely identifies this `VTPhysicalMemory` memory area.

Returns

a string representing the value of `this`.

B.3 Rationale

These are interface and classes that have been shown to be less than ideal. Except for feasibility analysis, they have been replaced by elements that better fulfill the require-

ments. Compatibility can be provided by implemenations that use existing facilities, so there is no reason to continue requiring their inclusion in new implementations.

Appendix C

Indices

C.1 Class Index

C.2 Method Index