Realtime and Embedded Specification for Java

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Editor
James J. Hunt
aicas GmbH
Haid-und-Neu-Straße 18
D-76131 Karlsruhe, Germany

The Realtime 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.

JSR-282 Expert Group Membership

James J. Hunt	aicas GmbH
Benjamin Brosgol	
Andy Wellings	
Kelvin Nilsen	
Ethan Blanton	

Past Expert Group Members

Peter Dibble	TimeSys
David Holmes	Oracle

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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 of 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 determine this.

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, adds additional requirements.

Providing realtime semantics and the additional programming interfaces required

is a core part of this specification. So much so that the original specification provided special memory areas to avoid the use of garbage collection. 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 base Java semantics and 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 set of programming interfaces requires some guiding principles around which to organize the RTSJ. These principles delimit the scope of the RTSJ and its compatibility requirements with conventional Java.

1.1.1 Applicability to Particular 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. There are eight aspects of these refinements and additions 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 scheduling 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 serial 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 implement 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 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 of 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 realtime 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

[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.

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 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 format <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 scheduler, 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 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. If 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 policy, 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 Async-BaseEventHandler: AsyncEventHandler, AsyncLongEventHandler, and AsyncOb-jectEventHandler. 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 POSIXRealtimeSignal 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 in only 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 signalling from another thread, or the passage of time, 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 iteration cost and bound. 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.

2.3.3 Principles

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.

2.3.3.1 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, static initializers, and synchronized statements.
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).

2.3.3.2 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.

2.3.3.3 Semantic Principles

1. If 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. If 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.

2.3.3.4 Pragmatic Principles

1. There should be straightforward idioms for common cases such as timer handlers and realtime thread termination.
2. If 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.

2.3.4 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 (if 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 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 (if coded to be so) but orderly clean up and termination of the realtime thread. Note that the oracle can comprise as many or as few asynchronous event handlers as appropriate.

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 longs worth of seconds and another integer for nanoseconds.

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 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 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.

2.9 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, 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 Langauge.

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

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.AbstractAsyncEventHandler 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 AbstractAsyncEventHandler. 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 thread or schedulable, including Java threads.

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 it 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 the implementation 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 like functionality together in a way that promotes maximal adoption for various implementation classes. A conventional JVM may simply implement the Base 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 Base 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 give the implementation some choice over which modules and features to include and which not.

3.2.2.1 Base Module

The Base 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 8.3.3.1)
- Affinity (Section 6.3.3.1)
- AperiodicParameters (Section 6.3.3.2)
- AsyncBaseEvent (Section 8.3.3.2)
- AsyncBaseEventHandler (Section 8.3.3.3)
- AsyncEvent (Section 8.3.3.4)
- AsyncEventHandler (Section 8.3.3.5)
- AsyncLongEvent (Section 8.3.3.6)
- AsyncLongEventHandler (Section 8.3.3.7)
- AsyncObjectEvent (Section 8.3.3.8)
- AsyncTimable (Section 10.3.1.1)
- AsyncObjectEventHandler (Section 8.3.3.9)
- BoundAsyncBaseEventHandler (Section 8.3.1.2)
- BoundAsyncEventHandler (Section 8.3.3.10)
- BoundAsyncLongEventHandler (Section 8.3.3.11)
- BoundAsyncObjectEventHandler (Section 8.3.3.12)
- Clock (Section 10.3.2.1)
- Chronograph (Section 10.3.1.2)
- ConfigurationParameters (Section 5.3.2.1)
- FirstInFirstOutScheduler (Section 6.3.3.4)
- GarbageCollector (Section 14.2.2.1)
- HeapMemory (Section 11.3.3.1)
- HighResolutionTime (Section 9.3.1.2)
- ImmortalMemory (Section 11.3.3.2)
- ImportanceParameters (Section 6.3.3.5)
- Interruptible (Section 8.3.1.3)
- MemoryArea (Section 11.3.3.3)
- MemoryAreaVisitor (Section 11.3.1.1)
- MemoryParameters (Section 11.3.3.4)[1]
- MonitorControl (Section 7.3.1.1)
- OneShotTimer (Section 10.3.2.2)
- PeriodicParameters (Section 6.3.3.6)
- PeriodicTimer (Section 10.3.2.3)
- PhasingPolicy (Section 5.3.1.1)

[1]The mayUseHeap flag is present, but can only be set if the Memory Module is supported.

- PriorityCeilingEmulation (Section 7.3.1.2)
- PriorityInheritance (Section 7.3.1.3)
- PriorityParameters (Section 6.3.3.7)
- PriorityScheduler (Section 6.3.3.8)
- ProcessingGroup (Section 6.3.3.9)
- QueueOverflowPolicy (Section 6.3.2.2)
- RealtimeExecutionContext (Section 6.3.1.2)
- RealtimeSecurity (Section 14.2.2.2)
- RealtimeSystem (Section 14.2.2.3)
- RealtimeThread (Section 5.3.2.2)
- RelativeTime (Section 9.3.1.3)
- Releasable (Section 8.3.1.4)
- ReleaseParameters (Section 6.3.3.10)
- RoundRobinScheduler (Section 6.3.3.11)
- RTSJModule (Section 14.2.1.1)
- Schedulable (Section 6.3.1.3)
- Scheduler (Section 6.3.3.12)
- SchedulingParameters (Section 6.3.3.14)
- SizeEstimator (Section 11.3.3.5)
- SporadicParameters (Section 6.3.3.15)
- Timable (Section 10.3.1.3)
- Timed (Section 8.3.2.3)
- TimeDispatcher (Section 10.3.2.4)
- Timer (Section 10.3.2.6)
- 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 15.2.3.1)
- ArrivalTimeQueueOverflowException (Section 15.2.2.1)
- CeilingViolationException (Section 15.2.2.2)
- DeregistrationException (Section 15.2.2.3)
- IllegalAssignmentError (Section 15.2.3.2)
- InaccessibleAreaException (Section 15.2.2.5)
- LateStartException (Section 15.2.2.6)
- MemoryAccessError (Section 15.2.3.3)
- MemoryInUseException (Section 15.2.2.8)
- MemoryScopeException (Section 15.2.2.9)
- MemoryTypeConflictException (Section 15.2.2.10)
- MITViolationException (Section 15.2.2.7)
- OffsetOutOfBoundsException (Section 15.2.2.11)

- POSIXException (Section 15.2.2.12)
- POSIXInvalidSignalException (Section 15.2.2.13)
- POSIXInvalidTargetException (Section 15.2.2.14)
- POSIXSignalPermissionException (Section 15.2.2.15)
- ProcessorAffinityException (Section 15.2.2.16)
- RangeOutOfBoundsException (Section 15.2.2.17)
- RegistrationException (Section 15.2.2.18)
- ResourceLimitError (Section 15.2.3.4)
- ScopedCycleException (Section 15.2.2.19)
- StaticCheckedException (Section 15.2.2.21)
- StaticError (Section 15.2.3.5)
- StaticOutOfMemoryError (Section 15.2.3.6)
- StaticRuntimeException (Section 15.2.2.22)
- StaticThrowable (Section 15.2.1.1)
- StaticThrowableStorage (Section 15.2.3.7)
- SizeOutOfBoundsException (Section 15.2.2.20)
- ThrowBoundaryError (Section 15.2.3.8)
- UnsupportedPhysicalMemoryException (Section 15.2.2.23)
- UnsupportedRawMemoryRegionException (Section 15.2.2.24)

3.2.2.2 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.

- Happening (Section 12.3.2.3)
- HappeningDispatcher (Section 12.3.2.4)
- InterruptServiceRoutine (Section 12.3.2.5)
- DMABufferFactory (Section 12.3.2.1)
- RawMemory (Section 12.3.1.16)
- RawMemoryFactory (Section 12.3.2.6)
- RawMemoryRegion (Section 12.3.2.7)
- RawMemoryRegionFactory (Section 12.3.1.17)
- RawByte (Section 12.3.1.1)
- RawByteReader (Section 12.3.1.2)
- RawByteWriter (Section 12.3.1.3)
- RawDouble (Section 12.3.1.4)
- RawDoubleReader (Section 12.3.1.5)

- RawDoubleWriter (Section 12.3.1.6)
- RawFloat (Section 12.3.1.7)
- RawFloatReader (Section 12.3.1.8)
- RawFloatWriter (Section 12.3.1.9)
- RawInt (Section 12.3.1.10)
- RawIntReader (Section 12.3.1.11)
- RawIntWriter (Section 12.3.1.12)
- RawLong (Section 12.3.1.13)
- RawLongReader (Section 12.3.1.14)
- RawLongWriter (Section 12.3.1.15)
- RawShort (Section 12.3.1.18)
- RawShortReader (Section 12.3.1.19)
- RawShortWriter (Section 12.3.1.20)

3.2.2.3 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.

- LTMemory (Section 11.4.3.1)
- PhysicalMemoryCharacteristic (Section 11.4.1.1)
- PhysicalMemoryFactory (Section 11.4.3.2)
- PhysicalMemoryRegion (Section 11.4.3.3)
- PhysicalMemorySelector (Section 11.4.3.4)
- PinnableMemory (Section 11.4.3.5)
- ScopedMemory (Section 11.4.3.6)
- StackedMemory (Section 11.4.3.7)

3.2.3 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 it 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 13.3.1.1)
- RealtimeSignalDispatcher (Section 13.3.1.2)
- Signal (Section 13.3.1.3)

- SignalDispatcher (Section 13.3.1.4)

3.2.4 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

Hard cost enforcement	Provides an automatic means of controlling the processor usage of a task or group of tasks.
Processing Group deadline less than period	Enables the application to specify a processing group deadline less than the processing group period
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.

The ProcessingGroup class only intervenes in scheduling on systems that support the hard cost enforcement option. 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. When cost enforcement is supported, the precision of enforcement is the drive precision of the clock being used. In any event, cost and deadline overrun handlers are fired with the resolution specified for hard cost enforcement.

In implementations where processing group deadline less than period is not supported, values passed to the constructor for ProcessingGroup and its setDeadline method are constrained to be equal to the period. If the option is supported, processing group deadlines less than the period shall be supported and function as specified.

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.

3.2.5 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:

- DuplicateFilterException (Section A.2.2.3)
- ImmortalPhysicalMemory (Section A.2.3.10)
- LTMemory (Section A.2.3.11)
- LTPhysicalMemory (Section A.2.3.12)
- NoHeapRealtimeThread (Section A.2.3.15)
- PhysicalMemoryManager (Section A.2.3.20)
- PhysicalMemoryTypeFilter (Section A.2.1.1)
- ProcessingGroupParameters (Section A.2.3.23)
- POSIXSignalHandler (Section A.2.3.17)
- RationalTime (Section A.2.3.24)
- RawMemoryAccess (Section A.2.3.25)
- RawMemoryFloatAccess (Section A.2.3.26)
- ScopedMemory (Section A.2.3.32)
- UnknownHappeningException (Section A.2.2.6)
- VTMemory (Section A.2.3.36)
- VTPhysicalMemory (Section A.2.3.37)
- WaitFreeDequeue (Section A.2.3.38)

They are documented fully in Chapter A.

3.2.6 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 for Safety Critical Java, may subset classes and packages herein, but must implement the methods and classes defined in that specification.

3.2.6.1 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 and at least 28 unique priority levels. 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.

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 unique 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.

3.2.6.2 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 implemen-

tation 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 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 nonheap context, 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 a extraheap context, the documentation shall detail the effect of these restrictions for each RTSJ API.

8. The worst-case response interval between firing an AsyncEvent because of 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 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 refering 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 catagory 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 11.2.6.)
- Some Throwables, in particular, those implementing StaticThrowable, which includes StaticOutOfMemoryError, which an RTSJ VM throws 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 15.1.)

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 11.2.7.)
- 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 6.3.3.8.3.)
- 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 8.3.3.5.)

The third and final category is behaviors experienced 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 8.2.3.)
- 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 8.2.3.)
- Exceptions propagating into asynchronously interruptible regions of code will be lost if an AsynchronouslyInterruptibleException is pending. (See Section 8.2.3.)
- Subclasses of AsynchronouslyInterruptibleException indicated in the signature of a method do not indicate that the method is asynchronously interruptible. (See Section 8.2.3.)
- Catch clauses for AsynchronouslyInterruptibleException or its subclasses in asynchronously interruptible methods will not catch an AIE. (See Section 8.2.3.)
- A Throwable crossing a MemoryArea boundary might be transformed into a ThrowBoundaryError, and the original exception may be lost. (See Section 15.2.3.8 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 SchedulingGroup.

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 SchedulingGroup are

instead used for these purposes, and an alternative to enumerate is provided on SchedulingGroup in the form of a visitor.

Scheduling groups, i.e., instances of SchedulingGroup (a subclass of ThreadGroup, are designed to be able to reference threads, schedulables, and other scheduling groups, even when they are in scoped memory. These are only reachable using a visitor with a lambda expression. Consequently schedulables and scheduling groups are not part of any thread group and will hold a scheduling 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 SchedulingGroup 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 SchedulingGroup.
3. Call the SchedulingGroup.enumerate(Thread[]) and SchedulingGroup.enumerate(Thread[], boolean) only return Java threads.
4. Call the SchedulingGroup.enumerate(ThreadGroup[]) and SchedulingGroup.enumerate(ThreadGroup boolean) only return threads groups and scheduling 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 scheduling group of it 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 scheduling group of the handler's dispatcher, when that dispatcher's scheduling 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 scheduling group, either explicitly via it 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 12.2.1), and DMABufferFactory fence methods are all ordered in a way that is consistent with respect to native code or hardware devices that use platform-native memory coherence 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 improving 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 implementation 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 method 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 undoubtably 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 ore 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 sematics 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*. ProcessingGroup, a class derived from ThreadGroup provides cost enforcement on groups of tasks. The ConfigurationParameters class defines, amongst other things, the size of Java 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 facilities 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 detecting 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 SchedulingGroup.
8. System-related termination activity (such as execution of finalizers for scoped objects in scoped memory areas that become unreferenced) triggered by termi-

nation 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 java.lang.Thread.setPriority(int), which causes it to be treated as a conventional java thread until a new SchedulingParameters object is set.

5.3 javax.realtime

5.3.1 Enumerations

5.3.1.1 PhasingPolicy

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.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().

Available since RTSJ 2.0

5.3.1.1.1 Enumeration Constants

ADJUST_IMMEDIATE

public static final ADJUST_IMMEDIATE

Description

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

ADJUST_FORWARD

public static final ADJUST_FORWARD

Description

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

	ADJUST IMMEDIATE	ADJUST FORWARD	ADJUST BACKWARD	STRICT PHASING
Relative 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.	The time of start method invocation plus start time.
Absolute Time, 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.
Absolute Time, 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

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.

ADJUST_BACKWARD

public static final 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 STRICT_PHASING

Description

Indicates that a periodic thread started after the absolute time given for its start time should throw the LateStartException[1] 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

[1] Section 15.2.2.6

5.3.2 Classes

5.3.2.1 ConfigurationParameters

Inheritance
java.lang.Object
javax.realtime.ConfigurationParameters

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[2] associated with a Schedulable[3].

Note that these parameters are immutable.

Available since RTSJ 2.0

5.3.2.1.1 Constructors

ConfigurationParameters(int, int, long)

Signature

```
public
ConfigurationParameters(int messageLength,
                        int stackTraceLength,
                        long[] sizes)
throws IllegalStateException
```

Description

Creates a parameter object for initializing the state of a Schedulable[4]. The parameters provide the data for this initialization. For RealtimeThread[5] and bound versions of AsyncBaseEventHandler[6], the stack and message buffers can

[2]Section 15.2.3.8
[3]Section 6.3.1.3
[4]Section 6.3.1.3
[5]Section 5.3.2.2
[6]Section 8.3.3.3

be set exactly, but for the unbound event handlers, the system cannot give any guarentees to allow thread sharing.

Parameters

messageLength is 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[7] 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.

stackTraceLength Length of the stack trace buffer, in units of a number of StackTraceElement instances, reserved use by preallocated exceptions and errors thrown in the execution context of the Schedulable[8] 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.

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.

ConfigurationParameters(long)

Signature

public
ConfigurationParameters(long[] sizes)

Description

Same as ConfigurationParameters(int,int,long[])[9] with arguments -1, -1, sizes.

5.3.2.1.2 Methods

[7] Section 6.3.1.3
[8] Section 6.3.1.3
[9] Section 5.3.2.1.1

getMessageLength

Signature

public int
getMessageLength()

Description

Gets the size of the buffer dedicated to storing the message of the last thrown throwable in the context of instances of Schedulable[10] created with these parameters. The value 0 indicates that no message will be stored.

Returns

Reserved memory size in units of char.

getStackTraceLength

Signature

public int
getStackTraceLength()

Description

Gets the length of the stack trace buffer dedicated to Schedulable[11] objects created with these parameters' preallocated exceptions, measured in number of StackTraceElement instances. The amount of space this requires is implementation-specific. The value 0 indicates that no stack trace will be stored.

Returns

Reserved memory size in implementation-dependent stack frames.

getSizes

Signature

public long[]
getSizes()

Description

[10]Section 6.3.1.3
[11]Section 6.3.1.3

Gets the array of implementation-specific sizes associated with Schedulable[12] objects created with these parameters. *This method may allocate memory.*

Returns
A copy of the array of implementation-specific sizes.

5.3.2.2 RealtimeThread

Inheritance
java.lang.Object
java.lang.Thread
javax.realtime.RealtimeThread
Interfaces
javax.realtime.BoundSchedulable
javax.realtime.AsyncTimable
Description

Class RealtimeThread extends Thread and adds access to realtime services such as asynchronous transfer of control, nonheap memory, and advanced scheduler services.

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.

5.3.2.2.1 Constructors

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

Signature

[12] Section 6.3.1.3

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

Description

Create a realtime thread with the given characteristics and a specified Runnable. The scheduling 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.

Available since RTSJ 2.0

Parameters

scheduling The SchedulingParameters[13] associated with this (And possibly other instances of Schedulable[14]). When scheduling is null and the creator is a schedulable, SchedulingParameters[15] 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[16] associated with this (and possibly other instances of Schedulable[17]). 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[18] associated with this (and possibly other instances of Schedulable[19]). 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.

[13] Section 6.3.3.14
[14] Section 6.3.1.3
[15] Section 6.3.3.14
[16] Section 6.3.3.10
[17] Section 6.3.1.3
[18] Section 11.3.3.4
[19] Section 6.3.1.3

area the initial memory area of this handler.

config The ConfigurationParameters[20] associated with this (and possibly other instances of Schedulable[21]). 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[22] to use for realtime sleep and determining the period of a periodic thread.

group The SchedulingGroup of the newly created realtime thread or the parent's scheduling 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

IllegalArgumentException when the parameters are not compatible with the associated scheduler or the current thread group is not a SchedulingGroup and group is null.

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 ares 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.

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

[20] Section 5.3.2.1
[21] Section 6.3.1.3
[22] Section 10.3.2.4

Signature

public
RealtimeThread(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory,
MemoryArea area,
ConfigurationParameters config,
Runnable logic)

Description

Create a realtime thread with the given SchedulingParameters[23], ReleaseParameters[24], MemoryParameters[25], ConfigurationParameters[26], a specified Runnable, and default values for all other parameters.

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

Available since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters, ConfigurationParameters, Runnable)

Signature

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

Description

Create a realtime thread with the given SchedulingParameters[27], ReleaseParam-

[23]Section 6.3.3.14
[24]Section 6.3.3.10
[25]Section 11.3.3.4
[26]Section 5.3.2.1
[27]Section 6.3.3.14

eters[28], MemoryArea[29] and a specified Runnable and default values for all other parameters.

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

Available since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters, ConfigurationParameters)

Signature

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

Description

Create a realtime thread with the given SchedulingParameters[30], ReleaseParameters[31] and MemoryArea[32] and default values for all other parameters.

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

Available since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters, Runnable)

Signature

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

[28] Section 6.3.3.10
[29] Section 11.3.3.3
[30] Section 6.3.3.14
[31] Section 6.3.3.10
[32] Section 11.3.3.3

Description

Create a realtime thread with the given SchedulingParameters[33], ReleaseParameters[34] 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).

Available since RTSJ 2.0

RealtimeThread(SchedulingParameters, ReleaseParameters)

Signature

public
RealtimeThread(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)

Description

Create a realtime thread with the given SchedulingParameters[35] and ReleaseParameters[36] and default values for all other parameters.

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

RealtimeThread(SchedulingParameters, TimeDispatcher)

Signature

public
RealtimeThread(SchedulingParameters scheduling,
TimeDispatcher dispatcher)

Description

[33]Section 6.3.3.14
[34]Section 6.3.3.10
[35]Section 6.3.3.14
[36]Section 6.3.3.10

Create a realtime thread with the given SchedulingParameters[37] and TimeDispatcher[38] and default values for all other parameters. This constructor is equivalent to RealtimeThread(scheduling, null, null, null, null, dispatcher, null, null).

Available since RTSJ 2.0

RealtimeThread(SchedulingParameters)

Signature

public
RealtimeThread(SchedulingParameters scheduling)

Description

Create a realtime thread with the given SchedulingParameters[39] 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

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

5.3.2.2.2 Methods

[37] Section 6.3.3.14
[38] Section 10.3.2.4
[39] Section 6.3.3.14

currentRealtimeThread

Signature

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

Description

Gets a reference to the current instance of RealtimeThread.

It is permissible to call currentRealtimeThread when control is in an AsyncEventHandler[40]. 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 that of a Java thread.

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 returns an instance of AsyncBaseEventHandler[41].

Throws

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

Returns

A reference to the current instance of Schedulable.

[40] Section 8.3.3.5
[41] Section 8.3.3.3

getCurrentMemoryArea

Signature

public static javax.realtime.MemoryArea
getCurrentMemoryArea()

Description

Return a reference to the MemoryArea[42] object representing the current allocation context.

When this method is invoked from a Java thread it will return that thread's current memory area (heap or immortal memory).

Returns

A reference to the MemoryArea[43] object representing the current allocation context.

getInitialMemoryAreaIndex

Signature

public static int
getInitialMemoryAreaIndex()
throws IllegalStateException,
ClassCastException

Description

Gets the position of the initial memory area for the current Schedulable[44] in the memory area stack. Memory area stacks may include inherited stacks from parent threads. The initial memory area of a RealtimeThread[45] or an AsyncBaseEventHandler[46] 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

IllegalSchedulableStateException 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.

[42] Section 11.3.3.3
[43] Section 11.3.3.3
[44] Section 6.3.1.3
[45] Section 5.3.2.2
[46] Section 8.3.3.3

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 that of a Java thread. 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.

getMemoryAreaStackDepth

Signature

public static int
getMemoryAreaStackDepth()
throws ClassCastException

Description

Gets the size of the stack of MemoryArea[47] instances to which the current schedulable has access.

Note, the current memory area (getCurrentMemoryArea()[48]) is found at memory area stack index of getMemoryAreaStackDepth() - 1.

Throws

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

Returns

The size of the stack of MemoryArea[49] instances.

getOuterMemoryArea(int)

Signature

```
public static javax.realtime.MemoryArea
getOuterMemoryArea(int index)
throws ClassCastException,
       MemoryAccessError
```

Description

Gets the instance of MemoryArea[50] in the memory area stack at the index given. When the given index does not exist in the memory area scope stack then null is returned.

Note, the current memory area (getCurrentMemoryArea()[51]) is found at memory area stack index getMemoryAreaStackDepth() - 1, so getCurrentMemoryArea() == getOutMemoryArea(getMemoryAreaStackDepth() - 1).

Parameters

index The offset into the memory area stack.

Throws

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

MemoryAccessError when the memory area is allocate in heap memory and the caller is a schedulable that may not use the heap.

Returns

The instance of MemoryArea[52] at index or null when the given value does not correspond to a position in the stack.

[47] Section 11.3.3.3
[48] Section 5.3.2.2.2
[49] Section 11.3.3.3
[50] Section 11.3.3.3
[51] Section 5.3.2.2.2
[52] Section 11.3.3.3

sleep(HighResolutionTime)

Signature

public static void
sleep(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
ClassCastException,
IllegalArgumentException

Description

A sleep method that is controlled by a generalized clock. Since the time is expressed as a HighResolutionTime[53], 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[54]. 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.

It is permissible to call sleep when control is in an AsyncEventHandler[55]. The method cause 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()[56] or AsynchronouslyInterruptedE
fire()[57] during the time between calling this method and returning from it.

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

IllegalArgumentException when time is null, when time is a relative time less than zero, or when the Chronograph[58] of time is not a Clock[59].

[53]Section 9.3.1.2
[54]Section 10.3.2.1
[55]Section 8.3.3.5
[56]Section 5.3.2.2.2
[57]Section 8.3.2.1.2
[58]Section 10.3.1.2
[59]Section 10.3.2.1

suspend(HighResolutionTime)

Signature

public static void
suspend(javax.realtime.HighResolutionTime<?> time)
throws ClassCastException,
IllegalArgumentException

Description

The same as sleep(HighResolutionTime)[60] 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 that of a Java thread.

IllegalArgumentException when time is null, when time is a relative time less than zero, or when the Chronograph[61] of time is not a Clock[62].

Available since RTSJ 2.0

spin(HighResolutionTime)

Signature

public static void
spin(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
ClassCastException,
IllegalArgumentException

Description

Similar to sleep(HighResolutionTime)[63] except it performs a busy wait by polling on the Chronograph[64] 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.

[60] Section 5.3.2.2.2
[61] Section 10.3.1.2
[62] Section 10.3.2.1
[63] Section 5.3.2.2.2
[64] Section 10.3.1.2

Parameters

time an absolute or relative time at which to stop spinning.

Throws

InterruptedException when the thread is interrupted by interrupt()[65] or AsynchronouslyInterruptedE fire()[66] during the time between calling this method and returning from it.

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

IllegalArgumentException when time is null, or when time is a relative time less than zero.

Available since RTSJ 2.0

spin(int)

Signature

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

Description

The same as calling spin(HighResolutionTime)[67] 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()[68] or AsynchronouslyInterruptedE fire()[69] during the time between calling this method and returning from it.

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

IllegalArgumentException when nanos is less than zero.

Available since RTSJ 2.0

[65] Section 5.3.2.2.2
[66] Section 8.3.2.1.2
[67] Section 5.3.2.2.2
[68] Section 5.3.2.2.2
[69] Section 8.3.2.1.2

waitForNextRelease

Signature

public static boolean
waitForNextRelease()
throws AsynchronouslyInterruptedException,
IllegalStateException,
ClassCastException

Description

Causes the current realtime thread to delay until the next release. (See release()[70].) Used by threads that have a reference to either periodic or aperiodic ReleaseParameters[71]. The first release starts when this thread is released as a consequence of the action of one of the start()[72] 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[73].)

Throws

AsynchronouslyInterruptedException when the thread is interrupted by interrupt()[74] or AsynchronouslyInterruptedException.fire()[75] during the time between calling this method and returning from it and the ReleaseParameters.isRousable()[76] 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.

IllegalStateException when this does not have a reference to a ReleaseParameters[77] type of either PeriodicParameters[78] or AperiodicParameters[79].

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

[70] Section 5.3.2.2.2
[71] Section 6.3.3.10
[72] Section 5.3.1
[73] Section 6.3.3.8
[74] Section 5.3.2.2.2
[75] Section 8.3.2.1.2
[76] Section 6.3.3.10.2
[77] Section 6.3.3.10
[78] Section 6.3.3.6
[79] Section 6.3.3.2

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.

Available since RTSJ 2.0

getMemoryArea

Signature

public javax.realtime.MemoryArea
getMemoryArea()

Description

Return 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.

Available since RTSJ 1.0.1

getMemoryParameters

Signature

public javax.realtime.MemoryParameters
getMemoryParameters()

Description

Gets a reference to the MemoryParameters[80] object for this schedulable.

Returns

A reference to the current MemoryParameters[81] object.

[80] Section 11.3.3.4
[81] Section 11.3.3.4

getSchedulingGroup

Signature

public javax.realtime.SchedulingGroup
getSchedulingGroup()

Description

Gets a reference to the SchedulingGroup[82] instance of this schedulable.

Returns

A reference to the current SchedulingGroup[83] object.

Available since since RTSJ 2.0

getConfigurationParameters

Signature

public javax.realtime.ConfigurationParameters
getConfigurationParameters()

Description

Gets a reference to the ConfigurationParameters[84] object for this schedulable.

Returns

A reference to the associated ConfigurationParameters[85] object.

Available since RTSJ 2.0

getReleaseParameters

Signature

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

Description

[82] Section 6.3.3.13
[83] Section 6.3.3.13
[84] Section 5.3.2.1
[85] Section 5.3.2.1

Gets a reference to the ReleaseParameters[86] object for this schedulable.

Returns
A reference to the current ReleaseParameters[87] object.

getScheduler

Signature
public javax.realtime.Scheduler
getScheduler()

Description
Gets a reference to the Scheduler[88] object for this schedulable.

Returns
A reference to the associated Scheduler[89] object.

getSchedulingParameters

Signature
public javax.realtime.SchedulingParameters
getSchedulingParameters()

Description
Gets a reference to the SchedulingParameters[90] object for this schedulable.

Returns
A reference to the current SchedulingParameters[91] object.

release

Signature
public void
release()

[86] Section 6.3.3.10
[87] Section 6.3.3.10
[88] Section 6.3.3.12
[89] Section 6.3.3.12
[90] Section 6.3.3.14
[91] Section 6.3.3.14

Description

Generate 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.

Throws

IllegalStateException when this does not have a reference to a ReleaseParameters[92] type of AperiodicParameters[93].

Available since RTSJ 2.0

interrupt

Signature

public void
interrupt()

Description

Make the generic AsynchronouslyInterruptedException[94] 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 cause an early release. In any case, AsynchronouslyInterruptedException is thrown once a method is entered that implements AsynchronouslyInterruptedException.

Available since RTSJ 2.0

isInterrupted

Signature

public boolean
isInterrupted()

Description

Determines whether or not the generic AsynchronouslyInterruptedException[95] is pending.

[92] Section 6.3.3.10
[93] Section 6.3.3.2
[94] Section 8.3.2.1
[95] Section 8.3.2.1

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

Available since RTSJ 2.0

interrupted

Signature
public static boolean
interrupted()
throws ClassCastException

Description
Indicate whether or not an AsynchronouslyInterruptedException is pending for the currently active Schedulable.

Throws
ClassCastException when the current execution context is that of a standard Java thread.

Returns
true if an AIE is pending for the currently active Schedulable, false otherwise.

Open issue 5.3.1
Did we intend for this to be any AIE, or the generic AIE?
End of issue 5.3.1
Available since RTSJ 2.0

deschedule

Signature
public void
deschedule()

Description
Perform any *deschedule* actions specified by this thread's scheduler, either immediately when in waitForNextRelease()[96] or the next time the thread enters waitForNextRelease().

[96]Section 5.3.2.2.2

Available since RTSJ 2.0

reschedule

Signature

public void
reschedule()
throws IllegalSchedulableStateException

Description

Returns the thread to the blocked-for-next-release state. This causes the next event release the thread and waitForNextRelease[97] to return. Deadline miss and cost enforcement are re-enabled.

The details of the interaction of this method with deschedule[98], waitForNextRelease[99] and release[100] are dictated by this thread's scheduler.

Throws

IllegalSchedulableStateException when the configured Scheduler and SchedulingParameters for this RealtimeThread are not compatible.

Available since RTSJ 2.0

startPeriodic(PhasingPolicy)

Signature

public void
startPeriodic(PhasingPolicy phasingPolicy)
throws LateStartException,
IllegalSchedulableStateException,
IllegalArgumentException

Description

Start the thread with the specified phasing policy.

Parameters

[97] Section 5.3.2.2.2
[98] Section 5.3.1
[99] Section 5.3.2.2.2
[100] Section 5.3.2.2.2

phasingPolicy The phasing policy to be applied when the start time given in the realtime thread's associated PeriodicParameters[101] 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[102].

IllegalArgumentException when the thread is not periodic, or when its start time is not absolute.

IllegalSchedulableStateException when the configured Scheduler and SchedulingParameters for this RealtimeThread are not compatible.

Available since RTSJ 2.0

start

Signature

public void
start()

Description

Set up the realtime thread's environment and start it. The set up might include delaying it until the assigned start time and initializing the thread's scope stack. (See ScopedMemory[103].)

Throws

IllegalStateException when the configured Scheduler and SchedulingParameters for this RealtimeThread are not compatible.

Available since RTSJ 2.0 adds new exception

getLastReleaseTime

Signature

public javax.realtime.AbsoluteTime
getLastReleaseTime()

Description

[101] Section 6.3.3.6
[102] Section 5.3.1.1.1
[103] Section A.2.3.32

Equivalent to getLastReleaseTime(null)

Available since RTSJ 2.0

getLastReleaseTime(AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
getLastReleaseTime(AbsoluteTime dest)

Description

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

Available since RTSJ 2.0

getEffectiveStartTime

Signature

public javax.realtime.AbsoluteTime
getEffectiveStartTime()

Description

Equivalent to getEffectiveStartTime(null).

Available since RTSJ 2.0

getEffectiveStartTime(AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
getEffectiveStartTime(AbsoluteTime dest)

Description

Determine 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, return the effective start time in an AbsoluteTime[104] instance created in the current memory area.

Available since RTSJ 2.0

getCurrentConsumption(RelativeTime)

Signature

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

Description

Determine the CPU consumption for this release.

Throws

IllegalStateException when the caller is not a Schedulable[105].

Returns

When dest is null, return the CPU consumption in a RelativeTime[106] instance created in the current execution context. When dest is not null, return the CPU consumption in dest

Available since RTSJ 2.0

[104] Section 9.3.1.1
[105] Section 6.3.1.3
[106] Section 9.3.1.3

getCurrentConsumption

Signature

public static javax.realtime.RelativeTime
getCurrentConsumption()

Description

Equivalent to getCurrentConsumption(null).

Available since RTSJ 2.0

getMinConsumption(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)

Description

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

Throws

IllegalStateException when the caller is not a Schedulable[107].

Returns

the minimum CPU consumption in dest. When dest is null return the minimum CPU consumption in a RelativeTime[108] instance created in the current memory area.

Available since RTSJ 2.0

getMinConsumption

Signature

public javax.realtime.RelativeTime
getMinConsumption()

Description

[107] Section 6.3.1.3
[108] Section 9.3.1.3

Equivalent to getMinConsumption(null).

Available since RTSJ 2.0

getMaxConsumption(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMaxConsumption(RelativeTime dest)

Description

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

Throws

IllegalStateException when the caller is not a Schedulable[109].

Returns

the maximum CPU consumption in dest. When dest is null return the maximum CPU consumption in a RelativeTime[110] instance created in the current memory area.

Available since RTSJ 2.0

getMaxConsumption

Signature

public javax.realtime.RelativeTime
getMaxConsumption()

Description

Equivalent to getMaxConsumption(null).

Available since RTSJ 2.0

[109] Section 6.3.1.3
[110] Section 9.3.1.3

getDispatcher

Signature

public javax.realtime.TimeDispatcher
getDispatcher()

Description

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

See Section Timable.getDispatcher()

Available since RTSJ 2.0

fire

Signature

public final void
fire()

Description

Used by the Clock[111] infrastructure to cause a call to waitForNextRelease[112] to return.

See Section AsyncTimable.fire()

Available since RTSJ 2.0

mayUseHeap

Signature

public boolean
mayUseHeap()

Description

Determine whether or not this schedulable may use the heap.

Returns

[111] Section 10.3.2.1
[112] Section 5.3.2.2.2

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

Available since RTSJ 2.0

awaken

Signature

public final void
awaken()

Description

Used by the Clock[113] infrastructure to cause a call to sleep[114] to return.

See Section Schedulable.awaken()

Available since RTSJ 2.0

setMemoryParameters(MemoryParameters)

Signature

public javax.realtime.RealtimeThread
setMemoryParameters(MemoryParameters memory)

Description

Sets the memory 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 object. See the documentation for the scheduler for details.

Parameters

memory memory A MemoryParameters[115] 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[116].)

[113] Section 10.3.2.1
[114] Section 5.3.2.2.2
[115] Section 11.3.3.4
[116] Section 6.3.3.8

Throws

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

IllegalStateException null

Returns

this

setReleaseParameters(ReleaseParameters)

Signature

public javax.realtime.RealtimeThread
setReleaseParameters(javax.realtime.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[117] 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[118].)

Throws

IllegalArgumentException Thrown 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.

[117] Section 6.3.3.10
[118] Section 6.3.3.8

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

Returns
this

setScheduler(Scheduler)

Signature
public javax.realtime.RealtimeThread
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()[119] has been called on it and RealtimeThread.join() would block.

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

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

SecurityException SecurityException when the caller is not permitted to set the scheduler for this schedulable.

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

Returns
this

[119] Section 5.3.1

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

public javax.realtime.RealtimeThread
setScheduler(Scheduler scheduler,
SchedulingParameters scheduling,
javax.realtime.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[120] 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[121].)

release A reference to the ReleaseParameters[122] 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[123].)

memoryParameters A reference to the MemoryParameters[124] 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[125].)

Throws

IllegalArgumentException Thrown 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.

[120] Section 6.3.3.14
[121] Section 6.3.3.8
[122] Section 6.3.3.10
[123] Section 6.3.3.8
[124] Section 11.3.3.4
[125] Section 6.3.3.8

SecurityException when the caller is not permitted to set the scheduler for this schedulable.

Returns
this

setSchedulingParameters(SchedulingParameters)

Signature
public javax.realtime.RealtimeThread
setSchedulingParameters(SchedulingParameters scheduling)

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[126] 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[127].)

Throws
IllegalArgumentException Thrown 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.

IllegalSchedulableStateException when the task is active and the new scheduling parameters are not compatible with the current scheduler.

Returns
this

5.4 Rationale

Realtime programming requires a schedule method radically different than what a conventional Java programmer would expect, but most other aspects of thread

[126]Section 6.3.3.14
[127]Section 6.3.3.8

behavior is the same, it is reasonable to model a realtime thread as a java.lang.Thread. The main additions that where needed are for adding additional 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 differentiator 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. 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, affinity, and processing group 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. 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 are two important subclasses: SchedulingGroup and ProcessingGroup. These classes provide additional means of managing tasks.

An instance of the SchedulingGroup 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 SchedulingGroup or its subclass. Therefore the root thread group and the thread group of the initial thread must both be scheduling groups in an RTSJ implementation.

The ProcessingGroup class is a subclass of SchedulingGroup. An instance of the ProcessingGroup class contains values that define a temporal scope for a processing group. When a schedulable has an associated instance of the ProcessingGroup class, it is said to execute within the temporal scope defined by that instance. A single instance of the ProcessingGroup 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 ProcessingGroup 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 three execution states: *executing*, *blocked*, and *eligible-for-execution*.

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.

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. (Some actions implicitly clear any pending releases.)

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 occurrs.

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 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, a detail semantic 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.

The scheduler can be changed independently of the SchedulingParameters and vice versa only when the Schedulable in question is descheduled. Rescheduling will throw an IllegalSchedulableStateException when called on a Schedulable scheduling parameters that are inconsistent with its scheduler. Trying to add a handler with SchedulingParameters that do not match its scheduler to an event will also result in an IllegalSchedulableStateException being thrown.

6.2.1.1 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 the priority schedulers are as follows.
   (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 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).
   (c) Memory parameters default to null which signifies that memory allocation by the schedulable is not constrained by the scheduler.
   (d) The default scheduling parameter values for parameter objects created by a schedulable controlled by the base scheduler are given by the following table (see FirstInFirstOutScheduler).

Attribute	Default Value
Priority parameters priority	 norm priority
Importance parameters importance	 No default. A value must be supplied.

2. All numeric or RelativeTime attributes in parameter values must be greater than or equal to zero.
3. Values of period must be greater than zero.
4. 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.
5. 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 immediately except when constrained by priority inversion avoidance algorithms.
   (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 ProcessingGroup or associated Schedulable, respectively.

6.2.1.2 Release Control

Schedulables are released in response to the occurance 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.

6.2.1.2.1 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 schedulable objects 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.

Arrival-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 async 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 async 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.

6.2.1.2.2 Releases of 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
   (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

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

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 set 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 tell 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 waitForNextRelease method with release parameters where ReleaseParameters.isRousable return 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) When an instance of AIE becomes pending on the realtime thread while it is blocked-for-release-event, and the realtime thread is descheduled, then 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 7d where the time value used as t_{int} is the time at which the schedulable was rescheduled.

(c) When an instance of AIE becomes pending on the realtime thread while it is blocked-for-release-event and it is not descheduled, then this acts as a release event. Execution then continues as in 7d, where the time value used as t_{int} is the time at which the AIE becomes pending.

(d) 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 then 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 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 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 new parameters are aperiodic, the release is immediate, and when 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.

6.2.1.2.3 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 example 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 finish. 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 release and blocked for missed release. It is only in these states that descheduling 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.

6.2.1.2.4 Releases of 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 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, then 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) When interrupt is called on an instance of RealtimeThread that is waiting for its next release or its start time, the interrupt is made pending.
   (c) 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.
   (d) 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.

6.2.1.3 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 simularly with respect to their own scheduler eligibility levels.

1. A Schedulable can become a running schedulable only when it is ready and one of the processors in its requested 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 PriorityParameters setPriority() method, 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.

6.2.1.4 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 now 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 schedulable 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 6.2.1.2.2 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. There sematics 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 sematics, 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 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 only 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, as with the base scheduler, but also 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

No only the presents or absence of a time quantum, but also the semantics for scheduling eligibility differs 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. The values themselves have the same relative meaning between schedulers, but the details of their semantics vary between the two schedulers.

6.2.2.1.1 First-In-First-Out-Scheduler

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

1. The base scheduler must support at least 28 distinct values (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.
11. Use of Thread.setPriority(), 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 a 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 12.2.4).

6.2.2.1.2 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.

6.2.3 Associating Schedulables with Schedulers

The Scheduler associated with a Schedulable at the time it is started is derived from its configuration and the configuration of the task (an 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 SchedulingGroup 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.

Schedulables must always have a compatible Scheduler and SchedulingParameters any time these are explicitly configured. 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.

6.2.4 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.

6.2.4.1 Scheduling Groups

The SchedulingGroup 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 tasks in a scheduling group may use a realtime scheduler,
2. instances of Schedulable may only be created in a scheduling group,
3. the root ThreadGroup instance must be an instance of SchedulingGroup,
4. the ThreadGroup instance of the initial thread must be an instance of SchedulingGroup,
5. an instance of SchedulingGroup may not have a parent that is not an instance of SchedulingGroup, and
6. all children of a SchedulingGroup allocated in a ScopedMemory must be instances of SchedulingGroup.

Furthermore, the enumeration methods on a scheduling group are aware of scoped memory and the referential integrity restrictions discussed in Chapter 11, Alternative Memory Areas. The enumeration methods of SchedulingGroup will not return references to any descendants allocated in a ScopedMemory to which references may not be made from the current allocation context. That is, if a newly allocated object

in the current allocation context could not safely hold a reference to a descendant of the ScopedMemory, that descendant will not be included in the array returned by enumerate(). For processing such SchedulingGroups, a visitor must be used.

The maximum priority and scheduler restrictions on SchedulingGroup 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.

Changing the maximum eligibility allowed to tasks in a SchedulingGroup (via the SchedulingGroup.setMaxEligibility(SchedulingParameters) method) takes effect immediately, and will do the following.

1. For any task t in the affected SchedulingGroup 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 SchedulingGroup child sg of the affected SchedulingGroup 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 SchedulingGroup children in sg.

6.2.4.2 Processing Groups

A processing group is defined by an instance of the ProcessingGroup subclass of SchedulingGroup and each schedulable that is bound to that parameter object is called a *member* of that processing group. A processing group instance acts as a proxy for its members, but enforcement does have an effect on the execution of member threads. As a subclass of ThreadGroup, SchedulingGroup instances are members of the thread group hierarchy of thread groups in the system. Since a SchedulingGroup may have another SchedulingGroup instance as its ancestor, a task might be in more than one scheduling group, and hence can be in more than one processing group.

1. The deadline of a processing group is defined by the value returned by invoking the getDeadline method of the processing group object.
2. A deadline miss for the processing group is triggered when any member of the processing group consumes CPU time at a time greater than the deadline for the most recent release of the processing group.
3. When a processing group misses a deadline:
   (a) when the processing group has a miss handler, it is released for execution,
   (b) otherwise, the processing group has no miss handler, no action is taken.

4. The cost of a processing group is defined by the value returned by invoking the getCost method of the processing group object.
5. When a processing group is initially released, its current CPU consumption is zero and as the members of the processing group 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 group or a change in the group's cost, the current CPU consumption becomes greater than or equal to the current cost of the processing group, 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 release 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 group, if any, is released.
10. When more than one processing group monitoring a given task or set of tasks reach their limits at the same time, *all* corresponding handlers are released in an unspecified order.
11. *Any* group entering enforcement between a given group and the root enforces that group.
12. When cost enforcement is supported, enabled, and triggered, the processing group enters the enforced state. For each member of the processing group:
    (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.
13. When the release event occurs for a processing group, the action taken depends on the state of the processing group.
    (a) When the processing group is not in the enforced state, the current CPU consumption for the group is set to zero.
    (b) Otherwise, the processing group 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.
14. 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 group is enforced, then the processing group behaves as defined in semantic 13;

ii. otherwise, no cost monitoring and enforcement action occurs.

15. Changes to other parameters take place as follows:
    (a) changes to **start** have no effect;
    (b) **period** can be change at each release, so the next period is set based on the current value of the processing group's period;
    (c) **deadline** can change at each release, so the next deadline is set based on the current value of the processing group's deadline;
    (d) **OverrunHandler** can change at each release, so the overrunHandler is set based on the current value of the processing group's overrunHandler;
    (e) **MissHandler** can change at each release, so the missHandler is set based on the current value of the processing group's missHandler; and
    (f) **UnderrunHandler** can change at each release, so the underrunHandler is set based on the current value of the processing group's underrunHandler.
16. Changes to the membership of the processing group take effect immediately.
17. The start time for the processing group may be relative or absolute.
    (a) When the start time is absolute, the processing group 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 group is constructed.

Note that until a processing group starts (i.e., its start time has been reached) it will perform no cost monitoring or enforcement on the Schedulables that it contains. Once a processing group is started, it behaves effectively as if it runs continuously until the defining ProcessingGroup object is freed. The start time does not affect limits placed on the group that are inherited from ThreadGroup or SchedulingGroup, such as affinity and scheduling parameters.

Figure 6.1: Sequence Diagram of Some Example Realtime Thread Releases

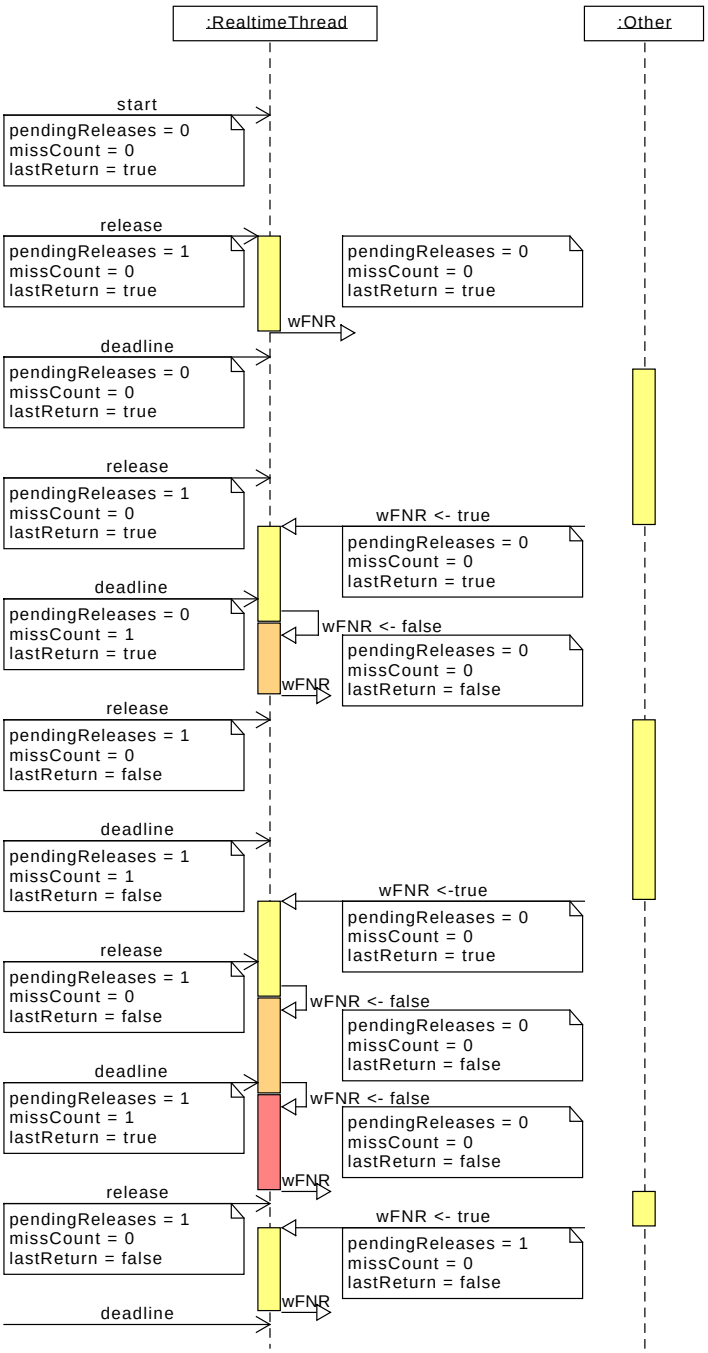


Figure 6.2: A State Chart for a Realtime Thread without a Deadline Miss Handler

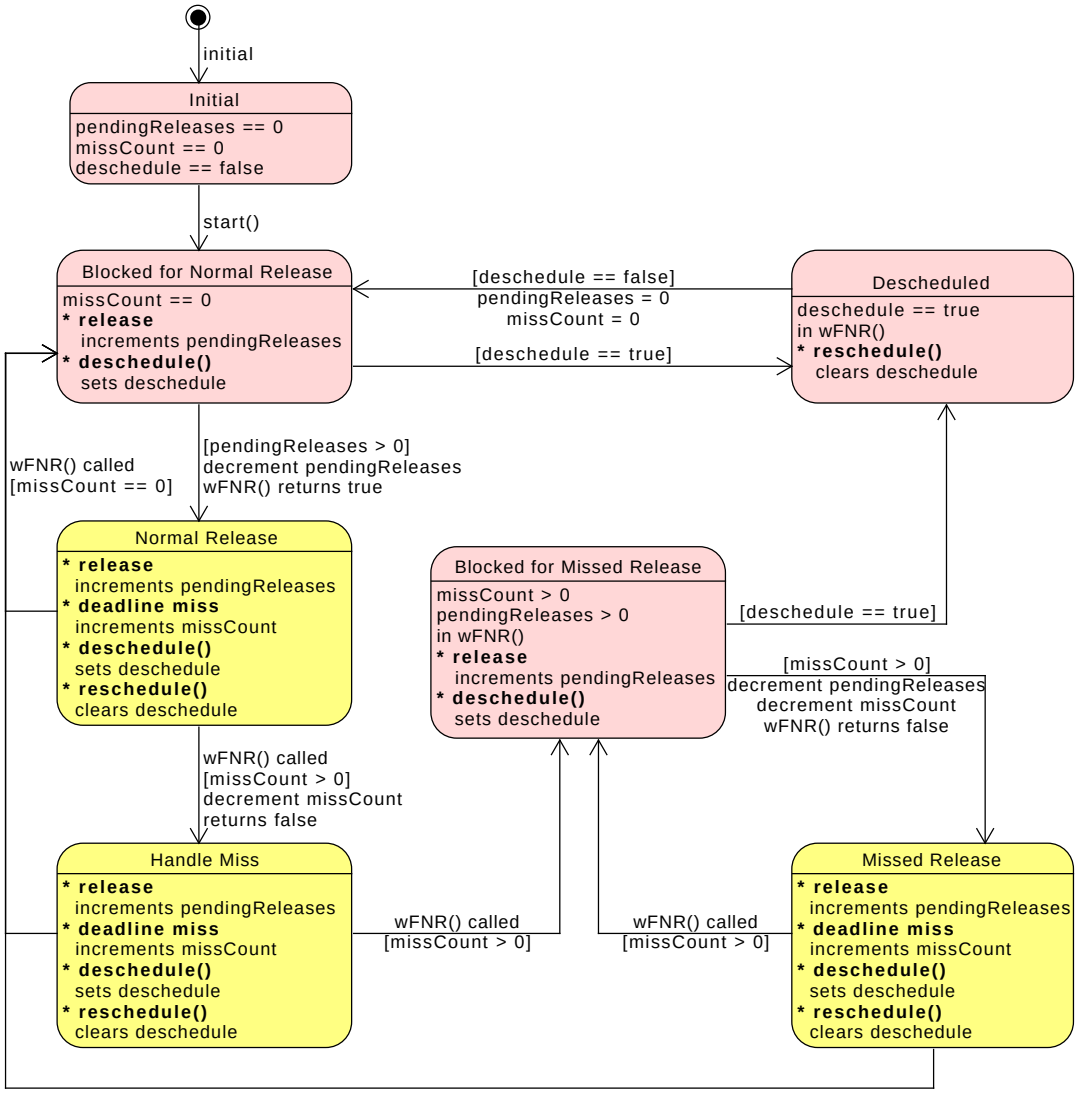
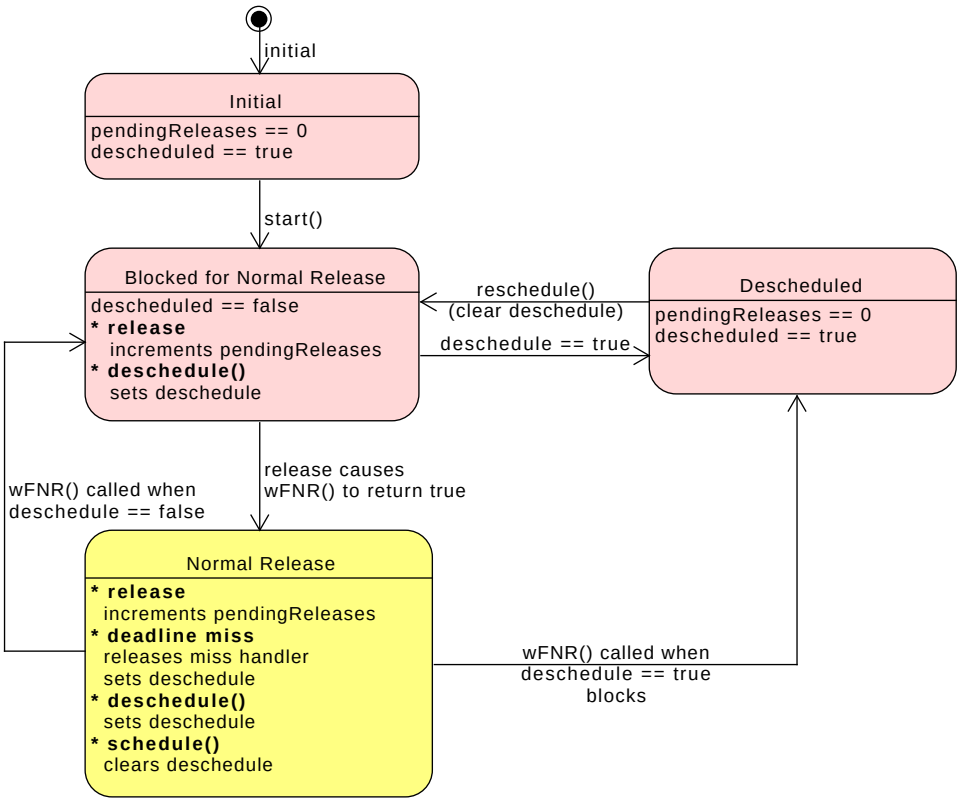


Figure 6.3: A State Chart for a Realtime Thread with a Deadline Miss Handler



6.3 javax.realtime

6.3.1 Interfaces

6.3.1.1 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[2] is by definition bound.

6.3.1.2 RealtimeExecutionContext

Description

All RTSJ objects that encapsulate execution. This type includes Schedulable and javax.realtime.device.InterruptServiceRoutine. It is used by Affinity to remove the need to have a reference into the javax.realtime.device package.

6.3.1.3 Schedulable

Interfaces
Runnable
javax.realtime.Timable
javax.realtime.RealtimeExecutionContext
Description

Handlers and other objects can be dispatched by a Scheduler[3] when they provide a run() method and the methods defined below. The Scheduler[4] uses this information to create a suitable context to execute the run() method.

[2]Section 5.3.2.2
[3]Section 6.3.3.12
[4]Section 6.3.3.12

6.3.1.3.1 Methods

getMemoryParameters

Signature

public javax.realtime.MemoryParameters
getMemoryParameters()

Description

Gets a reference to the MemoryParameters[5] object for this schedulable.

Returns

A reference to the current MemoryParameters[6] object.

setMemoryParameters(MemoryParameters)

Signature

public T extends javax.realtime.Schedulable<T>
setMemoryParameters(MemoryParameters memory)

Description

Sets the memory 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 object. See the documentation for the scheduler for details.

Parameters

memory A MemoryParameters[7] 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[8].)

Throws

[5] Section 11.3.3.4
[6] Section 11.3.3.4
[7] Section 11.3.3.4
[8] Section 6.3.3.8

IllegalArgumentException 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

getReleaseParameters

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

Description

Gets a reference to the ReleaseParameters[9] object for this schedulable.

Returns
A reference to the current ReleaseParameters[10] object.

setReleaseParameters(ReleaseParameters)

Signature
public T extends javax.realtime.Schedulable<T>
setReleaseParameters(javax.realtime.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

[9] Section 6.3.3.10
[10] Section 6.3.3.10

release A ReleaseParameters[11] 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[12].)

Throws

IllegalArgumentException Thrown 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.

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

Returns

this

getScheduler

Signature

public javax.realtime.Scheduler
getScheduler()

Description

Gets a reference to the Scheduler[13] object for this schedulable.

Returns

A reference to the associated Scheduler[14] object.

setScheduler(Scheduler)

Signature

public T extends javax.realtime.Schedulable<T>
setScheduler(Scheduler scheduler)

[11] Section 6.3.3.10
[12] Section 6.3.3.8
[13] Section 6.3.3.12
[14] Section 6.3.3.12

throws SecurityException,
IllegalSchedulableStateException

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

IllegalArgumentException Thrown 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.

SecurityException when the caller is not permitted to set the scheduler for this schedulable.

IllegalSchedulableStateException 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, ReleaseParameters, MemoryParameters)

Signature

public T extends javax.realtime.Schedulable<T>
setScheduler(Scheduler scheduler,
SchedulingParameters scheduling,
javax.realtime.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[15] 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[16].)

release A reference to the ReleaseParameters[17] 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[18].)

memoryParameters A reference to the MemoryParameters[19] 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[20].)

Throws

IllegalArgumentException Thrown 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.

SecurityException when the caller is not permitted to set the scheduler for this schedulable.

Returns

this

getSchedulingParameters

Signature

public javax.realtime.SchedulingParameters
getSchedulingParameters()

[15]Section 6.3.3.14
[16]Section 6.3.3.8
[17]Section 6.3.3.10
[18]Section 6.3.3.8
[19]Section 11.3.3.4
[20]Section 6.3.3.8

Description

Gets a reference to the SchedulingParameters[21] object for this schedulable.

Returns

A reference to the current SchedulingParameters[22] object.

setSchedulingParameters(SchedulingParameters)

Signature

```
public T extends javax.realtime.Schedulable<T>
setSchedulingParameters(SchedulingParameters scheduling)
throws IllegalSchedulableStateException,
       IllegalAssignmentError,
       IllegalArgumentException
```

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[23] 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[24].)

Throws

IllegalArgumentException Thrown 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.

IllegalSchedulableStateException when the task is active and the new scheduling parameters are not compatible with the current scheduler.

Returns

this

[21] Section 6.3.3.14
[22] Section 6.3.3.14
[23] Section 6.3.3.14
[24] Section 6.3.3.8

getSchedulingGroup

Signature

public javax.realtime.SchedulingGroup
getSchedulingGroup()

Description

Gets a reference to the SchedulingGroup[25] instance of this schedulable.

Returns

A reference to the current SchedulingGroup[26] object.

Available since since RTSJ 2.0

getConfigurationParameters

Signature

public javax.realtime.ConfigurationParameters
getConfigurationParameters()

Description

Gets a reference to the ConfigurationParameters[27] object for this schedulable.

Returns

A reference to the associated ConfigurationParameters[28] object.

Available since RTSJ 2.0

getMinConsumption(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)

Description

[25] Section 6.3.3.13
[26] Section 6.3.3.13
[27] Section 5.3.2.1
[28] Section 5.3.2.1

Determine 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, return the minimum consumption in a RelativeTime[29] instance from the current allocation context. When dest is not null, return the minimum consumption in dest

Parameters
dest when not null is the object in which to return the result.
Returns
the minimum time consumed in any release.

Available since RTSJ 2.0

getMinConsumption

Signature
public javax.realtime.RelativeTime
getMinConsumption()

Description

Equivalent to getMinConsumption(null).

Returns
the minimum time consumed in any release.

Available since RTSJ 2.0

getMaxConsumption(RelativeTime)

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

Description

Determine 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, return the

[29] Section 9.3.1.3

maximum consumption in a RelativeTime[30] instance from the current allocation context. When dest is not null, return the maximum consumption in dest

Parameters
dest when not null is the object in which to return the result.
Returns
the maximum time consumed in any release.

Available since RTSJ 2.0

getMaxConsumption

Signature
public javax.realtime.RelativeTime
getMaxConsumption()

Description
Equivalent to getMaxConsumption(null).

Returns
the maximum time consumed in any release.

Available 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 daemon. 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

[30] Section 9.3.1.3

IllegalThreadStateException when this schedulable is active.
SecurityException when the current schedulable cannot modify this event handler.

Available 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.

Available since RTSJ 2.0

mayUseHeap

Signature
public boolean
mayUseHeap()

Description
Determine 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.

Available since RTSJ 2.0

interrupt

Signature
public void
interrupt()

Description

Make the generic AsynchronouslyInterruptedException[31] 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 cause an early release. In any case, AsynchronouslyInterruptedException is thrown once a method is entered that implements AsynchronouslyInterruptedException.

Available since RTSJ 2.0

isInterrupted

Signature

public boolean
isInterrupted()

Description

Determines whether or not the generic AsynchronouslyInterruptedException[32] is pending.

Returns

true when and only when the generic AsynchronouslyInterruptedException is pending.

Available since RTSJ 2.0

awaken

Signature

public void
awaken()
throws IllegalStateException

Description

Provides a means for a Clock[33] to end a sleep.

Throws

[31] Section 8.3.2.1
[32] Section 8.3.2.1
[33] Section 10.3.2.1

IllegalStateException when called from user code.

Available since RTSJ 2.0

6.3.2 Enumerations

6.3.2.1 MinimumInterarrivalPolicy

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.MinimumInterarrivalPolicy

Description

Defines the set of policies for handling interarrival time violations in SporadicParameters[34]. Each policy governs every instance of Schedulable[35] which has SporadicParameters[36] with that minimum interarrival time policy.

Available since RTSJ 2.0

6.3.2.1.1 Enumeration Constants

EXCEPT

public static final 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 then the last release time plus its minimum interarrival time, the fire() method shall throw a preallocated instance of MITViolationException[37].

[34] Section 6.3.3.15
[35] Section 6.3.1.3
[36] Section 6.3.3.15
[37] Section 15.2.2.7

IGNORE

public static final 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 then the last release time plus its minimum interarrival time, the new arrival time is ignored.

REPLACE

public static final 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 then 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 ignore as with the "IGNORE" policy.

SAVE

public static final 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 then 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.

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
Determine the string corresponding to this value.

Returns
the corresponding string.

value(String)

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

Description
Convert a string into a policy type.

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

6.3.2.2 QueueOverflowPolicy

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.QueueOverflowPolicy

Description

Defines the set of policies for handling overflow on event queues used by ReleaseParameters[38]. 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.

Available since RTSJ 2.0

6.3.2.2.1 Enumeration Constants

DISABLE

public static final 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[39] with no payload and instances of RealtimeThread[40] with PeriodicParameters[41]. In contrast to IGNORE[42], 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[43] with SporadicParameters[44]. This policy is also the default for

[38] Section 6.3.3.10
[39] Section 8.3.1.1
[40] Section 5.3.2.2
[41] Section 6.3.3.6
[42] Section 6.3.2.2.1
[43] Section 6.3.1.3
[44] Section 6.3.3.15

PeriodicParameters[45]. Instances of RealtimeThread without with null release parameters have this policy implicitly, as they do not have an event queue either.

EXCEPT

public static final 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[46]. When fire is used within a Timer[47], the exception is ignored and the fire does nothing, i.e., it acts the same as “IGNORE”.

IGNORE

public static final 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 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.

[45]Section 6.3.3.6
[46]Section 15.2.2.1
[47]Section 10.3.2.6

SAVE

public static final 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[48].

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

[48]Section 6.3.3.2

value

Signature
public java.lang.String
value()

Description
Determine the string corresponding to this value.

Returns
the corresponding string.

value(String)

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

Description
Convert 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

Inheritance
java.lang.Object
javax.realtime.Affinity
Description
This is the API for all processor-affinity-related aspects of the RTSJ. It includes a factory that generates Affinity objects, and methods that control the CPU affinity used by java.lang.ThreadGroup to control the affinity of all its tasks. With it, the affinity of every task in the JVM can be controlled.

An affinity is a set of processors that can be associated with certain types of tasks. Each task (java.lang.Thread and RealtimeExecutionContext[49]) can be associated with an affinity. Groups of these can be assigned an affinity through their java.lang.ThreadGroup.

Each implementation supports an array of predefined affinity sets. 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 affinity sets with cardinality of one. This restriction reflects the concern that not all operating systems will support multiprocessor affinity sets.

The processor membership of an affinity set is immutable. The tasks associations of an affinity set are mutable. The processor affinity of a task can be changed by static methods in this class. 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 affinity set factory only generates usable Affinity instances; i.e., affinity sets that (at least when they are created) can be used with set(Affinity, RealtimeExecutionContext)[50], set(Affinity, Thread)[51], and set(Affinity, ThreadGroup)[52]. The factory cannot create an affinity set with more than one processor member, but such affinity sets are supported. They may be internally created by the RTSJ runtime at startup time.

The set of affinity sets created at startup (the predefined set) is visible through the getPredefinedAffinities(Affinity[])[53] method. The affinity set factory may be used to create affinity sets with a single processor member at any time. This operation only supports processor members that are available to the JVM at the time of creation.

External changes to the set of processors available to the RTSJ runtime is likely to cause serious trouble ranging from violation of assumptions underlying schedulability analysis to freezing the entire RTSJ runtime, so when a system is capable of such manipulation it should not exercise it on RTSJ processes.

Tasks are subject to both their own processor affinity and that of their thread group. Their processor affinity is governed by the intersection of the thread group's affinity and the task's affinity. The intersection of a thread group's affinity set with the schedulable's affinity set must contain at least one entry.

[49]Section 6.3.1.2
[50]Section 6.3.3.1.1
[51]Section 6.3.3.1.1
[52]Section 6.3.3.1.1
[53]Section 6.3.3.1.1

Trying to set a tasks affinity outside its thread group always fails. Trying to setting the affinity of a thread group that does not intersect with the thread group of its tasks will also fail.

Ordinarily, an execution context inherits its creator's affinity set, but

- Java threads do not inherit affinity from Schedulable[54]s,
- instances of AsyncBaseEventHandler[55] that are not bound do not inherit affinity, and
- Schedulables do not inherit affinity from Java threads.

When a task does not inherit its creator's affinity set, its initial affinity set is set to all processors and is thus only limited by its thread group.

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

Available since RTSJ 2.0

6.3.3.1.1 Methods

getPredefinedAffinitiesCount

Signature

public static final int
getPredefinedAffinitiesCount()

Description

Determine the minimum array size required to store references to all the predefined processor affinity sets.

Returns

The minimum array size required to store references to all the predefined affinity sets.

getPredefinedAffinities

Signature

[54]Section 6.3.1.3
[55]Section 8.3.3.3

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

Description

Equivalent to invoking getPredefinedAffinitySets(null).

Returns

an array of the predefined affinity sets.

getPredefinedAffinities(Affinity)

Signature

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

Description

Determine what affinity sets are predefined by the Java runtime.

Parameters

dest The destination array, or null.

Throws

IllegalArgumentException when dest is not large enough.

Returns

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

isSetAffinitySupported

Signature

public static final boolean
isSetAffinitySupported()

Description

Determine whether or not affinity control is supported.

Returns

true when the set(Affinity, Thread)[56] family of methods is supported.

[56] Section 6.3.3.1.1

generate(BitSet)

Signature

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

Description

Determine the Affinity corresponding to a BitSet, where each bit in set represents a CPU.

Platforms that support specific affinity sets will register those Affinity instances with Affinity[57]. They appear in the arrays returned by getPredefinedAffinities()[58] and getPredefinedAffinities(Affinity[])[59].

Parameters

set is the BitSet to convert into an Affinity.

Throws

NullPointerException when set is null.

IllegalArgumentException when set does not refer to a valid set of processors, where "valid" is defined as the bitset from a predefined affinity set, or a bitset of cardinality one containing a processor from the set returned by getAvailableProcessors(). The definition of "valid set of processors" is system dependent; however, every set consisting of one valid processor makes up a valid bit set, and every bit set correspond to a predefined affinity set is valid.

Returns

The resulting Affinity.

getAvailableProcessors

Signature

public static final java.util.BitSet
getAvailableProcessors()

Description

This method is equivalent to getAvailableProcessors(BitSet)[60] with a null argument.

[57] Section 6.3.3.1
[58] Section 6.3.3.1.1
[59] Section 6.3.3.1.1
[60] Section 6.3.3.1.1

Returns
the set of processors available to the program.

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 processssors 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)[61].

get(RealtimeExecutionContext)

Signature
public static final javax.realtime.Affinity
get(RealtimeExecutionContext task)

Description

Determine the affinity set instance associated with task.

Parameters
task is the execution context to query.
Returns
The associated affinity.

[61] Section 6.3.3.1.1

set(Affinity, RealtimeExecutionContext)

Signature

public static final void
set(Affinity set,
RealtimeExecutionContext task)
throws ProcessorAffinityException

Description

Set the processor affinity of a task.

Parameters

set is the processor affinity

task is the execution context whose affinity will be set.

Throws

IllegalArgumentException when the intersection of set the affinity of any ThreadGroup instance containing task is empty.

ProcessorAffinityException is thrown when the runtime fails to set the affinity for platform-specific reasons.

NullPointerException when set or task is null.

get(Thread)

Signature

public static final javax.realtime.Affinity
get(Thread thread)

Description

Determmine the affinity set instance associated with thread.

Parameters

thread a Java thread, or one of its subclasses (including RealtimeThread[62]).

Returns

The associated affinity set.

[62] Section 5.3.2.2

set(Affinity, Thread)

Signature

public static final void
set(Affinity set,
Thread thread)
throws ProcessorAffinityException

Description

Set the processor affinity of a Java thread or RealtimeThread[63] to set.

Parameters

set The processor affinity set

thread The thread or realtime thread.

Throws

IllegalArgumentException when the intersection of set and the affinity of any ThreadGroup instance containing thread is empty.

ProcessorAffinityException when the runtime fails to set the affinity for platform-specific reasons.

NullPointerException when set or thread is null.

get(ThreadGroup)

Signature

public static final javax.realtime.Affinity
get(ThreadGroup group)

Description

Determine the affinity set instance associated with group.

Parameters

group An instance of java.lang.ThreadGroup

Returns

The associated affinity set.

[63] Section 5.3.2.2

set(Affinity, ThreadGroup)

Signature

public static final void
set(Affinity set,
ThreadGroup group)
throws ProcessorAffinityException

Description

Set the processor affinity of group to set with immediate effect.

Parameters

set The processor affinity set

group The processing group parameters instance.

Throws

IllegalArgumentException when the intersection of set and the affinity of any task in group is empty, or when the disjunction of set and the affinity of any ThreadGroup containing group is non-empty.

ProcessorAffinityException when the runtime fails to set the affinity for platform-specific reasons or group contains more than one processor.

NullPointerException when set or group is null.

getProcessors

Signature

public final java.util.BitSet
getProcessors()

Description

Return 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

Determine 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

Ask 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.

applyTo(BoundAsyncEventHandler)

Signature

public final void
applyTo(BoundAsyncEventHandler aeh)
throws ProcessorAffinityException

Description

Set the processor affinity of a bound AEH to this.

Parameters

aeh The bound async event handler

Throws

IllegalArgumentException when intersection of this with the affinity of any group containing aeh is empty.

ProcessorAffinityException Thrown when the runtime fails to set the affinity for platform-specific reasons.

NullPointerException when aeh is null.

applyTo(Thread)

Signature

public final void
applyTo(Thread thread)
throws ProcessorAffinityException

Description

Set the processor affinity of a Java thread or RealtimeThread[64] to this.

Parameters

thread The thread or realtime thread.

Throws

IllegalArgumentException when intersection of this with the affinity of any group containing thread is empty.

ProcessorAffinityException when the runtime fails to set the affinity for platform-specific reasons.

NullPointerException when thread is null.

applyTo(ThreadGroup)

Signature

public final void
applyTo(ThreadGroup group)
throws ProcessorAffinityException

Description

Set the processor affinity of group to this.

Parameters

group The processing group parameters instance.

Throws

IllegalArgumentException when the intersection of this and the affinity of any task in group is empty, or when the disjunction of this and the affinity of any ThreadGroup containing group is non-empty.

ProcessorAffinityException when the runtime fails to set the affinity for platform-specific reasons or group contains more than one processor.

NullPointerException when group is null.

[64] Section 5.3.2.2

applyTo(ActiveEventDispatcher)

Signature

public final void
applyTo(javax.realtime.ActiveEventDispatcher<?, ?> dispatcher)
throws ProcessorAffinityException

Description

Set the processor affinity of dispatcher to this.

Parameters

dispatcher is the dispatcher instance.

Throws

IllegalArgumentException when intersection of this with the affinity of any group containing dispatcher is empty.

ProcessorAffinityException when the runtime fails to set the affinity for platform-specific reasons.

NullPointerException when dispatcher is null.

6.3.3.2 AperiodicParameters

Inheritance

java.lang.Object
  javax.realtime.ReleaseParameters
    javax.realtime.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 that 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 schedulable's that use the parameter object until a setter method on the AperiodicParameters object is invoked, or the parameter object is used in setReleaseParameters() or a constructor for a schedulable.

The implementation must use modified copy semantics for each HighResolutionTime[65] 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[66] the arrival time is the time at which the start() is invoked. For other instances of Schedulable[67], the required behaviors may require the implementation to behave 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()[68] 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

[65] Section 9.3.1.2
[66] Section 5.3.2.2
[67] Section 6.3.1.3
[68] Section 5.3.2.2.2

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 Fields

6.3.3.2.2 Constructors

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

Signature

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

Description

Create an AperiodicParameters object.

Available 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

IllegalArgumentException 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)[69] 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).

[69] Section 6.3.3.2.2

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

IllegalArgumentException 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)[70] with the argument list (null, deadline, null, missHandler, rousable).

Available since RTSJ 2.0

AperiodicParameters(RelativeTime)

Signature

public
AperiodicParameters(RelativeTime deadline)

Description

[70] Section 6.3.3.2.2

Equivalent to AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[71] with the argument list (null, deadline, null, null, false).

Available since RTSJ 2.0

AperiodicParameters

Signature

public
AperiodicParameters()

Description

Equivalent to AperiodicParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[72] with the argument list (null, null, null, null, false).

Available since RTSJ 1.0.1

6.3.3.2.3 Methods

setDeadline(RelativeTime)

Signature

public javax.realtime.AperiodicParameters
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)[73]) the deadline of those schedulables is altered as specified by each schedulable's respective scheduler.

[71] Section 6.3.3.2.2
[72] Section 6.3.3.2.2
[73] Section 5.3.1

Parameters

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

Throws

IllegalArgumentException when 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 IllegalAssignmentError when deadline cannot be stored in this.

Returns

this

6.3.3.3 BackgroundParameters

Inheritance

java.lang.Object
  javax.realtime.ReleaseParameters
    javax.realtime.BackgroundParameters

Description

Parameters for realtime threads that are only released once. A thread using this release parameters may not use RealtimeThread.waitForNextRelease()[74] or have its RealtimeThread.release()[75] methods called. Calling these methods results in an IllegalThreadStateException. Event handlers may not use this type of ReleaseParameters.

6.3.3.3.1 Constructors

BackgroundParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

[74]Section 5.3.2.2.2
[75]Section 5.3.2.2.2

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. **Available since** RTSJ 2.0

Parameters

cost is the maximum cost for the initial release

deadline is the deadline for the initial release

overrunHandler is the handler to call on cost overrun.

missHandler is the handler to call on deadline miss.

Throws

IllegalArgumentException 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[76].

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)

[76] Section 10.3.2.1

Available since RTSJ 2.0

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 FirstInFirstOutScheduler

Inheritance

java.lang.Object
javax.realtime.Scheduler
javax.realtime.PriorityScheduler
javax.realtime.FirstInFirstOutScheduler

Description

A version of PriorityScheduler[77] 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 6.4: FirstInFirstOut Default PriorityParameter Values

Attribute	Default Value
Priority	norm priority

[77] Section 6.3.3.8

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()[78] method is the *base scheduler* and is returned by Scheduler.getDefaultScheduler()[79] unless the default scheduler is reset with Scheduler.setDefaultScheduler(Scheduler)[80].

Available since RTSJ 2.0

6.3.3.4.1 Methods

instance

Signature

public static javax.realtime.FirstInFirstOutScheduler
instance()

Description

Obtain 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

Obtain the maximum priority available for a schedulable managed by this scheduler.

Returns

The value of the maximum priority.

[78] Section 6.3.3.4.1
[79] Section 6.3.3.12.2
[80] Section 6.3.3.12.2

getMinPriority

Signature

public int
getMinPriority()

Description

Obtain 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

Obtain 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

Obtain the policy name of this.

Returns

The policy name (Fixed Priority First In First Out) as a string.

reschedule(Thread, int)

Signature

public void
reschedule(Thread thread,
int priority)

Description

Promotes a java.lang.Thread to realtime priority under this scheduler. The affected thread will be scheduled as if it were a RealtimeThread[81] of the given priority. This does not make the affected thread a RealtimeThread, however, and it will not have access to facilities reserved for instances of RealtimeThread.

Parameters

thread The thread to promote to realtime scheduling.

priority An integer priority equivalent to a priority set via PriorityParameters[82] on a RealtimeThread.

Throws

IllegalArgumentException when priority is not between getMinPriority()[83] and getMaxPriority()[84], inclusive.

6.3.3.5 ImportanceParameters

Inheritance

java.lang.Object
javax.realtime.SchedulingParameters
javax.realtime.PriorityParameters
javax.realtime.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

[81] Section 5.3.2.2
[82] Section 6.3.3.7
[83] Section 6.3.3.4.1
[84] Section 6.3.3.4.1

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[85] must not consider importance.

6.3.3.5.1 Constructors

ImportanceParameters(int, int)

Signature

public
ImportanceParameters(int priority,
int importance)

Description

Create 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.

6.3.3.5.2 Methods

---

getImportance

Signature

public int
getImportance()

Description

Gets the importance value.

[85] Section 6.3.3.8

Returns
The value of importance for the associated instances of Schedulable[86].

setImportance(int)

Signature

public javax.realtime.ImportanceParameters
setImportance(int importance)

Description

Set the importance 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)[87]) 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
IllegalArgumentException when the given importance value is incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

Returns
this

toString

Signature

public java.lang.String
toString()

Description

Print the value of the priority and importance values of the associated instance of Schedulable[88]

[86] Section 6.3.1.3
[87] Section 5.3.1
[88] Section 6.3.1.3

6.3.3.6 PeriodicParameters

Inheritance

java.lang.Object
  javax.realtime.ReleaseParameters
    javax.realtime.PeriodicParameters

Description

This release parameter indicates that the schedulable is released on a regular basis. For an AsyncEventHandler[89], this means that the handler is either released by a periodic timer, or the associated event occurs periodically. For a RealtimeThread[90], this means that the RealtimeThread.waitForNextRelease[91] 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 changes to a PeriodicParameters object caused by methods on that object cause the change to propagate to all schedulable objects using the object. For instance, calling setCost on an PeriodicParameters object will make the change, then notify that 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 PeriodicParameters object is invoked, or the parameter object is used in setReleaseParameters() or a constructor for an SO.

Periodic parameters use HighResolutionTime[92] values for period and start time. Since these times are expressed as a HighResolutionTime[93] 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

[89] Section 8.3.3.5
[90] Section 5.3.2.2
[91] Section 5.3.2.2.2
[92] Section 9.3.1.2
[93] Section 9.3.1.2

with each time value.

The implementation must use modified copy semantics for each HighResolutionTime[94] 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 6.5: 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)

[94] Section 9.3.1.2

Signature

public
PeriodicParameters(javax.realtime.HighResolutionTime<?> start,
RelativeTime period,
RelativeTime cost,
RelativeTime deadline,
AsyncEventHandler overrunHandler,
AsyncEventHandler missHandler,
boolean rousable)

Description

Create a PeriodicParameters object with attributes set to the specified values.

Available 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, and interrupt will cause an early release, otherwise not.

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, or when the clock associated with the cost is not the realtime clock, or when the clock associated with the start, 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(javax.realtime.HighResolutionTime<?> start,
                   RelativeTime period,
                   RelativeTime cost,
                   RelativeTime deadline,
                   AsyncEventHandler overrunHandler,
                   AsyncEventHandler missHandler)
```

Description

Equivalent to PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[95] with the argument list (start, period, cost, deadline, overrunHandler, missHandler, false);

PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler, boolean)

Signature

```
public
PeriodicParameters(javax.realtime.HighResolutionTime<?> start,
                   RelativeTime period,
                   RelativeTime deadline,
```

[95] Section 6.3.3.6.1

AsyncEventHandler missHandler,
boolean rousable)

Description

Equivalent to PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[96] with the argument list (start, period, deadline, null, null, missHandler, rousable);

Available since RTSJ 2.0

PeriodicParameters(HighResolutionTime, RelativeTime)

Signature

public
PeriodicParameters(javax.realtime.HighResolutionTime<?> start,
RelativeTime period)

Description

Equivalent to PeriodicParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[97] with the argument list (start, period, null, null, null, null, false);

Available since RTSJ 1.0.1

PeriodicParameters(RelativeTime)

Signature

public
PeriodicParameters(RelativeTime period)

Description

Create 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)

[96] Section 6.3.3.6.1
[97] Section 6.3.3.6.1

Available since RTSJ 1.0.1

6.3.3.6.2 Methods

getPeriod

Signature

public javax.realtime.RelativeTime
getPeriod()

Description

Determine 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

Determine 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.

getStart

Signature

public javax.realtime.HighResolutionTime<?>
getStart()

Description

Determine 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.

setDeadline(RelativeTime)

Signature
public javax.realtime.PeriodicParameters
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)[98]) the deadline of those schedulables is altered as specified by each schedulable's respective scheduler.

Parameters
deadline The latest permissible completion time measured from the release time of the associated invocation of the schedulable. When deadline is null, the deadline is set to a new instance of RelativeTime equal to period.

Throws
IllegalArgumentException when 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 IllegalAssignmentError when deadline cannot be stored in this.

Returns
this

setPeriod(RelativeTime)

Signature
public javax.realtime.PeriodicParameters
setPeriod(RelativeTime period)

[98]Section 5.3.1

Description

Sets the period.

Parameters

period The value to which period is set.

Throws

IllegalArgumentException 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[99] is associated with a Timer[100] whose period does not match period.

IllegalAssignmentError when period cannot be stored in this.

Returns

this

setStart(HighResolutionTime)

Signature

public javax.realtime.PeriodicParameters
setStart(javax.realtime.HighResolutionTime<?> start)

Description

Sets the start time.

The effect of changing the start time for any schedulables associated with this parameter object is determined by the scheduler associated with each schedulable.

Note: 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

IllegalArgumentException 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.

[99] Section 8.3.3.3
[100] Section 10.3.2.6

Returns
this

6.3.3.7 PriorityParameters

Inheritance
java.lang.Object
javax.realtime.SchedulingParameters
javax.realtime.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[101] is such a scheduler.

6.3.3.7.1 Constructors

PriorityParameters(int)

Signature
public
PriorityParameters(int priority)

Description

Create an instance of PriorityParameters[102] with the given priority.

Parameters
priority The priority assigned to schedulables that use this parameter instance.

6.3.3.7.2 Methods

---

[101] Section 6.3.3.8
[102] Section 6.3.3.7

isCompatible(Class)

Signature
public boolean
isCompatible(java.lang.Class<javax.realtime.Scheduler> type)

Description
Determine whether this scheduling parameters can be used by tasks scheduled by instances of type.

Parameters
type of scheduler to check against
Returns
true when and only when this can be used with type as the scheduler.

Available since RTSJ 2.0

getPriority

Signature
public int
getPriority()

Description
Gets the priority value.

Returns
The priority.

setPriority(int)

Signature
public javax.realtime.PriorityParameters
setPriority(int priority)

Description
Set 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)[103]) the

[103]Section 5.3.1

base priority of those schedulables is altered as specified by each schedulable's scheduler.

Parameters
priority The value to which priority is set.
Throws
IllegalArgumentException when the given priority value is incompatible with the scheduler for any of the schedulables which are presently using this parameter object.

Returns
this

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

Inheritance
java.lang.Object
javax.realtime.Scheduler
javax.realtime.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:

Note that the system contains one instance of the PriorityScheduler which is the system's base scheduler and is returned by FirstInFirstOutScheduler.instance()[104].

[104]Section 6.3.3.4.1

Table 6.6: PriorityScheduler Default PriorityParameter Values

Attribute	Default Value
Priority	norm priority

It may, however, contain instances of subclasses of PriorityScheduler created through this class' protected constructor. The instance returned by the FirstInFirstOutScheduler.instance() method, the *base scheduler*, is returned by Scheduler.getDefaultScheduler()[105] unless the default scheduler is changed with Scheduler.setDefaultScheduler(Scheduler)[106].

6.3.3.8.1 Fields

6.3.3.8.2 Constructors

PriorityScheduler

Signature

protected
PriorityScheduler()

Description

Construct an instance of PriorityScheduler. Applications will likely not need any instance other than the default instance.

6.3.3.8.3 Methods

[105] Section 6.3.3.12.2
[106] Section 6.3.3.12.2

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.

reschedule(Thread, int)

Signature

public abstract void
reschedule(Thread thread,
int priority)

Description

Promotes a java.lang.Thread to realtime priority under this scheduler. The affected thread will be scheduled as if it were a RealtimeThread[107] of the given priority. This does not make the affected thread a RealtimeThread, however, and it will not have access to facilities reserved for instances of RealtimeThread.

Parameters

thread The thread to promote to realtime scheduling.

priority An integer priority equivalent to a priority set via PriorityParameters[108] on a RealtimeThread.

Throws

IllegalArgumentException when priority is not between getMinPriority()[109] and getMaxPriority()[110], inclusive.

Available since RTSJ 2.0

[107] Section 5.3.2.2
[108] Section 6.3.3.7
[109] Section 6.3.3.8.3
[110] Section 6.3.3.8.3

6.3.3.9 ProcessingGroup

Inheritance

java.lang.Object
  java.lang.ThreadGroup
    javax.realtime.SchedulingGroup
      javax.realtime.ProcessingGroup

Description

A descendant class of ThreadGroup for handling tasks (instances of Schedulable[111] and java.lang.Thread) as a group. As with ThreadGroup and SchedulingGroup[112], instances of ProcessingGroup can be nested. A processing group can contain all group types, i.e., instance of all three classes. The cost of the group, including all tasks in its subgroups, can be both tracked and limited over a given period, by bounding the execution demands of those tasks.

A processing group has an associated affinity. The precision of cost monitoring is dependent on the number of processors in the thread group. 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 SchedulingGroup.

For all tasks with a reference to an instance of ProcessingGroup 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 in 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 groups monitoring state.

Logically, a ProcessingGroup represents a virtual server. 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 (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

[111] Section 6.3.1.3
[112] Section 6.3.3.13

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 HighResolutionTime[113] values for cost, deadline, period and start time. Since those times are expressed as a HighResolutionTime[114], 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 ProcessingGroup 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 ProcessingGroup object becomes the processing group parameters object bound to that schedulable object. Changes to the values in the ProcessingGroup object affect that schedulable object. When bound to more than one schedulable then changes to the values in the ProcessingGroup 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 copy semantics for each HighResolutionTime[115] 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 ProcessingGroup object caused by methods on that object are immediately visible to the scheduler. For instance, invoking setPeriod() on a ProcessingGroup object will make the change, then notify that 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 ProcessingGroup object is invoked or 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.

[113] Section 9.3.1.2
[114] Section 9.3.1.2
[115] Section 9.3.1.2

Table 6.7: ProcessingGroup 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)
minimum	null, no minimum
overrunHandler	None
missHandler	None
underrunHandler	None

Caution: The cost parameter time should be considered to be measured against the target platform.

Available since RTSJ 2.0

6.3.3.9.1 Constructors

ProcessingGroup(SchedulingGroup, String, HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingGroup(SchedulingGroup parent,
                String name,
                javax.realtime.HighResolutionTime<?> start,
                RelativeTime period,
                RelativeTime cost,
                AsyncEventHandler overrun,
                RelativeTime minimum,
                AsyncEventHandler underrun)
```

Description

Create a ProcessingGroup

Parameters

parent is the parent SchedulingGroup[116] of this ProcessingGroup.

name is a string identifier for this group.

start is when monitoring should begin.

period is an amount of time for cost and overrun monitoring and for cost enforcement.

cost is the maximum total execution time of all tasks in the group during a given period.

overrun is called when the the total execution of all tasks in the group exceeds cost for a given period.

minimum is the least amount of processing time for all the tasks in this group together.

underrun is called at the end of period when the total processing time of all tasks was less than minimum in the last period.

ProcessingGroup(SchedulingGroup, String, HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingGroup(SchedulingGroup parent,
                String name,
                javax.realtime.HighResolutionTime<?> start,
                RelativeTime period,
                RelativeTime cost,
                AsyncEventHandler overrun)
```

Description

Equivalent to ProcessingGroup(SchedulingGroup, String, HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)[117] with the argument list (parent, name, start, period, cost, overrun, null, null).

[116] Section 6.3.3.13

[117] Section 6.3.3.9.1

ProcessingGroup(String, HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler)

Signature

```
public
ProcessingGroup(String name,
                javax.realtime.HighResolutionTime<?> start,
                RelativeTime period,
                RelativeTime cost,
                AsyncEventHandler overrun)
```

Description

Equivalent to ProcessingGroup(SchedulingGroup, String, HighResolutionTime, RelativeTime, RelativeTime, AsyncEventHandler, RelativeTime, AsyncEventHandler)[118] with the argument list (Scheduler.currentSchedulable().getSchedulingGroup(), name, start, period, cost, overrun, null, null).

6.3.3.9.2 Methods

---

getEffectiveStart(AbsoluteTime)

Signature

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

Description

Obtain the actual time of the group started 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 is 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.

[118] Section 6.3.3.9.1

getEffectiveStart

Signature

public javax.realtime.AbsoluteTime
getEffectiveStart()

Description

Obtain the actual time of the group started as recorded by the system.
Equivalent to getEffectiveStart(AbsoluteTime)[119] where dest is set to null.

Returns

A reference 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 and returns it in the provided RelativeTime[120] 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

[119] Section 6.3.3.9.2
[120] Section 9.3.1.3

Gets the value of period.
Equivalent to getPeriod(null).

Returns
A reference to a newly allocated instance of RelativeTime[121] that represents the value of period.

setPeriod(RelativeTime)

Signature
public javax.realtime.ProcessingGroup
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.

Returns
this

getMaxCost(RelativeTime)

Signature
public javax.realtime.RelativeTime
getMaxCost(RelativeTime dest)

Description

[121] Section 9.3.1.3

Gets the value of cost. and returns it in the provided RelativeTime[122] 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.

getMaxCost

Signature

public javax.realtime.RelativeTime
getMaxCost()

Description

Gets the value of cost.
Equivalent to getMaxCost(null).

Returns

a reference to a newly allocated object containing the value of cost.

setMaxCost(RelativeTime)

Signature

public javax.realtime.ProcessingGroup
setMaxCost(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.

Returns

this

[122] Section 9.3.1.3

getMinimumCost(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMinimumCost(RelativeTime dest)

Description

Gets the value of minimum. and returns it in the provided RelativeTime[123] 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.ProcessingGroup
setMinimumCost(RelativeTime cost)
throws IllegalArgumentException,
IllegalAssignmentError

[123]Section 9.3.1.3

Description

Sets the value of minimum.

Parameters

cost The new value for minimum. When null, an exception is thrown.

Throws

IllegalArgumentException 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 AsyncEventHandler[124] that is cost overrun handler of this.

setCostUnderrunHandler(AsyncEventHandler)

Signature

public javax.realtime.ProcessingGroup
setCostUnderrunHandler(AsyncEventHandler handler)
throws IllegalAssignmentError

Description

Sets the cost underrun 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

[124] Section 8.3.3.5

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 AsyncEventHandler[125] that is cost overrun handler of this.

setCostOverrunHandler(AsyncEventHandler)

Signature
public javax.realtime.ProcessingGroup
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.

Returns
this

[125]Section 8.3.3.5

enforcingCost

Signature
public boolean
enforcingCost()

Description
Determine whether or not cost is being enforced for releases.

Returns
true when enforcing code.

enforceCost

Signature
public void
enforceCost()
throws UnsupportedOperationException

Description
Start cost enforcement at next release, when supported. Subsequent invocations have no effect.

Throws
UnsupportedOperationException when cost enforcement is not supported.

getCurrentCost(RelativeTime)

Signature
public javax.realtime.RelativeTime
getCurrentCost(RelativeTime dest)

Description
Get the cost used in the current period so far.

Parameters
dest 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 current period

getLastCost(RelativeTime)

Signature

public javax.realtime.RelativeTime
getLastCost(RelativeTime dest)

Description

Get the total cost used in the last period.

Parameters

dest 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

getGranularity

Signature

public long
getGranularity()

Description

Determine the measurement granularity of cost monitoring and cost enforcement.

Returns

the granularity in nanoseconds.

See Section setGranularity

setGranularity(long)

Signature

public javax.realtime.ProcessingGroup
setGranularity(long nanos)
throws IllegalArgumentException

Description

Set 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 is sliently 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 percission 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 measure at most once per the elapse of this ganularity.

Parameters
nanos the new granularity in nanoseconds.
Throws
IllegalArgumentException when nanos is less than one.

Returns
this

6.3.3.10 ReleaseParameters

Inheritance
java.lang.Object
javax.realtime.ReleaseParameters
Interfaces
Cloneable
Serializable
Description

The top-level class for release characteristics used by Schedulable[126]. 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 that 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

[126] Section 6.3.1.3

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, or the parameter object is used in setReleaseParameters() or a constructor for a schedulable.

Release parameters use HighResolutionTime[127] values for cost, and deadline. Since the times are expressed as a HighResolutionTime[128] 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[129] 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 6.8: 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 Constructors

[127] Section 9.3.1.2
[128] Section 9.3.1.2
[129] Section 9.3.1.2

ReleaseParameters(RelativeTime, RelativeTime, AsyncEvent-Handler, AsyncEventHandler)

Signature

```
protected
ReleaseParameters(RelativeTime cost,
                  RelativeTime deadline,
                  AsyncEventHandler overrunHandler,
                  AsyncEventHandler missHandler)
```

Description

Create 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 a schedulable object is executed, 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. 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

IllegalArgumentException 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[130].

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

ReleaseParameters

Signature

[130] Section 10.3.2.1

protected
ReleaseParameters()

Description

Equivalent to ReleaseParameters(RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)[131] with the argument list (null, null, null, null).

6.3.3.10.2 Methods

---

clone

Signature

public java.lang.Object
clone()

Description

Return 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.)

Available since RTSJ 1.0.1

getCost

Signature

public javax.realtime.RelativeTime
getCost()

Description

Determine the current value of cost.

[131] Section 6.3.3.10.1

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
Determine the current value of cost.

Returns
value or, when null, the last object used to set the cost, set to the current value of cost.

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
Determine 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

Determine the current value of deadline.

Returns

value or, when null, the last object used to set the deadline, set to the current value of deadline.

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)[132]) the cost of those schedulables is altered as specified by each schedulable's respective scheduler.

Parameters

[132]Section 5.3.1

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

IllegalArgumentException 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

setCostOverrunHandler(AsyncEventHandler)

Signature

```
public T extends javax.realtime.ReleaseParameters<T>
setCostOverrunHandler(AsyncEventHandler handler)
throws UnsupportedOperationException,
       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)[133]) the cost overrun handler of those schedulables is altered as specified by each schedulable's respective scheduler.

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.

UnsupportedOperationException when cost enforcement is not supported.

Returns

this

[133] Section 5.3.1

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)[134]) the deadline of those schedulables is altered as specified by each schedulable's respective scheduler.

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

IllegalArgumentException 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

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)[135]) the deadline miss handler of those schedulables is altered as specified by each schedulable's respective scheduler.

[134] Section 5.3.1
[135] Section 5.3.1

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

isRousable

Signature

public boolean
isRousable()

Description

Determine whether or not a thread interrupt will cause instances of Schedulable associated with an instance of this class will be prematurely released.

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[136]. In the former case, there are no releases to interrupt and, in the case, the handler does not have a ActiveEventDispatcher[137] to release it.

Returns

true when rousable and false when not.

Available since RTSJ 2.0

setRousable(boolean)

Signature

public T extends javax.realtime.ReleaseParameters<T>
setRousable(boolean value)

Description

[136] Section 8.3.1.1
[137] Section 8.3.3.1

Dictate whether or not a thread interrupt will cause instances of Schedulable associated with an instance of this class will be prematurely released.

Parameters
value is true when rousable and false when not.
Returns
this

Available since RTSJ 2.0

enforcingCost

Signature
public boolean
enforcingCost()

Description
Determine whether or not cost is being enforced for releases.

Returns
true when enforcing code.

Available since RTSJ 2.0

enforceCost(boolean)

Signature
public void
enforceCost(boolean value)
throws UnsupportedOperationException

Description
Set cost enforcement.

Parameters
value true when enforcing code.
Throws
UnsupportedOperationException when cost enforcement is not supported on this platform.

Available 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.

Available 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 is a queue overflow policy to use for handlers associated with this.

Returns

this

Available 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.

Available since RTSJ 2.0 replacing 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
IllegalArgumentException when initial is less than zero.

Returns
this

Available since RTSJ 2.0 replacing AperiodicParameters.setInitialArrivalTimeQueueLength(int)[138].

6.3.3.11 RoundRobinScheduler

Inheritance
java.lang.Object
javax.realtime.Scheduler

[138]Section A.2.3.2.2

javax.realtime.PriorityScheduler
javax.realtime.RoundRobinScheduler

Description

Class which represents a priority-based round-robin scheduler.

The default instance of this scheduler (returned by instance()[139]) represents the RTSJ-specified round-robin scheduler.

Available since RTSJ 2.0

6.3.3.11.1 Methods

instance

Signature

public static javax.realtime.RoundRobinScheduler
instance()

Description

Return a reference to the distinguished instance of RoundRobinScheduler which is the RTSJ-specified round-robin scheduler.

Throws

UnsupportedOperationException 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 UnsupportedOperationException,
IllegalArgumentException

[139] Section 6.3.3.11.1

Description

Set 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

UnsupportedOperationException if this scheduler's quantum is not configurable at runtime.

IllegalArgumentException 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

Get 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

Get the quantum of this instance of RoundRobinScheduler.

Parameters

dest return the quantum in dest . When dest is null, allocate a new RelativeTime[140]

[140]Section 9.3.1.3

instance 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, int)

Signature

public void
reschedule(Thread thread,
int priority)

Description

Promotes a java.lang.Thread to realtime priority under this scheduler. The affected thread will be scheduled as if it were a RealtimeThread[141] of the given priority. This does not make the affected thread a RealtimeThread, so it will not have access to facilities reserved for instances of RealtimeThread.

The method Thread.setPriority(int) can be used to reschedule back to the conventional Java priority levels.

Parameters

thread The thread to promote to realtime scheduling.

priority An integer priority equivalent to a priority set via PriorityParameters[142] on a RealtimeThread.

Throws

IllegalArgumentException when thread is null or priority is not between getMinPriority()[143] and getMaxPriority()[144], inclusive.

[141] Section 5.3.2.2
[142] Section 6.3.3.7
[143] Section 6.3.3.11.1
[144] Section 6.3.3.11.1

6.3.3.12 Scheduler

Inheritance

java.lang.Object
javax.realtime.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[145] (e.g., EDFScheduler).

6.3.3.12.1 Constructors

Scheduler

Signature

protected
Scheduler()

Description

Create an instance of Scheduler.

6.3.3.12.2 Methods

getDefaultScheduler

Signature

[145] Section 6.3.3.12.2

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[146] at startup.

Parameters

scheduler The Scheduler that becomes the default scheduler assigned to new schedulables created by Java threads. When null nothing happens.

Throws

SecurityException when the caller is not permitted to set the default scheduler.

inSchedulableExecutionContext

Signature

public static boolean
inSchedulableExecutionContext()

Description

Determine whether the current calling context is a Schedulable[147]: RealtimeThread[148] or AsyncBaseEventHandler[149].

[146] Section 6.3.3.8
[147] Section 6.3.1.3
[148] Section 5.3.2.2
[149] Section 8.3.3.3

Returns
true when yes and false otherwise.

Available since RTSJ 2.0

currentSchedulable

Signature
public static javax.realtime.Schedulable<?>
currentSchedulable()

Description
Get the current execution context when called from a Schedulable[150] execution context.

Throws
ClassCastException when the caller is not a Schedulable[151]

Returns
the current Schedulable[152].

Available 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[153] when accessed.

Returns
A String object which is the name of the scheduling policy used by this.

[150] Section 6.3.1.3
[151] Section 6.3.1.3
[152] Section 6.3.1.3
[153] Section 15.2.3.3

6.3.3.13 SchedulingGroup

Inheritance
java.lang.Object
  java.lang.ThreadGroup
    javax.realtime.SchedulingGroup

Description

An enhanced ThreadGroup in which a Schedulable[154] may be started. Limits for what realtime scheduler and scheduling parameters can be enforced on all tasks in this group. A normal ThreadGroup may not contain instance of Schedulable[155], but may contain other instances of SchedulingGroup to form a hierarchy. Every task is in some instance of ThreadGroup and every instance of Schedulable is in some instance of SchedulingGroup.

Available since RTSJ 2.0

6.3.3.13.1 Constructors

SchedulingGroup(SchedulingGroup, String)

Signature

```
public
SchedulingGroup(SchedulingGroup parent,
                String name)
```

Description

Create a new scheduling group.

Parameters

parent is the parent group of the new group

name is the name of the new group

Throws

[154] Section 6.3.1.3
[155] Section 6.3.1.3

IllegalStateException when the parent ThreadGroup instance is not an instance of SchedulingGroup.

IllegalAssignmentError when the parent ThreadGroup instance is not assignable to this.

SchedulingGroup(String)

Signature

public
SchedulingGroup(String name)
throws IllegalStateException,
IllegalAssignmentError

Description

Create a new group with the current ThreadGroup instance as its parent, so long as it is an instance of SchedulingGroup.

Parameters

name is the name of the new group

Throws

IllegalStateException when the parent ThreadGroup instance is not an instance of SchedulingGroup.

IllegalAssignmentError when the parent ThreadGroup instance is not assignable to this.

6.3.3.13.2 Methods

---

getMaxEligibility

Signature

public javax.realtime.SchedulingParameters
getMaxEligibility()

Description

Find 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, null when no such bound has been specified.

setMaxEligibility(SchedulingParameters)

Signature

public javax.realtime.SchedulingGroup
setMaxEligibility(SchedulingParameters parameters)
throws IllegalStateException

Description

Set 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 a child of this SchedulingGroup 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 SchedulingGroup or a child of this SchedulingGroup 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.

Parameters

parameters the scheduling parameter instance denoting the new upper bound on the scheduling eligibility of threads in this group.

Throws

IllegalStateException when parameters are not consistent with the scheduler type.

IllegalArgumentException when parameters is a higher eligibility than the max eligibility enforced by a SchedulingParameters above this in the hierarchy.

Returns

this

getScheduler

Signature

public java.lang.Class<javax.realtime.Scheduler>
getScheduler()

Description

Find 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

setScheduler(Class)

Signature

public javax.realtime.SchedulingGroup
setScheduler(java.lang.Class<javax.realtime.Scheduler> type)

Description

Limit the schedulers that may be used for tasks in this group.

Parameters
type is the type of scheduler of which the schedulers of all tasks must be instances.
Throws
IllegalStateException when a thread in the group has a scheduler that is not an instance of type or getMaxEligibility[156] returns parameters that are inconsistent with the scheduler type.

Returns
this

visitChildren(Predicate)

Signature

public boolean
visitChildren(java.util.function.Predicate<java.lang.ThreadGroup> visitor)

Description

[156]Section 6.3.3.13.2

Perform some operation on all the children of the current group. The traversal of the children continues as long as visitor return true. Thus the traversal can be prematurely ended by visitor returning false, e.g., when a particular element is found.

Parameters

visitor the function to be called on each child thread group.

6.3.3.14 SchedulingParameters

Inheritance

java.lang.Object
  javax.realtime.SchedulingParameters

Interfaces

Cloneable
Serializable

Description

Subclasses of SchedulingParameters (PriorityParameters[157], ImportanceParameters[158], and any others defined for particular schedulers) provide the parameters to be used by the Scheduler[159]. Changes to the values in a parameters object affects the scheduling behavior of all the Schedulable[160] 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

Signature

[157]Section 6.3.3.7
[158]Section 6.3.3.5
[159]Section 6.3.3.12
[160]Section 6.3.1.3

protected
SchedulingParameters()

Description

Create a new instance of SchedulingParameters.

Available since RTSJ 1.0.1

6.3.3.14.2 Methods

---

clone

Signature

public java.lang.Object
clone()

Description

Return 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.)

Available since RTSJ 1.0.1

isCompatible(Class)

Signature

public boolean
isCompatible(java.lang.Class<javax.realtime.Scheduler> type)

Description

Determine whether this scheduling parameters can be used by tasks scheduled by instances of type.

Parameters
type of scheduler to check against
Returns
true when and only when this can be used with type as the scheduler.

Available since RTSJ 2.0

6.3.3.15 SporadicParameters

Inheritance
java.lang.Object
javax.realtime.ReleaseParameters
javax.realtime.AperiodicParameters
javax.realtime.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[161] 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 that 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

[161] Section 9.3.1.2

object is invoked, or the parameter object is used in setReleaseParameters() or a constructor for an SO.

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

Table 6.9: 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 possible behaviors that indicate 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, what to do when, for any reason, the queue overflows, and the initial size of the queue.

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 Fields

6.3.3.15.2 Constructors

SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)

Signature

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

Description

Create a SporadicParameters object.

Available 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 effect 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

IllegalArgumentException 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[162].

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)[163] 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)[164] with an argument list of (minInterarrival, null, deadline, null, missHandler, rousable).

[162]Section 10.3.2.1
[163]Section 6.3.3.15.2
[164]Section 6.3.3.15.2

Available since RTSJ 2.0

SporadicParameters(RelativeTime)

Signature

public
SporadicParameters(RelativeTime minInterarrival)

Description

Equivalent to SporadicParameters(RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler, boolean)[165] with an argument list of (minInterarrival, null, null, null, null, false).

Available since RTSJ 1.0.1

6.3.3.15.3 Methods

---

getMinimalInterarrival

Signature

public javax.realtime.RelativeTime
getMinimalInterarrival()

Description

Determine 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

[165] Section 6.3.3.15.2

public javax.realtime.RelativeTime
getMinimumInterarrival(RelativeTime value)

Description

Determine 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.

Available since RTSJ 2.0

setMinimumInterarrival(RelativeTime)

Signature

public javax.realtime.SporadicParameters
setMinimumInterarrival(RelativeTime minimum)

Description

Set the minimum interarrival time.

Parameters

minimum The release times of the schedulable will occur no closer than this interval.

Throws

IllegalArgumentException when minimum is null or its time value is not greater than zero.

IllegalAssignmentError when minimum cannot be stored in this.

Returns

this

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 is the current policy for MIT violations.
Available 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.

Available since RTSJ 2.0

setEventQueueOverflowPolicy(QueueOverflowPolicy)

Signature
public javax.realtime.SporadicParameters
setEventQueueOverflowPolicy(QueueOverflowPolicy policy)
throws IllegalArgumentException

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
IllegalArgumentException when policy is QueueOverflowPolicy.DISABLE[166].

Returns
this

[166]Section 6.3.2.2.1

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 timeslicing 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 SchedulingGroup and ProcessingGroup

The SchedulingGroup and ProcessingGroup classes were added in RTSJ 2.0 to both support the notion of a subsystem constrained by the greater system configuration and generalize the existing notion of cost monitoring and enforcement for schedulables to groups of schedulables. In addition, they provide 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 SchedulingGroup hierarchy may be used to constrain the maximum priority directly configurable by an entire subsystem. To achieve this, a SchedulingGroup with an appropriate maximum priority must be created, the security manager must be configured to disallow threads in that SchedulingGroup from accessing their parent SchedulingGroup, and all threads for the subsystem must be created in that SchedulingGroup. This tactic may even be used recursively. Similar practice can be used with ProcessingGroup to constrain the maximum execution time allowable to a subsystem, or other properties configurable in a processing group.

As previously mentioned, a motivation for adding SchedulingGroup 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 SchedulingGroup. 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 SchedulingGroup. 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.

A ProcessingGroup can also be used to apply cost monitoring and enforcement to a collection of standard Java threads. However, note that placing a Java thread directly in a ProcessingGroup, which is an instance of SchedulingGroup, 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 ProcessingGroup and applying security manager restrictions.

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. The following have had the most impact on the level of support that has been specified.

1. 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. However, to add them to the parameter classes requires the support to be distributed throughout the specification with a proliferation of new constructor methods. To avoid this, support is grouped together within the Affinity class. The class also provides the addition of processor affinity support to Java threads without modifying the thread object's visible API.

2. The range of processors on which global scheduling is possible is dictated by the operating system. For SMP architectures, global scheduling across all the 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 increase, the scalability of global scheduling is called into question. Hence, for NUMA architectures some partitioning of the processors is likely to performed by the OS. Hence, global scheduling across all processors will not be possible in these systems. For these reasons, the RTSJ supports an array of *predefined* affinities. These are implementation-defined. 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, say, Java threads, extraheap realtime schedulables etc. A program is only allowed to dynamically create new affinities with cardinality of one. This restriction reflects the concern that not all operating systems will support multiprocessor affinities.
3. 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. Hence, the RTSJ assumes that the processor set allocated to the RTSJ process does not change during its execution. A system that is capable of such manipulations should not exercise it on RTSJ processes.
4. The reason the expert group decided not to add affinities to scheduling parameters is that ASEH do not have a single server thread, hence forcing a particular affinity would complicate the implementation.

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 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 SCJ facility is supported using a time-triggered event. All time-triggered computation can suffer from release jitter. Hence, any deadline miss handler may 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 signalled 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 signalled 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 requirement 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 instances of schedulable objects without heap access and schedulable objects 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 IllegalSchedulableStateException is thrown. An implementation that defines a new MonitorControl subclass must document which schedulers, if any, do not support this policy.

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 scheduling groups' maximum scheduling parameters.
3. The *active priority* for a task is independent of its scheduling 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), when 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), when sg is in t's SchedulingGroup 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. The new Scheduler subclass must conform to the sematics 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

Inheritance
java.lang.Object
javax.realtime.MonitorControl
Description

Abstract superclass for all monitor control policy objects.

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 obj)

Description

Gets the monitor control policy of the given instance of Object.

Parameters
obj The object being queried.
Throws
IllegalArgumentException when obj is null.

Returns
The monitor control policy of the obj 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)

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 subsequently constructed, 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)[1], the setting of the default monitor control policy occurs immediately.

Parameters

[1]Section 7.3.1.1.2

policy The new monitor control policy. When null, the default MonitorControl policy is not changed.

Throws

SecurityException when the caller is not permitted to alter the default monitor control policy.

IllegalArgumentException when policy is not in immortal memory.

UnsupportedOperationException when policy is not a supported monitor control policy.

Returns

The default MonitorControl policy in effect on completion.

Available 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.

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

IllegalArgumentException Thrown when obj is null or policy is not in immortal memory.

UnsupportedOperationException 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.

Available since RTSJ 1.0.1 The return type is changed from void to MonitorControl.

7.3.1.2 PriorityCeilingEmulation

Inheritance

java.lang.Object
  javax.realtime.MonitorControl
    javax.realtime.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)[2]) 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

[2]Section 7.3.1.1.2

- the maximum ceiling priority value that any thread or schedulable object could 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 PriorityCeilingEmulation-governed object with ceiling ceil, then ceil must be within the priority range allowed by t's scheduler; otherwise, an IllegalSchedulableStateException 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[3] PriorityInheritance[4], and CeilingViolationException[5].

7.3.1.2.1 Methods

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instance(int)

[3]Section 7.3.1.1
[4]Section 7.3.1.3
[5]Section 15.2.2.2

Signature

public static javax.realtime.PriorityCeilingEmulation
instance(int ceiling)

Description

Return 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

IllegalArgumentException when ceiling is outside of the range of permitted priority values (e.g., less than PriorityScheduler.instance().getMinPriority() or greater than PriorityScheduler.instance().getMaxPriority() for the base scheduler).

Available since RTSJ 1.0.1

getCeiling

Signature

public int
getCeiling()

Description

Gets the priority ceiling for this PriorityCeilingEmulation object.

Returns

The priority ceiling.

Available 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().

Available since RTSJ 1.0.1

7.3.1.3 PriorityInheritance

Inheritance

java.lang.Object
  javax.realtime.MonitorControl
    javax.realtime.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 IllegalSchedulableStateException is thrown in t1.

Note on the 2nd rule, throwing the exception in t1, rather than in t2, ensures that the exception is synchronous.

See also MonitorControl[6] and PriorityCeilingEmulation[7]

7.3.1.3.1 Methods

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[6]Section 7.3.1.1
[7]Section 7.3.1.2

instance

Signature

public static javax.realtime.PriorityInheritance
instance()

Description

Return 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

Inheritance

java.lang.Object
javax.realtime.WaitFreeReadQueue

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 a instance of Schedulable with 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 IllegalArgumentException,
       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, 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[8] in which internal elements are allocated.

notify A flag that establishes whether a reader is notified when the queue becomes non-empty.

Throws

IllegalArgumentException 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)
```

[8] Section 11.3.3.3

throws IllegalArgumentException,
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 IllegalArgumentException,
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)

Available since RTSJ 1.0.1

WaitFreeReadQueue(int, boolean)

Signature

public
WaitFreeReadQueue(int maximum,
boolean notify)
throws IllegalArgumentException

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)

Available 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 UnsupportedOperationException,
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

UnsupportedOperationException when this has not been constructed with notify set to true.

InterruptedException when the thread is interrupted by interrupt() or AsynchronouslyInterruptedExceptio fire()[9] during the time between calling this method and returning from it.

Available 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.

[9] Section 8.3.2.1.2

Throws

InterruptedException when the thread is interrupted by interrupt() or AsynchronouslyInterruptedExc
fire()[10] 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.

Available 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

Inheritance

java.lang.Object
javax.realtime.WaitFreeWriteQueue

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

[10] Section 8.3.2.1.2

- 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 IllegalArgumentException,
       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 is 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[11] in which this and internal elements are allocated.

Throws

IllegalArgumentException 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 IllegalArgumentException,
       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,mximum, memory)

Available since RTSJ 1.0.1

[11] Section 11.3.3.3

WaitFreeWriteQueue(int)

Signature

public
WaitFreeWriteQueue(int maximum)
throws IllegalArgumentException

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)

Available 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 AsynchronouslyInterruptedExc
fire()[12] 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.

Available since RTSJ 1.0.1 Throws InterruptedException

[12]Section 8.3.2.1.2

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,
IllegalArgumentException

Description

Unconditionally insert 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.

IllegalArgumentException 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,
IllegalArgumentException

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.

IllegalArgumentException 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.

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 the support for asynchronous control flow. Mechanisms are provided for both starting a task asynchronously and interrupting the execution of a thread or other task. This specifications provides mechanisms that

- bind the execution of program logic to the occurrence of internal and external events;
- enable asynchronous transfer of control; and
- facilitate the asynchronous termination of realtime threads.

The first of 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. The second is Asynchronous Transfer of Control (ATC), which provides a means of stopping some calculation prematurely. ATC may also be used to terminate a realtime thread safely.

Events and Event Handling

Asynchronous event handling is captured by the classes AsyncBaseEvent (AE), AsyncBaseEventHandler (AEH) and AbstractBoundAsyncEventHandler, 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.

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

Memory assignment rules apply to the payload passed to AsyncObjectEvent-Handler.

An AEH is a schedulable embodying code that is released for execution in 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 manner in which the implementation selects a realtime thread to release a given AEH at a given release is implementation-defined. The interface Bound-AsyncBaseEventHandler 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.

Asynchronous Transfer of Control

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 new 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.

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 one of the subclasses of the BoundAsyncBaseEventHandler class.

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 synchronized statement, a static initializer or any method or constructor without AsynchronouslyInterruptedException 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.

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 AsyncBaseEventHandler that is firable.

Interruptible Blocking Methods — The RTSJ and standard Java methods that are explicitly interruptible by an AIE. The interruptible blocking methods comprise

- HighResolutionTime.waitForObject(),
- Object.wait(),
- Thread.sleep(),
- RealtimeThread.sleep(),
- Thread.join(),
- ScopedMemory.join(),
- ScopedMemory.joinAndEnter(),
- RealtimeThread.waitForNextRelease(),
- WaitFreeWriteQueue.read(),
- WaitFreeReadQueue.waitForData(),
- WaitFreeReadQueue.write(),
- WaitFreeDequeue.blockingRead(),
- WaitFreeDequeue.blockingWrite()

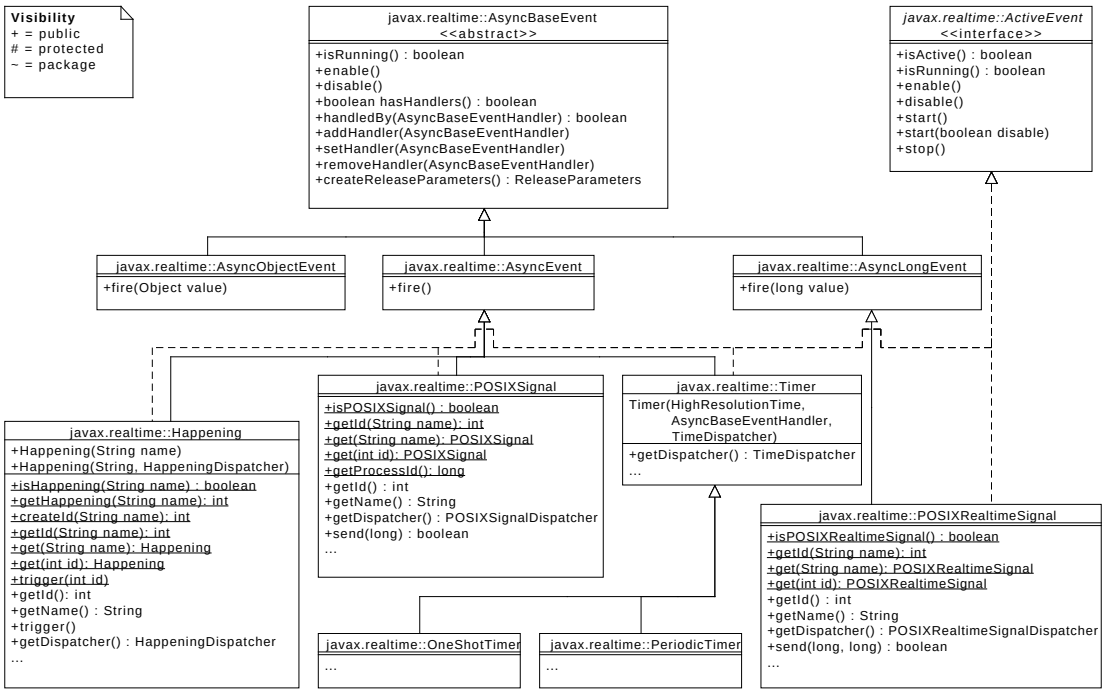
and their overloaded forms.

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 12), 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 twelve 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 (by either program logic or by the triggering of a happening) and the event is enabled, its attached handlers (that is, AEHs that have been added to the AE by the execution of addHandler()) are released for execution. Every occurrence of an event increments the fireCount in each

attached handler. Handlers may elect to execute logic for each occurrence of the event or not.

2. The release of attached handlers occurs in execution eligibility order (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.
3. The release of attached handlers is an atomic operation with respect to adding and removing handlers.
4. The logical release of an attached handler may occur before the previous release has completed.
5. Each handler has an application configurable, handler type dependent queue for holding events that have been released before a previous release has completed.
6. The overflow policy of a handlers queue is also application configurable.
7. A deadline may be associated with each logical release of an attached handler. The deadline is relative to the occurrence of the associated event.
8. AEs and AEHs may be created and used by any program logic within the constraints of the memory assignment rules.
9. 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.
10. The same AEH may be added to more than one AE.
11. By default all AEHs are considered to be daemons (the daemon status being 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.
12. 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.
13. 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.
14. 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.

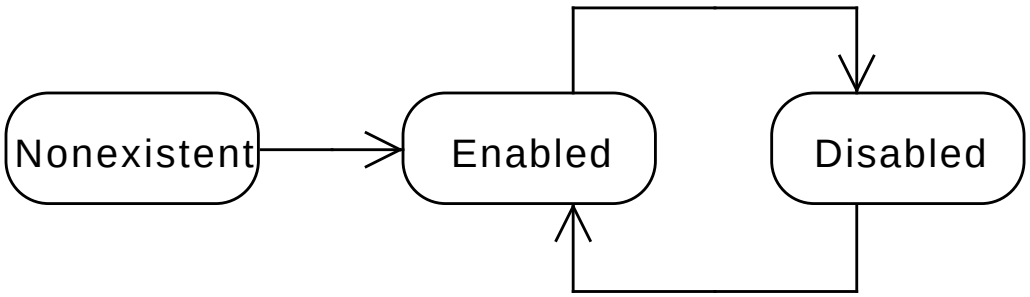
An RTSJ program terminates when and only when

1. all nondaemon threads (either regular Java threads or realtime threads) are terminated,
2. the fireCounts of all nondaemon bound AEHs or nondaemon AEHs are zero and all releases are completed, and
3. there are no nondaemon Bound AEHs or AEHs attached to timers or async

events associated with happenings.
Though dispatchers have a thread, this thread is a daemon thread and does not itself hinder termination.

AsyncBaseEvent provides two basic states: enabled and disabled. In the enabled state, fire causes all associated handlers to be dispatched, whereas fire does nothing when the event is disabled. Figure 8.2 illustrates this state space.

Figure 8.2: 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, or at least that context is of necessity limited and often needs to have a very short duration; dispatching an unlimited number of handlers is not acceptable. They require 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 this other 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 does determine the priority and the affinity of a dispatcher, as well as determine 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 8.2. ActiveEvent adds the notion of active and inactive on top of enabled and disabled, as depicted in Figure 8.3. Note that the enabled-disabled distinction only splits the active state. The inactive state is by definition disabled.

8.2.3 Asynchronous Transfer of Control

Asynchronously interrupting a schedulable consists of the following activities.

1. **Generation** of an asynchronous interrupt exception — this is the event in the underlying system that makes the AIE available to the program.
2. **Delivery** of the asynchronous interrupt exception to the target schedulable— this is the action that invokes the search for and execution of an appropriate handler.

Between the generation of an AIE and its delivery, the exception is held *pending*. The AIE remains pending (even after delivery) until it is **cleared** by the program logic using clear() or doInterruptible().

The following eight points define the semantics of ATC. Semantics that apply to particular classes, constructors, methods, and fields will be found in their detail sections, respectively.

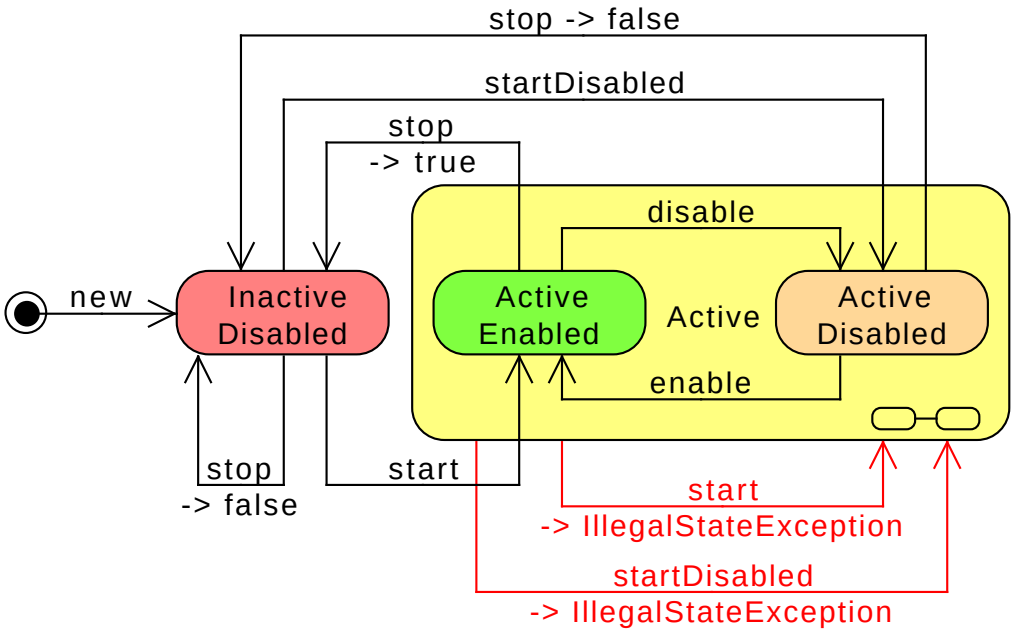
Please review for elb: InterruptedIOException and ATC

Verify that 3(b) below captures what we discussed on call 2016-03-21.

End review request

1. An AIE is generated for a given schedulable when the fire() method is called on an AIE for which the schedulable object 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. An AIE

Figure 8.3: States of an ActiveEvent



becomes pending upon generation and remains pending until explicitly cleared or replaced by another AIE.

2. The Schedulable.interrupt() method causes the target task to throw a generic AIE and has the behaviors defined for Thread.interrupt(). This is the only interaction between the ATC mechanism and the conventional interrupt() mechanism.
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 set 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 then 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 (for example, 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. 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.
5. Native methods that include AsynchronouslyInterruptedException in their throws clause have implementation-specific behavior.
6. 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.
7. 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.

8. 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 affect on the pending state of any AIE, and no affect on the firing of the AIE concerned.

Open issue 8.2.1 (jjh)

Rousable does not appear anywhere here; clarify the behavior of an interrupted schedulable when isRousable() is true and interrupt() is called. We should probably also discuss rousable in and of itself.

End of issue 8.2.1

8.2.3.1 Summary of ATC Operation

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 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 which is in an ATC-deferred section. 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* second edition [] 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.

Open issue 8.2.2 (elb)

Specify that when interrupt() is called on an AEH that is not currently releasable, the interrupter receives an exception.

End of issue 8.2.2

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) 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.

8.3 javax.realtime

8.3.1 Interfaces

8.3.1.1 ActiveEvent

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[1] 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.

8.3.1.1.1 Methods

---

isActive

Signature

public boolean
isActive()

Description

Determine the activation state of this event, i.e., it has been started but not yet stopped again.

Returns

[1]Section 8.3.1.1.1

true when active, false otherwise.

isRunning

Signature
public boolean
isRunning()

Description
Determine 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 IllegalStateException

Description
Start this active event.

Throws
IllegalStateException when this event has already been started.

start(boolean)

Signature
public void
start(boolean disabled)
throws IllegalStateException

Description
Start this active event.

Parameters
disabled true for starting in a disabled state.
Throws
IllegalStateException when this event has already been started.

stop

Signature

public boolean
stop()
throws IllegalStateException

Description

Stop this active event.

Throws

IllegalStateException when this event is not running.

Returns

the previous enabled state.

enable

Signature

public void
enable()

Description

Change the state of the event so that associated handlers are release on fire. Each subclass provides a means of dispatching its handlers when requested. This method enables that request mechanism.

disable

Signature

public void
disable()

Description

Change 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.

8.3.1.2 BoundAsyncBaseEventHandler

Interfaces
javax.realtime.BoundSchedulable
Description

An marker interface for all schedulables that are bound to a single thread of control. It is required to enable references to all bound handlers. A thread is bound to a handler of this type when it is first attached to an event. Thus security checks for thread use can be done when AsyncBaseEvent.addHandler[2] and AsyncBaseEvent.setHandler[3] are called.

8.3.1.3 Interruptible

Description

Interruptible is an interface implemented by classes that will be used as arguments on the methodsdoInterruptible() of AsynchronouslyInterruptedException[4] and its subclasses. doInterruptible() invokes the implementations of the methods in this interface.

8.3.1.3.1 Methods

run(AsynchronouslyInterruptedException)

Signature

```
public void
run(AsynchronouslyInterruptedException exception)
throws AsynchronouslyInterruptedException
```

Description

[2]Section 8.3.3.2.1
[3]Section 8.3.3.2.1
[4]Section 8.3.2.1

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[5] 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. 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[6] from within the interruptAction() method.

8.3.1.4 Releasable

Description

A base interface for everything that has a dispatcher.

8.3.1.4.1 Methods

---

[5]Section 8.3.2.1
[6]Section 8.3.2.1

getDispatcher

Signature

public D extends javax.realtime.ActiveEventDispatcher<D, T>
getDispatcher()

Description

Obtain the dispatcher for this.

Returns

that dispatcher.

8.3.2 Exceptions

8.3.2.1 AsynchronouslyInterruptedException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.InterruptedException
        javax.realtime.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[7] 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[8] method is called of an AIE for which s has a doInterruptible method call in progress.

[7] Section 8.3.2.1
[8] Section 8.3.2.1.2

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[9], 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-schedulable object.

Other sources (e.g., AsynchronouslyInterruptedException.fire() and Timed[10]) will generate specific instances of AsynchronouslyInterruptedException which applications can identify and thus limit propagation.

8.3.2.1.1 Constructors

AsynchronouslyInterruptedException

Signature

[9]Section 6.3.1.3.1
[10]Section 8.3.2.3

public
AsynchronouslyInterruptedException()

Description

Create an instance of AsynchronouslyInterruptedException.

8.3.2.1.2 Methods

getGeneric

Signature

public static javax.realtime.AsynchronouslyInterruptedException
getGeneric()

Description

Gets the singleton system generic AsynchronouslyInterruptedException that is generated when Schedulable.interrupt()[11] is invoked.

Throws

IllegalThreadStateException when the current thread is a Java thread.

Returns

The generic AsynchronouslyInterruptedException.

enable

Signature

public boolean
enable()

Description

Enable 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

[11] Section 6.3.1.3.1

true, when this was disabled before the method was called and the call was invoked whilst the associated doInterruptible() is in progress, and false otherwise.

disable

Signature

public synchronized boolean
disable()

Description

Disable the throwing of this exception. When the fire[12] 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

Query 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.

[12]Section 8.3.2.1.2

fire

Signature

public boolean
fire()

Description

Generate 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)[13] 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.

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[14]. This method may be on the stack in exactly one Schedulable[15] 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 given Interruptible is always entered with the exception in the enabled state, but that state can be modified with enable()[16] and disable()[17] and the state can be observed with isEnabled()[18].

This AIE is cleared on return from doInterruptible().

Parameters

[13] Section 8.3.2.1.2
[14] Section 8.3.1.3
[15] Section 6.3.1.3
[16] Section 8.3.2.1.2
[17] Section 8.3.2.1.2
[18] Section 8.3.2.1.2

logic An instance of an Interruptible[19] whose run() method will be called.

Throws

IllegalSchedulableStateException when called on the generic AsynchronouslyInterruptedException.

IllegalArgumentException when logic is null.

Returns

true, when the method call completed normally, and false, when another call to doInterruptible has not completed.

Available since RTSJ 2.0 nolonger throws an exception when called from a Java thread.

clear

Signature

public boolean
clear()

Description

Atomically see if this is pending on the currently executing schedulable, and when so, make it non-pending.

Returns

true, when this was pending, and false, when this was not pending.

Available since RTSJ 1.0.1

Available since RTSJ 2.0 nolonger throws an exception when called from a Java thread.

8.3.2.2 EventQueueOverflowException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException

[19] Section 8.3.1.3

javax.realtime.StaticRuntimeException
javax.realtime.EventQueueOverflowException

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.

Available since RTSJ 1.0.1 this is unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

8.3.2.2.1 Methods

---

get

Signature

public static javax.realtime.EventQueueOverflowException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

8.3.2.3 Timed

Inheritance

java.lang.Object
java.lang.Throwable
java.lang.Exception
java.lang.InterruptedException
javax.realtime.AsynchronouslyInterruptedException
javax.realtime.Timed

Description

Create a scope in a Schedulable[20] 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 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);

8.3.2.3.1 Constructors

Timed(HighResolutionTime)

Signature

```
public
Timed(javax.realtime.HighResolutionTime<?> time)
throws IllegalArgumentException,
       UnsupportedOperationException
```

Description

Create an instance of Timed with a timer set to time. When the time is in the past the AsynchronouslyInterruptedException[21] mechanism is activated immediately after or when the doInterruptible() method is called.

Parameters

time When time is a RelativeTime[22] value, it is the interval of time between the invocation of doInterruptible() and when the schedulable is asynchronously interrupted. When time is an AbsoluteTime[23] value, the timer asynchronously

[20] Section 6.3.1.3
[21] Section 8.3.2.1
[22] Section 9.3.1.3
[23] Section 9.3.1.1

interrupts at this time (assuming the timer has not been cancelled).

Throws

IllegalArgumentException when time is null.

UnsupportedOperationException when time is not based on a Clock[24].

8.3.2.3.2 Methods

doInterruptible(Interruptible)

Signature

public boolean
doInterruptible(Interruptible logic)

Description

Execute a time-out method. Starts the timer and executes the run() method of the given Interruptible[25] object.

Parameters

logic logic An instance of an Interruptible[26] whose run() method will be called.

Throws

IllegalArgumentException IllegalArgumentException 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

[24]Section 10.3.2.1
[25]Section 8.3.1.3
[26]Section 8.3.1.3

To set the time-out 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[27], the time-out is not changed.

restart(HighResolutionTime)

Signature

public void
restart(javax.realtime.HighResolutionTime<?> time)

Description

Reset the timeout. When this Timed[28] instance is executing, adjust the timeout to time and restart the timer. When the instance is not executing, adjust the timeout for the next invocation.

Parameters

time The new timeout.

Throws

IllegalArgumentException when time is null or a relative time less than zero.

UnsupportedOperationException when time is not based on a Clock[29]

Available since RTSJ 2.0

8.3.3 Classes

8.3.3.1 ActiveEventDispatcher

Inheritance

java.lang.Object
javax.realtime.ActiveEventDispatcher

Interfaces

javax.realtime.RealtimeExecutionContext

Description

[27]Section 10.3.2.1
[28]Section 8.3.2.3
[29]Section 10.3.2.1

Provides a means of dispatching a set of ActiveEvent[30]s. It acts as if it contains a 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.

8.3.3.1.1 Constructors

ActiveEventDispatcher(SchedulingParameters, SchedulingGroup)

Signature

protected
ActiveEventDispatcher(SchedulingParameters schedule,
SchedulingGroup group)

Description

Create a new dispatcher.

Parameters

schedule provide scheduling information to the new object.

group the SchedulingGroup of the thread of this dispatcher.

ActiveEventDispatcher(SchedulingParameters)

Signature

protected
ActiveEventDispatcher(SchedulingParameters schedule)

Description

Create a new dispatcher.

Parameters

schedule provide scheduling information to the new object.

[30]Section 8.3.1.1

8.3.3.1.2 Methods

getSchedulingParameters

Signature

public javax.realtime.SchedulingParameters
getSchedulingParameters()

Description

Determine how the thread associated with this dispatcher is scheduled.

Returns

the scheduling parameters of the dispatcher thread.

getSchedulingGroup

Signature

public javax.realtime.SchedulingGroup
getSchedulingGroup()

Description

Determine in which group the thread associated with this dispatcher is.

Returns

the scheduling group of the dispatcher thread.

register(T)

Signature

public abstract void
register(T event)
throws RegistrationException,
IllegalStateException,
IllegalArgumentException

Description

Register an active event with this dispatcher.

Parameters
event to register
Throws
RegistrationException when event is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when event is not stopped.

deregister(T)

Signature

```
public abstract void
deregister(T event)
throws DeregistrationException,
       IllegalStateException,
       IllegalArgumentException
```

Description
Deregister an active event from this dispatcher.

Parameters
event to deregister
Throws
DeregistrationException when event is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when event is not stopped.

destroy

Signature

```
public abstract void
destroy()
throws IllegalStateException
```

Description
Makes the dispatcher unusable.

Throws
IllegalStateException when called on a dispatcher that has one or more registered objects.

8.3.3.2 AsyncBaseEvent

Inheritance

java.lang.Object
  javax.realtime.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[31] with AsyncLongEvent[32] and AsyncObjectEvent[33].

Note that when this class is collected, all its handlers are automatically removed as if setHandler[34] was called with a null parameter.

Available since RTSJ 2.0

8.3.3.2.1 Methods

---

isRunning

Signature

public boolean
isRunning()

Description

Determine the firing state (releasing or skipping) of this event, i.e., whether it is enabled or disabled.

Returns

true when releasing, false when skipping.

[31] Section 8.3.3.4
[32] Section 8.3.3.6
[33] Section 8.3.3.8
[34] Section 8.3.3.2.1

handledBy(AsyncBaseEventHandler)

Signature

public boolean
handledBy(javax.realtime.AsyncBaseEventHandler<?> handler)

Description

Test to see if 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.

enable

Signature

public void
enable()

Description

Change the state of the event so that associated handlers are release on fire. Each subclass provides a means of dispatching its handlers when requested. This method enables that request mechanism.

disable

Signature

public void
disable()

Description

Change 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.

addHandler(AsyncBaseEventHandler)

Signature

public void
addHandler(javax.realtime.AsyncBaseEventHandler<?> handler)

Description

Add 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, 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

IllegalArgumentException when handler is null or the handler has PeriodicParameters[35]. Only the subclass PeriodicTimer[36] is allowed to have handlers with PeriodicParameters[37].

IllegalAssignmentError when this AsyncBaseEvent cannot hold a reference to handler.

IllegalStateException 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.

setHandler(AsyncBaseEventHandler)

Signature

public void
setHandler(javax.realtime.AsyncBaseEventHandler<?> handler)

[35]Section 6.3.3.6
[36]Section 10.3.2.3
[37]Section 6.3.3.6

Description

Associate a new handler with this event and remove 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[38] to be associated with this. When handler is null then no handler will be associated with this, i.e., behave effectively as if setHandler(null) invokes removeHandler(AsyncBaseEventHandler)[39] for each associated handler.

Throws

IllegalArgumentException when handler has PeriodicParameters[40]. Only the subclass PeriodicTimer[41] is allowed to have handlers with PeriodicParameters[42].

IllegalAssignmentError when this AsyncBaseEvent cannot hold a reference to handler.

removeHandler(AsyncBaseEventHandler)

Signature

public void
removeHandler(javax.realtime.AsyncBaseEventHandler<?> handler)

Description

Remove 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.

[38] Section 8.3.3.3
[39] Section 8.3.3.2.1
[40] Section 6.3.3.6
[41] Section 10.3.2.3
[42] Section 6.3.3.6

hasHandlers

Signature

public boolean
hasHandlers()

Description

Determine whether or not this event has any handlers.

Returns

true when and only when at least one handler is associated with this event.

createReleaseParameters

Signature

public javax.realtime.ReleaseParameters<?>
createReleaseParameters()

Description

Create a ReleaseParameters[43] object appropriate to the release characteristics of this event. The default is the most pessimistic: AperiodicParameters[44]. 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[45] 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[46], there is no requirement for an implementation to check that the handler is released periodically.

Returns

A new ReleaseParameters[47] object.

8.3.3.3 AsyncBaseEventHandler

Inheritance

[43]Section 6.3.3.10
[44]Section 6.3.3.2
[45]Section 6.3.3.10
[46]Section 6.3.3.6
[47]Section 6.3.3.10

java.lang.Object
javax.realtime.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[48] with AsyncLongEventHandler[49] and AsyncObjectEventHandler[50].

Available since RTSJ 2.0

8.3.3.3.1 Methods

---

getCurrentConsumption(RelativeTime)

Signature

public static javax.realtime.RelativeTime
getCurrentConsumption(RelativeTime dest)
throws IllegalStateException

Description

Determine the CPU consumption for this release. When dest is null, return the CPU consumption in an otherwise unused RelativeTime[51] instance in the current execution context. Otherwise, when dest is not null, return the CPU consumption in dest

Parameters
dest when not null is the object in which to return the result.
Throws
IllegalStateException when the caller is not a Schedulable[52].
Returns
the time consumed in the current release.

[48] Section 8.3.3.5
[49] Section 8.3.3.7
[50] Section 8.3.3.9
[51] Section 9.3.1.3
[52] Section 6.3.1.3

getCurrentConsumption

Signature

public static javax.realtime.RelativeTime
getCurrentConsumption()

Description

Equivalent to getCurrentConsumption(null).

Returns

the time consumed in the current release.

getPendingFireCount

Signature

protected int
getPendingFireCount()

Description

This is an accessor method for fireCount. The fireCount field nominally holds the number of times associated instances of AsyncEvent[53] 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 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

[53] Section 8.3.3.4

may 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 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 the case 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[54] associated with this.

To determine the current status of the memory area stack associated with this, use the static methods defined in the RealtimeThread[55] class. That is RealtimeThread.getCurrentMemoryArea[56], RealtimeThread.getInitialMemoryAreaIndex[57], RealtimeThread.getMemoryAreaStackDepth[58].

Returns
The instance of MemoryArea[59] 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
Gets a reference to the MemoryParameters[60] object for this schedulable.

Returns

[54]Section 11.3.3.3
[55]Section 5.3.2.2
[56]Section 5.3.2.2.2
[57]Section 5.3.2.2.2
[58]Section 5.3.2.2.2
[59]Section 11.3.3.3
[60]Section 11.3.3.4

A reference to the current MemoryParameters[61] object.

getReleaseParameters

Signature

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

Description

Gets a reference to the ReleaseParameters[62] object for this schedulable.

Returns

A reference to the current ReleaseParameters[63] object.

getScheduler

Signature

public javax.realtime.Scheduler
getScheduler()

Description

Gets a reference to the Scheduler[64] object for this schedulable.

Returns

A reference to the associated Scheduler[65] object.

getSchedulingParameters

Signature

public javax.realtime.SchedulingParameters
getSchedulingParameters()

Description

Gets a reference to the SchedulingParameters[66] object for this schedulable.

[61] Section 11.3.3.4
[62] Section 6.3.3.10
[63] Section 6.3.3.10
[64] Section 6.3.3.12
[65] Section 6.3.3.12
[66] Section 6.3.3.14

Returns
A reference to the current SchedulingParameters[67] object.

getSchedulingGroup

Signature
public javax.realtime.SchedulingGroup
getSchedulingGroup()

Description
Gets a reference to the SchedulingGroup[68] instance of this schedulable.

Returns
A reference to the current SchedulingGroup[69] object.

Available since since RTSJ 2.0

getConfigurationParameters

Signature
public javax.realtime.ConfigurationParameters
getConfigurationParameters()

Description
Gets a reference to the ConfigurationParameters[70] object for this schedulable.

Returns
A reference to the associated ConfigurationParameters[71] object.

Available since RTSJ 2.0

setMemoryParameters(MemoryParameters)

Signature

[67] Section 6.3.3.14
[68] Section 6.3.3.13
[69] Section 6.3.3.13
[70] Section 5.3.2.1
[71] Section 5.3.2.1

public T extends javax.realtime.AsyncBaseEventHandler<T>
setMemoryParameters(MemoryParameters memory)

Description

Sets the memory 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 object. See the documentation for the scheduler for details.

Parameters

memory A MemoryParameters[72] 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[73].)

Throws

IllegalArgumentException 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

setReleaseParameters(ReleaseParameters)

Signature

public T extends javax.realtime.AsyncBaseEventHandler<T>
setReleaseParameters(javax.realtime.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.

[72]Section 11.3.3.4
[73]Section 6.3.3.8

Parameters

release A ReleaseParameters[74] 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[75].)

Throws

IllegalArgumentException Thrown 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.

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

Returns

this

setScheduler(Scheduler)

Signature

public T extends javax.realtime.AsyncBaseEventHandler<T>
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 if it is attached to an AsyncEvent (even if AsyncBaseEvent.isRunning()[76] would return false for that event).

Parameters

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

Throws

[74] Section 6.3.3.10
[75] Section 6.3.3.8
[76] Section 8.3.3.2.1

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

SecurityException SecurityException when the caller is not permitted to set the scheduler for this schedulable.

IllegalSchedulableStateException IllegalSchedulableStateException 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, ReleaseParameters, MemoryParameters)

Signature

```
public T extends javax.realtime.AsyncBaseEventHandler<T>
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             javax.realtime.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[77] 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[78].)

[77] Section 6.3.3.14
[78] Section 6.3.3.8

release A reference to the ReleaseParameters[79] 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[80].)

memoryParameters A reference to the MemoryParameters[81] 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[82].)

Throws

IllegalArgumentException Thrown 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.

SecurityException when the caller is not permitted to set the scheduler for this schedulable.

Returns

this

setSchedulingParameters(SchedulingParameters)

Signature

public T extends javax.realtime.AsyncBaseEventHandler<T>
setSchedulingParameters(SchedulingParameters scheduling)

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[83] object. When null, the default value is governed by the associated scheduler (a new object is created when

[79] Section 6.3.3.10
[80] Section 6.3.3.8
[81] Section 11.3.3.4
[82] Section 6.3.3.8
[83] Section 6.3.3.14

the default value is not null). (See PriorityScheduler[84].)

Throws

IllegalArgumentException Thrown 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.

IllegalSchedulableStateException when the task is active and the new scheduling parameters are not compatible with the current scheduler.

Returns

this

setDaemon(boolean)

Signature

public final 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 daemon. 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.

SecurityException when the current schedulable cannot modify this event handler.

Available since RTSJ 2.0

isDaemon

Signature

public final boolean
isDaemon()

[84] Section 6.3.3.8

Description

Tests if this event handler is a daemon handler.

Returns

True when this event handler is a daemon handler; false otherwise.

Available since RTSJ 2.0

getDispatcher

Signature

public javax.realtime.TimeDispatcher
getDispatcher()

Description

Get the dispatcher associated with this Timable.

See Section Timable.getDispatcher()

getQueueLength

Signature

public int
getQueueLength()

Description

Find 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.

getMinConsumption(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMinConsumption(RelativeTime dest)

Description

Determine the minimum CPU consumption of all completed releases. When dest is null, return the CPU consumption in an otherwise unused RelativeTime[85] instance in the current execution context. Otherwise, when dest is not null, return the CPU consumption in dest

Parameters
dest when not null is 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)[86] with a null argument.

Returns
the minimum time consumed in any release.

getMaxConsumption(RelativeTime)

Signature

public javax.realtime.RelativeTime
getMaxConsumption(RelativeTime dest)

Description

Determine the maximum CPU consumption of all completed releases. When dest is null, return the CPU consumption in an otherwise unused RelativeTime[87] instance in the current execution context. Otherwise, when dest is not null, return the CPU consumption in dest.

Parameters
dest when not null is the object in which to return the result.

[85] Section 9.3.1.3
[86] Section 8.3.3.3.1
[87] Section 9.3.1.3

Returns
the maximum time consumed in any release.

getMaxConsumption

Signature
public javax.realtime.RelativeTime
getMaxConsumption()

Description

Same as getMaxConsumption(RelativeTime)[88] with a null argument.

Returns
the maximum time consumed in any release.

mayUseHeap

Signature
public boolean
mayUseHeap()

Description

Determine 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

Determines whether or not the generic AsynchronouslyInterruptedException[89] is pending.

[88]Section 8.3.3.3.1
[89]Section 8.3.2.1

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

Available since RTSJ 2.0

interrupt

Signature
public void
interrupt()

Description

Make the generic AsynchronouslyInterruptedException[90] 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 cause an early release. In any case, AsynchronouslyInterruptedException is thrown once a method is entered that implements AsynchronouslyInterruptedException.

Available since RTSJ 2.0

isRousable

Signature
public boolean
isRousable()

Description

Determine if it is possible for an interruptible to prematurely release the handler.

Returns
true when it is possible, otherwise it is not.

setRousable(boolean)

Signature

[90] Section 8.3.2.1

public T extends javax.realtime.AsyncBaseEventHandler<T>
setRousable(boolean value)

Description

Set the state for whether a interrupt can prematurely release this handler or not.

Parameters
value is the new value of the wake by interrupt state.
Returns
this

awaken

Signature
public final void
awaken()

Description

Indicate that a sleep has ended.

See Section Schedulable.awaken()

run

Signature
public void
run()

Description

This method is only to be used by the infrastructure, and should not be called by the application.

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 that method or provide a logic object for the default implementation to invoke.

8.3.3.4 AsyncEvent

Inheritance

java.lang.Object
javax.realtime.AsyncBaseEvent
javax.realtime.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[91]).

8.3.3.4.1 Constructors

AsyncEvent

Signature

public
AsyncEvent()

Description

Create a new AsyncEvent object.

8.3.3.4.2 Methods

---

fire

Signature

public void
fire()

Description

[91] Section 8.3.3.5

When enabled, release the asynchronous events associated with this instance of AsyncEvent. When no handlers are attached or this object is disabled the method does nothing, i.e., it skips the release.

- When the instance of AsyncEvent has more than one instance of AsyncEventHandler with release parameters object of type AperiodicParameters attached and the execution of AsyncEvent.fire() introduces the requirement to throw at least one type of exception, then all instances of AsyncEventHandler not affected by the exception are handled normally
- When the instance of AsyncEvent has more than one instance of AsyncEventHandler with release parameters object of type SporadicParameters attached and the execution of AsyncEvent.fire() introduces the simultaneous requirement to throw more than one type of exception or error then MITViolationException[92] has precedence over ArrivalTimeQueueOverflowException[93].

Throws

MITViolationException Thrown 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 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[94], this exception is ignored.

8.3.3.5 AsyncEventHandler

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEventHandler
    javax.realtime.AsyncEventHandler

Description

An asynchronous event handler encapsulates code that is released after an instance of AsyncEvent[95] to which it is attached occurs.

[92]Section 15.2.2.7
[93]Section 15.2.2.1
[94]Section 8.3.1.1
[95]Section 8.3.3.4

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()[96] method. Control over the number of calls to AsyncEventHandler.handleAsyncEvent()[97] is given by methods which manipulate a fireCount. These may be called by the application via sub-classing and overriding AsyncEventHandler.handleAsyncEvent()[98].

Instances of AsyncEventHandler with a release parameter of type SporadicParameters[99] or AperiodicParameters[100] have a list of release times which correspond to the occurrence times of instances of AsyncEvent[101] to which they are attached. The minimum interarrival time specified in SporadicParameters[102] 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()[103] 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[104] method.

Normally, handlers are bound to an execution context dynamically when the instances of AsyncEvent[105]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[106]s can be used.

The scheduler for an asynchronous event handler is inherited from the task that created it. When it was created from a Java thread, the scheduler is the current default scheduler.

The semantics for memory areas that were defined for realtime threads apply

[96] Section 8.3.3.5.2
[97] Section 8.3.3.5.2
[98] Section 8.3.3.5.2
[99] Section 6.3.3.15
[100] Section 6.3.3.2
[101] Section 8.3.3.4
[102] Section 6.3.3.15
[103] Section 8.3.3.5.2
[104] Section 5.3.2.2.2
[105] Section 8.3.3.4
[106] Section 8.3.3.10

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.

8.3.3.5.1 Constructors

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  javax.realtime.ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  SchedulingGroup group,
                  ConfigurationParameters config,
                  Runnable logic)
```

Description

Create a handler with the given scheduling, release, memory, group, and configuration parameters to run the given logic.

Available since RTSJ 2.0

Parameters

scheduling parameters for scheduling the new handler (and possibly other instances of Schedulable[107]). When scheduling is null and the creator is an instance of Schedulable[108], SchedulingParameters[109] 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.

[107] Section 6.3.1.3
[108] Section 6.3.1.3
[109] Section 6.3.3.14

release parameters for scheduling the new handler (and possibly other instances of Schedulable[110]). When release is null the new AsyncEventHandler will use a clone of the default ReleaseParameters[111] for the associated scheduler created in the memory area that contains the AsyncEventHandler object.

memory parameters for scheduling the new handler (and possibly other instances of Schedulable[112]). 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.

group A SchedulingGroup[113] object which will be associated with the constructed instance. When null, this will not be associated with any scheduling group.

config parameters for reserving space for preallocated exceptions and change implementation specific per Schedulable[114] memory reservations, such as Java stack size, for the new handler (and possibly other instances of Schedulable[115]. When initial is null, this AsyncEventHandler 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 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, ConfigurationParameters, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  javax.realtime.ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  ConfigurationParameters config,
                  Runnable logic)
```

[110] Section 6.3.1.3
[111] Section 6.3.3.10
[112] Section 6.3.1.3
[113] Section 6.3.3.13
[114] Section 6.3.1.3
[115] Section 6.3.1.3

Description

AsyncEventHandler(SchedulingParameters, ReleaseParameters, Runnable)

Signature

public
AsyncEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release,
Runnable logic)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[116] with arguments (scheduling, release, null, null, null, null, logic).

Available since RTSJ 2.0

AsyncEventHandler(SchedulingParameters, ReleaseParameters)

Signature

public
AsyncEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[117] with arguments (scheduling, release, null, null, null, null, null)

[116] Section 8.3.3.5.1
[117] Section 8.3.3.5.1

Available since RTSJ 2.0

AsyncEventHandler(Runnable)

Signature

public
AsyncEventHandler(Runnable logic)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[118] with arguments (null, null, null, null, null, null, logic).

AsyncEventHandler

Signature

public
AsyncEventHandler()

Description

Create an instance of AsyncEventHandler with default values for all parameters.

See Section AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)

8.3.3.5.2 Methods

handleAsyncEvent

Signature

[118] Section 8.3.3.5.1

public void
handleAsyncEvent()

Description

This method holds the logic which is to be executed when any AsyncEvent[119] 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.

run

Signature

public final void
run()

Description

This method is only to be used by the infrastructure, and should not be called by the application.

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 that method or provide a logic object for the default implementation to invoke.

8.3.3.6 AsyncLongEvent

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncLongEvent

[119] Section 8.3.3.4

Description

A new type of event that carries a long as a payload.

See Section AsyncEvent

Available since RTSJ 2.0

8.3.3.6.1 Constructors

AsyncLongEvent

Signature

public
AsyncLongEvent()

Description

Create a new AsyncLongEvent object.

8.3.3.6.2 Methods

---

fire(long)

Signature

public void
fire(long value)
throws MITViolationException,
EventQueueOverflowException

Description

When enabled, release the handlers associated with this instance of AsyncLongEvent with the long passed by fire(long)[120]. When no handlers are attached or this object is disabled the method does nothing, i.e., it skips the release.

[120] Section 8.3.3.6.2

- When the instance of AsyncLongEvent is associated with more than one instance of AsyncLongEventHandler[121] with release parameters object of type AperiodicParameters[122] and the execution of fire(long)[123] introduces the requirement to throw at least one type of exception, then all instances of AsyncLongEventHandler[124] not affected by the exception are handled normally.
- When this instance of AsyncLongEvent is associated with more than one instance of AsyncLongEventHandler[125] with release parameters object of type SporadicParameters[126] and the execution of fire(long)[127] introduces the simultaneous requirement to throw more than one type of exception or error, then MITViolationException[128] has precedence over ArrivalTimeQueueOverflowException[129].

Parameters

value is the payload passed to the event.

Throws

MITViolationException Thrown 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[130], this exception is ignored.

8.3.3.7 AsyncLongEventHandler

Inheritance

java.lang.Object

[121] Section 8.3.3.7
[122] Section 6.3.3.2
[123] Section 8.3.3.6.2
[124] Section 8.3.3.7
[125] Section 8.3.3.7
[126] Section 6.3.3.15
[127] Section 8.3.3.6.2
[128] Section 15.2.2.7
[129] Section 15.2.2.1
[130] Section 8.3.1.1

javax.realtime.AsyncBaseEventHandler
javax.realtime.AsyncLongEventHandler

Description

A version of AsyncBaseEventHandler[131] that carries a long value as paylaod.

Available since RTSJ 2.0

8.3.3.7.1 Constructors

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)

Signature

```
public
AsyncLongEventHandler(SchedulingParameters scheduling,
                      javax.realtime.ReleaseParameters<?> release,
                      MemoryParameters memory,
                      MemoryArea area,
                      SchedulingGroup group,
                      ConfigurationParameters config,
                      LongConsumer logic)
throws IllegalArgumentException
```

Description

Create an asynchronous event handler that receives a Long payload with each fire.

Parameters

scheduling parameters for scheduling the new handler (and possibly other instances of Schedulable[132]). When scheduling is null and the creator is an instance of Schedulable[133], SchedulingParameters[134] is a clone of the creator's value created in the same memory area as this. When scheduling is null and the

[131] Section 8.3.3.3
[132] Section 6.3.1.3
[133] Section 6.3.1.3
[134] Section 6.3.3.14

creator is a Java thread, the contents and type of the new SchedulingParameters object is governed by the associated scheduler.

release parameters for scheduling the new handler (and possibly other instances of Schedulable[135]). When release is null the new AsyncEventHandler will use a clone of the default ReleaseParameters[136] for the associated scheduler created in the memory area that contains the AsyncEventHandler object.

memory parameters for scheduling the new handler (and possibly other instances of Schedulable[137]). 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.

group parameters for providing CPU cost management on a set of Schedulable[138]s. When null, this will not be associated with any processing group.

config parameters for reserving space for preallocated exceptions and change implementation specific per Schedulable[139] memory reservations, such as Java stack size, for the new handler (and possibly other instances of Schedulable[140]. When initial is null, this AsyncEventHandler will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

logic is the logic to run for each fire. When logic is null, the handleAsyncEvent() method in the new object will serve as its logic.

Throws

IllegalArgumentException when the event queue overflow policy is QueueOverflowPolicy.DISABLE[141].

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, LongConsumer)

Signature

public
AsyncLongEventHandler(SchedulingParameters scheduling,

[135] Section 6.3.1.3
[136] Section 6.3.3.10
[137] Section 6.3.1.3
[138] Section 6.3.1.3
[139] Section 6.3.1.3
[140] Section 6.3.1.3
[141] Section 6.3.2.2.1

javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory,
MemoryArea area,
ConfigurationParameters config,
LongConsumer logic)
throws IllegalArgumentException

Description

Calling this constructor is equivalent to calling AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)[142] with arguments (scheduling, release, memory, area, null, config, logic). This constructor is needed for SCJ.

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, LongConsumer)

Signature

public
AsyncLongEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release,
LongConsumer logic)
throws IllegalArgumentException

Description

Calling this constructor is equivalent to calling AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)[143] with arguments (scheduling, release, null, null, null, null, logic).

AsyncLongEventHandler(SchedulingParameters, ReleaseParameters)

Signature

[142]Section 8.3.3.7.1
[143]Section 8.3.3.7.1

public
AsyncLongEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)
throws IllegalArgumentException

Description

Calling this constructor is equivalent to calling AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)[144] 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, SchedulingGroup, ConfigurationParameters, LongConsumer)[145] with arguments (null, null, null, null, null, null, null, logic).

AsyncLongEventHandler

Signature

public
AsyncLongEventHandler()

Description

Create an instance of AsyncLongEventHandler with default values for all parameters.

[144]Section 8.3.3.7.1
[145]Section 8.3.3.7.1

See Section AsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)

8.3.3.7.2 Methods

handleAsyncEvent(long)

Signature

public void
handleAsyncEvent(long payload)

Description

This method holds the logic which is to be executed when any AsyncEvent[146] 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 is the long value associated with a fire.

peekPending

Signature

public long
peekPending()
throws IllegalStateException

Description

Determine the next value queued for handling.

Throws

[146] Section 8.3.3.4

IllegalStateException when the fire count is zero.

Returns
The long value at the head of the queue of longs to be passed to handleAsyncEvent(long)[147].

run

Signature
public final void
run()

Description
This method is only to be used by the infrastructure, and should not be called by the application.

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 that method or provide a logic object for the default implementation to invoke.

8.3.3.8 AsyncObjectEvent

Inheritance
java.lang.Object
javax.realtime.AsyncBaseEvent
javax.realtime.AsyncObjectEvent

Description
A new type of event that carries an object as a payload.

See Section AsyncEvent

Available since RTSJ 2.0

8.3.3.8.1 Constructors

---

[147] Section 8.3.3.7.2

AsyncObjectEvent

Signature

public
AsyncObjectEvent()

Description

Create a new AsyncObjectEvent instance.

8.3.3.8.2 Methods

fire(P)

Signature

public void
fire(P value)
throws MITViolationException,
EventQueueOverflowException,
IllegalAssignmentError

Description

When enabled, fire this instance of AsyncObjectEvent. The asynchronous event handlers associated with this event will be released with the object passed by fire[148]. When no handlers are attached or this object is disabled the method does nothing, i.e., it skips the release.

- When the instance of AsyncObjectEvent is associated with more than one instance of AsyncObjectEventHandler[149] with release parameters object of type AperiodicParameters[150] and the execution of fire[151] introduces the requirement to throw at least one type of exception, then all instances of AsyncObjectEventHandler[152] not affected by the exception are handled normally.

[148] Section 8.3.3.8.2
[149] Section 8.3.3.9
[150] Section 6.3.3.2
[151] Section 8.3.3.8.2
[152] Section 8.3.3.9

- When this instance of AsyncObjectEvent is associated with more than one instance of AsyncObjectEventHandler[153] with release parameters object of type SporadicParameters[154] and the execution of fire[155] introduces the simultaneous requirement to throw more than one type of exception or error, then MITViolationException[156] has precedence over ArrivalTimeQueueOverflowException[157].

Parameters

value is the payload passed to the event.

Throws

MITViolationException Thrown 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[158], this exception is ignored.

IllegalAssignmentError when P is not assignable the event queue of one of the associated handlers.

8.3.3.9 AsyncObjectEventHandler

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEventHandler
    javax.realtime.AsyncObjectEventHandler

Description

A version of AsyncBaseEventHandler[159] that carries an Object value as paylaod.

Available since RTSJ 2.0

[153] Section 8.3.3.9
[154] Section 6.3.3.15
[155] Section 8.3.3.8.2
[156] Section 15.2.2.7
[157] Section 15.2.2.1
[158] Section 8.3.1.1
[159] Section 8.3.3.3

8.3.3.9.1 Constructors

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Consumer)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        javax.realtime.ReleaseParameters<?> release,
                        MemoryParameters memory,
                        MemoryArea area,
                        SchedulingGroup group,
                        ConfigurationParameters config,
                        java.util.function.Consumer<P> logic)
throws IllegalArgumentException
```

Description

Create an asynchronous event handler that receives a Long payload with each fire.

Parameters

scheduling parameters for scheduling the new handler (and possibly other instances of Schedulable[160]). When scheduling is null and the creator is an instance of Schedulable[161], SchedulingParameters[162] 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 parameters for scheduling the new handler (and possibly other instances of Schedulable[163]). When release is null the new AsyncEventHandler will use a clone of the default ReleaseParameters[164] for the associated scheduler created in the memory area that contains the AsyncEventHandler object.

[160] Section 6.3.1.3
[161] Section 6.3.1.3
[162] Section 6.3.3.14
[163] Section 6.3.1.3
[164] Section 6.3.3.10

memory parameters for scheduling the new handler (and possibly other instances of Schedulable[165]). 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.

group parameters for providing CPU cost management on a set of Schedulable[166]s. When null, this will not be associated with any processing group.

config parameters for reserving space for preallocated exceptions and change implementation specific per Schedulable[167] memory reservations, such as Java stack size, for the new handler (and possibly other instances of Schedulable[168]. When initial is null, this AsyncEventHandler will reserve no space for preallocated exceptions and implementation-specific values will be set to their implementation-defined defaults.

logic is the logic to run for each fire. When logic is null, the handleAsyncEvent method in the new object will serve as its logic.

Throws

IllegalArgumentException when the event queue overflow policy is QueueOverflowPolicy.DISABLE[169].

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ConfigurationParameters, Consumer)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        javax.realtime.ReleaseParameters<?> release,
                        MemoryParameters memory,
                        MemoryArea area,
                        ConfigurationParameters config,
                        java.util.function.Consumer<P> logic)
throws IllegalArgumentException
```

Description

[165]Section 6.3.1.3
[166]Section 6.3.1.3
[167]Section 6.3.1.3
[168]Section 6.3.1.3
[169]Section 6.3.2.2.1

Calling this constructor is equivalent to calling AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Consumer)[170] with arguments (scheduling, release, memory, area, null, config, logic). This constructor is needed for SCJ.

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, Consumer)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        javax.realtime.ReleaseParameters<?> release,
                        java.util.function.Consumer<P> logic)
throws IllegalArgumentException
```

Description

Calling this constructor is equivalent to calling AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Consumer)[171] with arguments (scheduling, release, null, null, null, null, logic).

AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters)

Signature

```
public
AsyncObjectEventHandler(SchedulingParameters scheduling,
                        javax.realtime.ReleaseParameters<?> release)
throws IllegalArgumentException
```

Description

Calling this constructor is equivalent to calling AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, Con-

[170] Section 8.3.3.9.1
[171] Section 8.3.3.9.1

figurationParameters, Consumer)[172] 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, SchedulingGroup, ConfigurationParameters, Consumer)[173] with arguments (null, null, null, null, null, null, null, logic).

Parameters

logic is the function to call on the object received.

AsyncObjectEventHandler

Signature

public
AsyncObjectEventHandler()

Description

Create an instance of AsyncObjectEventHandler with default values for all parameters.

See Section AsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Consumer)

8.3.3.9.2 Methods

[172] Section 8.3.3.9.1
[173] Section 8.3.3.9.1

handleAsyncEvent(P)

Signature

public void
handleAsyncEvent(P value)

Description

This method holds the logic which is to be executed when any AsyncEvent[174] 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 IllegalStateException

Description

Determine the next value queued for handling.

Throws

IllegalStateException when the fire count is zero.

Returns

The object reference at the head of the queue of object references to be passed to handleAsyncEvent[175]}.

[174] Section 8.3.3.4
[175] Section 8.3.3.9.2

run

Signature

public final void
run()

Description

This method is only to be used by the infrastructure, and should not be called by the application.

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 that method or provide a logic object for the default implementation to invoke.

8.3.3.10 BoundAsyncEventHandler

Inheritance

java.lang.Object
javax.realtime.AsyncBaseEventHandler
javax.realtime.AsyncEventHandler
javax.realtime.BoundAsyncEventHandler

Interfaces

javax.realtime.BoundAsyncBaseEventHandler

Description

A bound asynchronous event handler is an instance of AsyncEventHandler[176] 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.

8.3.3.10.1 Constructors

[176] Section 8.3.3.5

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       javax.realtime.ReleaseParameters<?> release,
                       MemoryParameters memory,
                       MemoryArea area,
                       SchedulingGroup group,
                       ConfigurationParameters config,
                       Runnable logic)
```

Description

Create an instance of BoundAsyncEventHandler with the specified parameters. The newly-created handler inherits the affinity of its creator.

Parameters

scheduling A SchedulingParameters[177] object which will be associated with the constructed instance. When null, and the creator is a Java thread, a SchedulingParameters object is created which has the default SchedulingParameters for the scheduler associated with the current thread. When null, and the creator is a schedulable object, the SchedulingParameters are inherited from the current schedulable (a new SchedulingParameters object is cloned).

release A ReleaseParameters[178] object which will be associated with the constructed instance. When null, this will have default ReleaseParameters for the BAEH's scheduler.

memory A MemoryParameters[179] 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[180] for this. When null, the memory area will be that of the current thread/schedulable.

group A SchedulingGroup[181] object which will be associated with the constructed instance. When null, this will not be associated with any scheduling group.

[177] Section 6.3.3.14
[178] Section 6.3.3.10
[179] Section 11.3.3.4
[180] Section 11.3.3.3
[181] Section 6.3.3.13

config The ConfigurationParameters[182] associated with this (and possibly other instances of Schedulable[183]. 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()[184]. When null, the default handleAsyncEvent() method invokes nothing.

Throws

IllegalArgumentException when mayUseHeap in memory is true and logic, any parameter object, or this is in heap memory. Also when noheap 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.

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, Runnable)

Signature

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       javax.realtime.ReleaseParameters<?> release,
                       Runnable logic)
```

Description

Create an instance of BoundAsyncEventHandler with the specified parameters. The newly-created handler inherits the affinity of its creator.

Equivalent to BoundAsyncEventHandler(scheduling, release, null, null, null, config, logic)

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters)

[182]Section 5.3.2.1
[183]Section 6.3.1.3
[184]Section 8.3.3.5.2

Signature

public
BoundAsyncEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)

Description

Create an instance of BoundAsyncEventHandler with the specified parameters. The newly-created handler inherits the affinity of its creator.

Equivalent to BoundAsyncEventHandler(scheduling, release, null, null, null, null, logic)

BoundAsyncEventHandler(Runnable)

Signature

public
BoundAsyncEventHandler(Runnable logic)

Description

Create an instance of BoundAsyncEventHandler with the specified parameters. The newly-created handler inherits the affinity of its creator.

Equivalent to BoundAsyncEventHandler(null, null, null, null, null, null, logic)

BoundAsyncEventHandler

Signature

public
BoundAsyncEventHandler()

Description

Create an instance of BoundAsyncEventHandler. The newly-created handler inherits the affinity of its creator.

Equivalent to BoundAsyncEventHandler(null, null, null, null, null, null, null)

8.3.3.11 BoundAsyncLongEventHandler

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEventHandler
    javax.realtime.AsyncLongEventHandler
      javax.realtime.BoundAsyncLongEventHandler

Interfaces

javax.realtime.BoundAsyncBaseEventHandler

Description

A bound asynchronous event handler is an instance of AsyncLongEventHandler[185] that is permanently bound to a dedicated realtime thread. 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.

Available since RTSJ 2.0

8.3.3.11.1 Constructors

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, LongConsumer)

Signature

```
public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
                           javax.realtime.ReleaseParameters<?> release,
                           MemoryParameters memory,
                           MemoryArea area,
                           SchedulingGroup group,
                           ConfigurationParameters config,
                           LongConsumer logic)
```

[185] Section 8.3.3.7

Description

Create an instance of BoundAsyncLongEventHandler which specifies all possible parameters. The newly-created handler inherits the affinity of its creator.

Parameters

scheduling A SchedulingParameters[186] object which will be associated with the constructed instance. When null, and the creator is a Java thread, a SchedulingParameters object is created which has the default SchedulingParameters for the scheduler associated with the current thread. When null, and the creator is a schedulable object, the SchedulingParameters are inherited from the current schedulable (a new SchedulingParameters object is cloned).

release A ReleaseParameters[187] object which will be associated with the constructed instance. When null, this will have default ReleaseParameters for the BAEH's scheduler.

memory A MemoryParameters[188] 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[189] for this. When null, the memory area will be that of the current thread/schedulable.

group A SchedulingGroup[190] object which will be associated with the constructed instance. When null, this will not be associated with any scheduling group.

config The ConfigurationParameters[191] associated with this (and possibly other instances of Schedulable[192]. 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)[193]. When null, the default handleAsyncEvent(long) method invokes nothing.

Throws

IllegalArgumentException when mayUseHeap in memory is true and logic, any parameter object, or this is in heap memory. Also when noheap is true and area is heap memory.

[186] Section 6.3.3.14
[187] Section 6.3.3.10
[188] Section 11.3.3.4
[189] Section 11.3.3.3
[190] Section 6.3.3.13
[191] Section 5.3.2.1
[192] Section 6.3.1.3
[193] Section 8.3.3.7.2

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.

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters, LongConsumer)

Signature

public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release,
LongConsumer logic)

Description

BoundAsyncLongEventHandler(SchedulingParameters, ReleaseParameters)

Signature

public
BoundAsyncLongEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)

Description

BoundAsyncLongEventHandler(LongConsumer)

Signature

public
BoundAsyncLongEventHandler(LongConsumer logic)

Description

BoundAsyncLongEventHandler

Signature

public
BoundAsyncLongEventHandler()

Description

Create an instance of BoundAsyncLongEventHandler using default values. This constructor is equivalent to BoundAsyncLongEventHandler(null, null, null, null, null, false, null)

8.3.3.12 BoundAsyncObjectEventHandler

Inheritance

java.lang.Object
javax.realtime.AsyncBaseEventHandler
javax.realtime.AsyncObjectEventHandler
javax.realtime.BoundAsyncObjectEventHandler

Interfaces

javax.realtime.BoundAsyncBaseEventHandler

Description

A bound asynchronous event handler is an instance of AsyncObjectEventHandler[194] that is permanently bound to a dedicated realtime thread. 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.

Available since RTSJ 2.0

[194] Section 8.3.3.9

8.3.3.12.1 Constructors

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroup, ConfigurationParameters, Consumer)

Signature

```
public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
                             javax.realtime.ReleaseParameters<?> release,
                             MemoryParameters memory,
                             MemoryArea area,
                             ProcessingGroup group,
                             ConfigurationParameters config,
                             java.util.function.Consumer<P> logic)
```

Description

Create an instance of BoundAsyncObjectEventHandler which specifies all possible parameters. The newly-created handler inherits the affinity of its creator.

Parameters

scheduling A SchedulingParameters[195] object which will be associated with the constructed instance. When null, and the creator is a Java thread, a SchedulingParameters object is created which has the default SchedulingParameters for the scheduler associated with the current thread. When null, and the creator is a schedulable object, the SchedulingParameters are inherited from the current schedulable (a new SchedulingParameters object is cloned).

release A ReleaseParameters[196] object which will be associated with the constructed instance. When null, this will have default ReleaseParameters for the BAEH's scheduler.

memory A MemoryParameters[197] 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[198] for this. When null, the memory area will be that of the

[195] Section 6.3.3.14
[196] Section 6.3.3.10
[197] Section 11.3.3.4
[198] Section 11.3.3.3

current thread/schedulable.

group A SchedulingGroup[199] object which will be associated with the constructed instance. When null, this will not be associated with any scheduling group.

config The ConfigurationParameters[200] associated with this (and possibly other instances of Schedulable[201]. 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[202]. When null, the default handleAsyncEvent method invokes nothing.

Throws

IllegalArgumentException when mayUseHeap in memory is true and logic, any parameter object, or this is in heap memory. Also when noheap 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.

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters, Consumer)

Signature

```
public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
                             javax.realtime.ReleaseParameters<?> release,
                             java.util.function.Consumer<P> logic)
```

Description

BoundAsyncObjectEventHandler(SchedulingParameters, ReleaseParameters)

[199]Section 6.3.3.13
[200]Section 5.3.2.1
[201]Section 6.3.1.3
[202]Section 8.3.3.9.2

Signature

public
BoundAsyncObjectEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release)

Description

BoundAsyncObjectEventHandler(Consumer)

Signature

public
BoundAsyncObjectEventHandler(java.util.function.Consumer<P> logic)

Description

BoundAsyncObjectEventHandler

Signature

public
BoundAsyncObjectEventHandler()

Description

Create an instance of BoundAsyncObjectEventHandler using default values. This constructor is equivalent to BoundAsyncObjectEventHandler(null, null, null, null, null, null)

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 (the interface BoundAsyncBaseEventHandler). The RTSJ does not define at what point a nonbound 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.

The ability to trigger an ATC in a schedulable is necessary in many kinds of realtime applications but 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.

One basic decision was to allow ATC in a method only if the method explicitly permits this. The default of no ATC is reasonable, since legacy code might be written expecting no 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().

Chapter 9

Time

Realtime systems must be able to handle both very short time durations and very long ones. They also needs 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. Neither provides 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.

Realtime Epoch — The time at which the realtime clock began ticking, defined by fiat as January 1, 1970 00:00:00 UTC.

Epoch — The date and time relative to which times on an RTSJ Chronograph, c are determined. The epoch for a chronograph is defined in terms of the *Realtime Epoch*, and is represented as the time elapsed on the realtime clock since the realtime Epoch at the time that c would have returned a timestamp 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.

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.

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

3. Time objects maintain and report time values in normalized form, but the normalized form is not required for input parameter values. This allows computations individually with time constituent 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

Inheritance

java.lang.Object
  javax.realtime.HighResolutionTime
    javax.realtime.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 default realtime 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 IllegalArgumentException
```

Description

Construct 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, 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 default realtime clock, but other classes of chronograph may define other epochs.

Available 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 chronograph providing the association for the newly constructed object. The realtime clock is used when this argument is null.

Throws

IllegalArgumentException when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(long, int)

Signature

```
public
AbsoluteTime(long millis,
             int nanos)
throws IllegalArgumentException
```

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[1] with the argument list (long, int, null)

Parameters

[1] Section 9.3.1.1.1

millis is the desired value for the millisecond component of this. The actual value is the result of parameter normalization.

nanos is the desired value for the nanosecond component of this. The actual value is the result of parameter normalization.

Throws

IllegalArgumentException when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(Date, Chronograph)

Signature

```
public
AbsoluteTime(Date date,
             Chronograph chronograph)
throws IllegalArgumentException
```

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[2] 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 chronograph association is made with the Chronograph parameter. When Chronograph is null the association is made with the default realtime clock.

Available since RTSJ 2.0

Parameters

date The java.util.Date representation of the time past the Epoch.

chronograph The chronograph providing the association for the newly constructed object.

Throws

IllegalArgumentException when the date parameter is null.

[2]Section 9.3.1.1.1

AbsoluteTime(Date)

Signature

public
AbsoluteTime(Date date)
throws IllegalArgumentException

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[3] with the argument list (date.getTime(), 0, null).

Parameters

date the java.util.Date representation of the time past the Epoch.

Throws

IllegalArgumentException when the date parameter is null.

AbsoluteTime(AbsoluteTime)

Signature

public
AbsoluteTime(AbsoluteTime time)
throws IllegalArgumentException

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[4] with the argument list (time.getMilliseconds(), time.getNanoseconds(), time.getChronograph()).

Parameters

time The AbsoluteTime object which is the source for the copy.

Throws

IllegalArgumentException when the time parameter is null.

AbsoluteTime(Chronograph)

Signature

[3]Section 9.3.1.1.1
[4]Section 9.3.1.1.1

public
AbsoluteTime(Chronograph chronograph)

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[5] with the argument list (0, 0, chronograph).

Available since RTSJ 2.0

Parameters

chronograph The chronograph providing the association for the newly constructed object.

AbsoluteTime

Signature

public
AbsoluteTime()

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[6] with the argument list (0, 0, null).

9.3.1.1.2 Methods

absolute(Chronograph)

Signature

public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)

Description

[5]Section 9.3.1.1.1
[6]Section 9.3.1.1.1

Return 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 The Chronograph parameter is used only as the new chronograph association with the result, since no conversion is needed.

Returns

The copy of this in a newly allocated AbsoluteTime object, associated with the Chronograph parameter.

absolute(Chronograph, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
         AbsoluteTime dest)
```

Description

Convert the time of this to an absolute time, using the given instance of Chronograph[7] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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[8] 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 there and returned. Otherwise, a new object is allocated for the result.

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.

[7] Section 10.3.1.2
[8] Section 10.3.1.2

relative(Chronograph)

Signature

public javax.realtime.RelativeTime
relative(Chronograph chronograph)

Description

Convert the time of this to a relative time, using the given instance of Chronograph[9] to determine the current time. The calculation is the current time indicated by the given instance of Chronograph[10] 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 chronograph association of the result is with the Chronograph passed as a parameter.

Parameters

chronograph The instance of Chronograph[11] 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.

Available since RTSJ 2.0

relative(Chronograph, RelativeTime)

Signature

public javax.realtime.RelativeTime
relative(Chronograph chronograph,
RelativeTime dest)

Description

Convert the time of this to a relative time, using the given instance of Chronograph[12] to determine the current time. The calculation is the current time indicated by the given instance of Chronograph[13] subtracted from the time given

[9] Section 10.3.1.2
[10] Section 10.3.1.2
[11] Section 10.3.1.2
[12] Section 10.3.1.2
[13] Section 10.3.1.2

by this. When Chronograph is null the default 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 with the Chronograph passed as a parameter.

Parameters

chronograph The instance of Chronograph[14] 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 there and returned. Otherwise, a new object is allocated for the result.

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 Chronograph parameter.

add(long, int)

Signature

```
public javax.realtime.AbsoluteTime
add(long millis,
    int nanos)
throws ArithmeticException
```

Description

Create 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.

[14] Section 10.3.1.2

add(long, int, AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
add(long millis,
int nanos,
AbsoluteTime dest)
throws ArithmeticException

Description

Return 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. Otherwise, a new object is allocated for the result.

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,
IllegalArgumentException

Description

Create 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

IllegalArgumentException 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,
       IllegalArgumentException
```

Description

Return 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 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 there and returned. Otherwise, a new object is allocated for the result.

Throws

IllegalArgumentException 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 UnsupportedOperationException

Description

Convert 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

UnsupportedOperationException 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 IllegalArgumentException

Description

Change 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

IllegalArgumentException when the parameter date is null.

Returns
this

subtract(AbsoluteTime)

Signature

public javax.realtime.RelativeTime
subtract(AbsoluteTime time)
throws IllegalArgumentException,
ArithmeticException

Description

Create 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
IllegalArgumentException 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 IllegalArgumentException,
ArithmeticException

Description

Return 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. Otherwise, a new object is allocated for the result.

Throws

IllegalArgumentException 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 IllegalArgumentException,
ArithmeticException

Description

Create 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

IllegalArgumentException 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 IllegalArgumentException,
ArithmeticException

Description

Return 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. Otherwise, a new object is allocated for the result.

Throws

IllegalArgumentException 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

Create 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

String object converted from the time given by this.

9.3.1.2 HighResolutionTime

Inheritance

java.lang.Object
javax.realtime.HighResolutionTime

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[15] or RelativeTime[16] 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

---

[15]Section 9.3.1.1
[16]Section 9.3.1.3

waitForObject(Object, HighResolutionTime)

Signature

public static boolean
waitForObject(Object target,
javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
IllegalMonitorStateException,
IllegalArgumentException,
UnsupportedOperationException

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 on 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[17] or AsynchronouslyInterruptedException.fire[18] while it is waiting.

IllegalArgumentException when time represents a relative time less than zero.

IllegalMonitorStateException when target is not locked by the caller.

UnsupportedOperationException 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.

[17] Section 5.3.2.2.2
[18] Section 8.3.2.1.2

Available since RTSJ 2.0 updated to add a return value.

equals(T)

Signature

public boolean
equals(T time)

Description

Returns true when the argument time has the same type and values as this. Equality includes Chronograph association.

Parameters

time Value compared to this.

Returns

true when the parameter time is of the same type and has the same values as this.

getClock

Signature

public final javax.realtime.Clock
getClock()
throws UnsupportedOperationException

Description

Returns a reference to the clock associated with this.

Throws

UnsupportedOperationException when the time is based on a Chronograph[19] that is not a Clock[20].

Returns

A reference to the clock associated with this.

Available since RTSJ 1.0.1

[19] Section 10.3.1.2
[20] Section 10.3.2.1

getChronograph

Signature

public final javax.realtime.Chronograph
getChronograph()

Description

Get a reference to the Chronograph[21] associated with this.

Returns

A reference to the Chronograph[22] associated with this.

Available since RTSJ 2.0

getMilliseconds

Signature

public final long
getMilliseconds()

Description

Get the milliseconds component of this.

Returns

The milliseconds component of the time represented by this.

getNanoseconds

Signature

public final int
getNanoseconds()

Description

Get the nanoseconds component of this.

Returns

The nanoseconds component of the time represented by this.

[21] Section 10.3.1.2
[22] Section 10.3.1.2

set(T)

Signature

public T extends javax.realtime.HighResolutionTime<T>
set(T time)

Description

Change 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

IllegalArgumentException 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

Available since RTSJ 1.0.1 The description of the method in 1.0 was erroneous.

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

set(long, int)

Signature

public T extends javax.realtime.HighResolutionTime<T>
set(long millis,
int nanos)
throws IllegalArgumentException

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

IllegalArgumentException when there is an overflow in the millisecond component while normalizing.

Returns

this

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 equals[23] equal have the same hash code.

Returns

The hashcode value for this instance.

[23] Section 9.3.1.2.1

clone

Signature

public java.lang.Object
clone()

Description

Return 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.

Available since RTSJ 1.0.1

compareTo(T)

Signature

public int
compareTo(T time)

Description

Compares this HighResolutionTime with the specified HighResolutionTime time.

Parameters

time Compares with the time of this.

Throws

ClassCastException when the time parameter is not of the same class as this.

IllegalArgumentException 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.

equals(Object)

Signature

public boolean
equals(Object object)

Description

Returns true when the argument object has the same type and values as this. Equality includes Chronograph association.

Parameters

object Value compared to this.

Returns

true when the parameter object is of the same type and has the same values as this.

absolute(Chronograph, AbsoluteTime)

Signature

public abstract javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
AbsoluteTime dest)

Description

Convert the time of this to an absolute time, using the given instance of Chronograph[24] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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[25] 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 there and returned. Otherwise, a new object is allocated for the result.

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

[24]Section 10.3.1.2
[25]Section 10.3.1.2

public abstract javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)

Description

Convert the time of this to an absolute time, using the given instance of Chronograph[26] 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 is the instance of Chronograph[27] 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

Convert the time of this to a relative time, using the given instance of Chronograph[28] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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[29] used to convert the time of this into relative time, and the new chronograph association for the result.

[26] Section 10.3.1.2
[27] Section 10.3.1.2
[28] Section 10.3.1.2
[29] Section 10.3.1.2

dest When dest is not null, the result is placed there and returned. Otherwise, a new object is allocated for the result.

Returns

The RelativeTime[30] conversion in dest when dest is not null, otherwise the result is returned in a newly allocated object.

relative(Chronograph)

Signature

public abstract javax.realtime.RelativeTime
relative(Chronograph chronograph)

Description

Convert the time of this to a relative time, using the given instance of Chronograph[31] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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[32] 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.

9.3.1.3 RelativeTime

Inheritance

java.lang.Object
  javax.realtime.HighResolutionTime
    javax.realtime.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.

[30] Section 9.3.1.3
[31] Section 10.3.1.2
[32] Section 10.3.1.2

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 IllegalArgumentException
```

Description

Construct a RelativeTime object representing an interval based on the parameter millis plus the parameter nanos. The construction is subject to millis and nanos parameters normalization. When there is an overflow in the millisecond component when normalizing then an IllegalArgumentException 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.

Available 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 chronograph providing the association for the newly constructed object. Defaults to the realtime clock when null.

Throws

IllegalArgumentException when there is an overflow in the millisecond component when normalizing.

RelativeTime(long, int)

Signature

public
RelativeTime(long millis,
int nanos)
throws IllegalArgumentException

Description

Equivalent to RelativeTime(long, int, Chronograph)[33] 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

IllegalArgumentException 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)[34] with argument list (time.getMilliseconds(), time.getNanoseconds(), time.getChronograph()).

Parameters

time The RelativeTime object which is the source for the copy.

[33] Section 9.3.1.3.1
[34] Section 9.3.1.3.1

RelativeTime(Chronograph)

Signature

public
RelativeTime(Chronograph chronograph)

Description

Equivalent to RelativeTime(long, int, Chronograph)[35] with argument list (0, 0, chronograph).

Available since RTSJ 2.0

Parameters

chronograph The chronograph providing the association for the newly constructed object.

RelativeTime

Signature

public
RelativeTime()

Description

Equivalent to RelativeTime(long, int, Chronograph)[36] with argument list (0, 0, null).

9.3.1.3.2 Methods

---

absolute(Chronograph)

Signature

public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph)

[35]Section 9.3.1.3.1
[36]Section 9.3.1.3.1

Description

Convert the time of this to an absolute time, using the given instance of Chronograph[37] 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.

Available since RTSJ 2.0

See Section HighResolutionTime.absolute(Chronograph)

absolute(Chronograph, AbsoluteTime)

Signature

```
public javax.realtime.AbsoluteTime
absolute(Chronograph chronograph,
         AbsoluteTime dest)
```

Description

Convert the time of this to an absolute time, using the given instance of Chronograph[38] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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.

Available since RTSJ 2.0

See Section HighResolutionTime.absolute(Chronograph, AbsoluteTime)

relative(Chronograph)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph)
```

[37] Section 10.3.1.2
[38] Section 10.3.1.2

Description

Convert the time of this to a relative time, using the given instance of Chronograph[39] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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.

Available since RTSJ 2.0

See Section HighResolutionTime.relative(Chronograph)

relative(Chronograph, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
relative(Chronograph chronograph,
         RelativeTime dest)
```

Description

Convert the time of this to a relative time, using the given instance of Chronograph[40] to determine the current time when necessary. When Chronograph is null the realtime chronograph 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.

Available since RTSJ 2.0

See Section HighResolutionTime.relative(Chronograph, RelativeTime)

add(long, int)

Signature

```
public javax.realtime.RelativeTime
add(long millis,
    int nanos)
```

[39] Section 10.3.1.2
[40] Section 10.3.1.2

throws ArithmeticException

Description

Create 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

Return 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. Otherwise, a new object is allocated for the result.

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 IllegalArgumentException,
ArithmeticException

Description

Create 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
IllegalArgumentException 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 IllegalArgumentException,
ArithmeticException

Description

Return 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. Otherwise, a new object is allocated for the result.

Throws

IllegalArgumentException 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 IllegalArgumentException,
       ArithmeticException
```

Description

Create 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

IllegalArgumentException 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 parameter time.

subtract(RelativeTime, RelativeTime)

Signature

```
public javax.realtime.RelativeTime
subtract(RelativeTime time,
         RelativeTime dest)
throws IllegalArgumentException,
       ArithmeticException
```

Description

Return 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

IllegalArgumentException when the 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

Change the length of this relative time by multiplying it by factor.

Parameters

factor by which to increase the time interval.

Returns

a new object with value of this scaled by factor.

Available since RTSJ 2.0

scale(int, RelativeTime)

Signature

public javax.realtime.RelativeTime
scale(int factor,
RelativeTime time)

Description

Set time to the value of this time by multiplied by factor.

Parameters

factor by which to increase the time interval.

time in which to store the results.

Returns

time with the value of this scaled by factor

Available since RTSJ 2.0

compareToZero

Signature

public int
compareToZero()

Description

Compare 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.

Available since RTSJ 2.0

compareTo(RelativeTime)

Signature

public int
compareTo(RelativeTime time)

Description

Compares this HighResolutionTime with the specified HighResolutionTime time.

Parameters

time Compares with the time of this.

Throws

ClassCastException when the time parameter is not of the same class as this.

IllegalArgumentException 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.

toString

Signature

public java.lang.String
toString()

Description

Create 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

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 visa verse.

Monotonic Timing Mechanism — A timing mechanism whose time values always progress in one direction.

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.

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 cocks) 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.
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 realtime 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.

10.2.2 Clocks and Timables

A Clock is the basic mechanism of measuring time and triggering events based on the passage of time. A Timer can request a signal from the clock when a given time is reached. That signal should come as closed to the actual time requested as possible. A schedulable also uses a clock to implement the realtime sleep methods. Each clock instance shall be capable of reporting the achievable resolution of timers based on that clock. Each implementation shall have a default clock that is used whenever no other clock is specified. An application can also defined additional clocks.

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 that is 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 *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* cause 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 (when *disabled* and *active* 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.

A Clock can also be used to regulate pauses in execution of any Schedulable through a realtime sleep method, hence timers and schedulables are classified as timables under the Timable interface.

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.

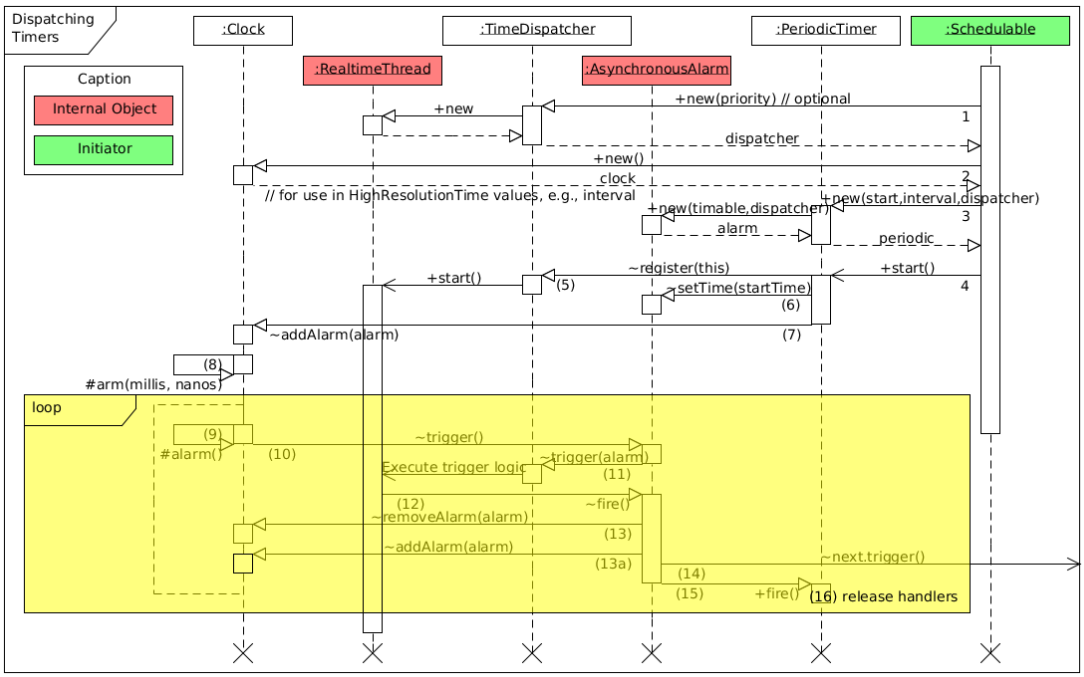
A Timer is an ActiveEvent. This means that is has an associated dispatcher called TimeDispatcher. As with other active events, the application can either use

the default dispatcher or create a new one with its own priority and affinity. A schedulable can also have a TimeDispatcher to manage sleeping.

At any given time, a timable, Timer 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.

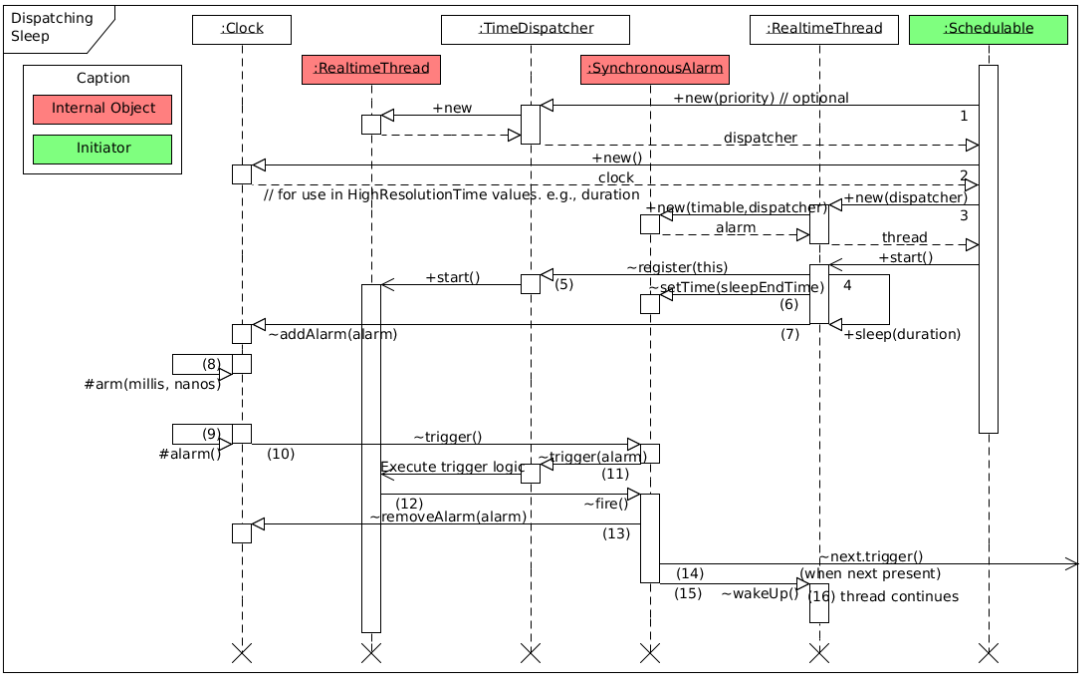
In the case of a timer, the dispatcher triggers the timer thereby indicating it should fire or skip. In the case of a schedulable, the dispatcher triggers the schedulable to wake up from its sleep. Figure 10.1 illustrates how a timer interacts with a application-defined clock and Figure 10.2 depicts the same for using realtime sleep in a schedulable.

Figure 10.1: Sequence Diagram for Using a Timer



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.

Figure 10.2: Sequence Diagram for Realtime Sleep



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, step three in both diagrams, when the timable is created and it represents the next alarm that the timable should receive: 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 start 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. For 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 many as 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 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 it 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 8.3. 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.

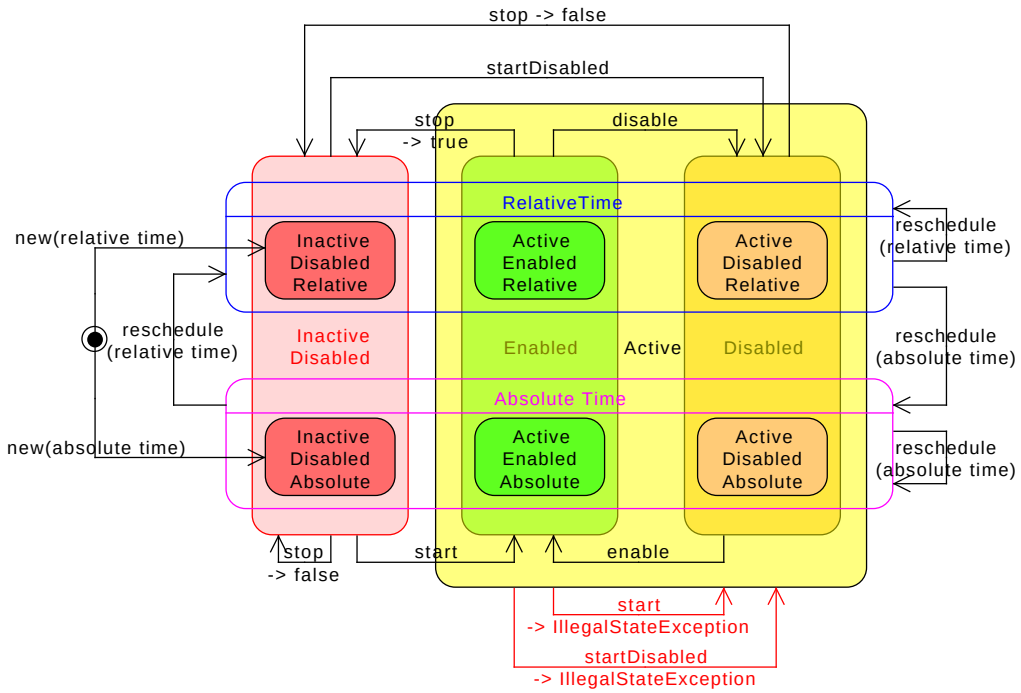
10.2.3.5 Phasing

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

Interfaces
javax.realtime.Timable
Description

A common type for Timer[2] and RealtimeThread[3] to indicate that they can be

[1]Note that the semantics of the fire transition differ among the subclasses of Timer.
[2]Section 10.3.2.6
[3]Section 5.3.2.2

associated with a Clock[4] and be suspended waiting for time events based on that clock.

Available since RTSJ 2.0

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

Description

The interface for all devices that support the measurement of time with great accuracy.

Available since RTSJ 2.0

10.3.1.2.1 Methods

[4]Section 10.3.2.1

getEpochOffset

Signature

public javax.realtime.RelativeTime
getEpochOffset()

Description

Determines the time on the realtime clock when this chronograph was zero.

Throws

UnsupportedOperationException when the chronograph does not have the concept of date.

Returns

A newly allocated RelativeTime[5] object in the current execution context with the realtime clock as its chronograph and containing time when this chronograph was zero.

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[6] in the current allocation context, representing the current time. The returned object has this its chronograph.

getTime(AbsoluteTime)

Signature

[5]Section 9.3.1.3
[6]Section 9.3.1.1

public javax.realtime.AbsoluteTime
getTime(AbsoluteTime dest)

Description

Obtain the current time. The time represented by the given AbsoluteTime[7] 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[8] object which will be updated in place.

Returns

The instance of AbsoluteTime[9] passed as parameter, or a new object when dest is null. The returned object represents the current time and is associated with this chronograph.

getQueryPrecision

Signature

public javax.realtime.RelativeTime
getQueryPrecision()

Description

Obtain the precision with which time can be read, i.e., the nominal interval between ticks. It is the same as calling getQueryPrecision(RelativeTime)[10] 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)

[7]Section 9.3.1.1
[8]Section 9.3.1.1
[9]Section 9.3.1.1
[10]Section 10.3.1.2.1

Description

Obtain the precision with which time can be read, i.e., the nominal interval between ticks.

Parameters

dest is a 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

Interfaces

javax.realtime.Releasable

Description

A type for all classes that can use a Clock[11] for timing, either for sleeping or for being released at a given time.

10.3.1.3.1 Methods

---

getDispatcher

Signature

public javax.realtime.TimeDispatcher
getDispatcher()

Description

Get the dispatcher associated with this Timable.

Available since RTSJ 2.0

[11] Section 10.3.2.1

10.3.2 Classes

10.3.2.1 Clock

Inheritance
java.lang.Object
javax.realtime.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 is the default Clock.

Returns

The singleton instance of the default Clock

getEpochOffset

Signature

public final javax.realtime.RelativeTime
getEpochOffset()
throws UnsupportedOperationException

Description

Determines the time on the realtime clock when this chronograph was zero.

Throws

UnsupportedOperationException UnsupportedOperationException when the chronograph does not have the concept of date.

Available since RTSJ 1.0.1

getTime

Signature

public final 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[12] in the current allocation context, representing the current time. The returned object has this its chronograph.

getTime(AbsoluteTime)

Signature
public abstract javax.realtime.AbsoluteTime
getTime(AbsoluteTime dest)

Description
Obtain the current time. The time represented by the given AbsoluteTime[13] 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 dest The instance of AbsoluteTime[14] object which will be updated in place.
Returns
The instance of AbsoluteTime[15] passed as parameter, or a new object when dest is null. The returned object represents the current time and is associated with this chronograph.

Available since RTSJ 1.0.1 The return value is updated from void to AbsoluteTime.

Available since RTSJ 2.0 When dest is null, a new object is allocated, when not chronograph is overwritten with this.

getQueryPrecision

Signature
public abstract javax.realtime.RelativeTime
getQueryPrecision()

Description

[12]Section 9.3.1.1
[13]Section 9.3.1.1
[14]Section 9.3.1.1
[15]Section 9.3.1.1

Obtain the precision with which time can be read, i.e., the nominal interval between ticks. It is the same as calling getQueryPrecision(RelativeTime)[16] with null as an argument.

Returns
a newly allocated time value holding the read precision.

Available since RTSJ 2.0

getQueryPrecision(RelativeTime)

Signature
public abstract javax.realtime.RelativeTime
getQueryPrecision(RelativeTime dest)

Description

Obtain the precision with which time can be read, i.e., the nominal interval between ticks.

Parameters
dest dest is a 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.

Available since RTSJ 2.0

getDrivePrecision

Signature
public abstract 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)[17] with null as its argument.

[16]Section 10.3.2.1.2
[17]Section 10.3.2.1.2

Returns
a value representing the drive precision.

Available 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 getQuery-Precision(RelativeTime)[18].

Parameters
dest return the relative time value in dest. When dest is null, it allocates a new RelativeTime[19] instance to hold the returned value.
Returns
dest set to values representing the drive precision.

Available since RTSJ 2.0

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[20], which in turn will cause a fire on an associated AsyncTimable[21]

[18]Section 10.3.2.1.2
[19]Section 9.3.1.3
[20]Section 10.3.2.4
[21]Section 10.3.1.1

This method should be implemented with a runtime complexity not exceeding O(1). Implementations exceeding this bound shall explicitly document the complexity their implementation. **Available 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 of the next alarm.

nanoseconds of the next alarm.

Available since RTSJ 2.0

clearAlarm

Signature

protected abstract void
clearAlarm()

Description

Implemented by subclasses to cancel the current outstanding alarm.

Available since RTSJ 2.0

10.3.2.2 OneShotTimer

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncEvent
      javax.realtime.Timer
        javax.realtime.OneShotTimer

Description

A timed AsyncEvent[22] that is driven by a Clock[23]. 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[24] 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(javax.realtime.HighResolutionTime<?> time,
                    TimeDispatcher dispatcher)
throws IllegalArgumentException,
       UnsupportedOperationException,
       IllegalAssignmentError
```

Description

Create an instance of OneShotTimer[25], based on the given clock, that will execute its fire method according to the given time. The Clock[26] association of the parameter time is ignored.

[22] Section 8.3.3.4
[23] Section 10.3.2.1
[24] Section 10.3.2.6
[25] Section 10.3.2.2
[26] Section 10.3.2.1

Available 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

IllegalArgumentException when time is a RelativeTime instance less than zero.

UnsupportedOperationException when the Chronograph[27] associated with time is not a Clock[28].

IllegalAssignmentError when this OneShotTimer cannot hold references to time, handler, or clock.

OneShotTimer(HighResolutionTime, AsyncEventHandler)

Signature

```
public
OneShotTimer(javax.realtime.HighResolutionTime<?> time,
             AsyncEventHandler handler)
```

Description

The equivalent of calling OneShotTimer(HighResolutionTime, TimeDispatcher)[29] with arguments time, null followed by a call to setHandler(handler).

Parameters

time is the time to release its handlers.

handler is the hanndler to release.

10.3.2.2.2 Methods

[27] Section 10.3.1.2
[28] Section 10.3.2.1
[29] Section 10.3.2.2.1

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()[30]. When distabled, but active, it only calls Timer.stop(). Otherwise it does nothing.

Available since RTSJ 2.0 moved here from Timer, since OneShotTimer and PeriodicTimer have slightly different semantics.

10.3.2.3 PeriodicTimer

Inheritance

java.lang.Object
javax.realtime.AsyncBaseEvent
javax.realtime.AsyncEvent
javax.realtime.Timer
javax.realtime.PeriodicTimer

Description

An AsyncEvent[31] 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[32].

[30] Section 10.3.2.6.2
[31] Section 8.3.3.4
[32] Section 5.3.1.1

Semantics details are described in the Timer[33] 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(javax.realtime.HighResolutionTime<?> start,
              RelativeTime interval,
              TimeDispatcher dispatcher)
throws IllegalArgumentException,
       IllegalAssignmentError,
       UnsupportedOperationException
```

Description

Create a timer that executes its fire method periodically.

Available 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 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[34].

dispatcher is the dispatcher to use for triggering this event.

Throws

[33] Section 10.3.2.6

[34] Section 10.3.2.2

IllegalArgumentException 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.

UnsupportedOperationException when the Chronograph[35] associated with time is not a Clock[36].

PeriodicTimer(HighResolutionTime, RelativeTime, AsyncEventHandler)

Signature

```
public
PeriodicTimer(javax.realtime.HighResolutionTime<?> start,
              RelativeTime interval,
              AsyncEventHandler handler)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Create 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(javax.realtime.AsyncBaseEventHandler<?> handler)
throws IllegalArgumentException,
       IllegalAssignmentError
```

[35]Section 10.3.1.2
[36]Section 10.3.2.1

Description

Add a handler to the set of handlers associated with this event. It overrides the method in AsyncBaseEvent[37] to allow the use of handlers with PeriodicParameters[38], but these parameters must match the period of this timer, otherwise IllegalArgumentException 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

IllegalArgumentException when handler is null or the handler has PeriodicParameters[39] with a period that does not match the period of this.

IllegalAssignmentError when this AsyncEvent cannot hold a reference to handler.

Available since RTSJ 2.0

setHandler(AsyncBaseEventHandler)

Signature

```
public void
setHandler(javax.realtime.AsyncBaseEventHandler<?> handler)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Associate a new handler with this event and remove all existing handlers. It overrides the method in AsyncBaseEvent[40] to allow the use of handlers with PeriodicParameters[41], but these parameters must match the period of this timer, otherwise IllegalArgumentException is thrown.

Parameters

handler The instance of AsyncBaseEventHandler[42] to be associated with this. When handler is null, no handler will be associated with this, i.e., behave effectively as when setHandler(null) invokes removeHandler(AsyncBaseEventHandler) for each associated handler.

[37] Section 8.3.3.2
[38] Section 6.3.3.6
[39] Section 6.3.3.6
[40] Section 8.3.3.2
[41] Section 6.3.3.6
[42] Section 8.3.3.3

Throws

IllegalArgumentException when handler has PeriodicParameters[43] with a period that does not match the period of this.

IllegalAssignmentError when this AsyncEvent cannot hold a reference to handler.

Available since RTSJ 2.0

start(PhasingPolicy)

Signature

```
public void
start(PhasingPolicy phasingPolicy)
throws LateStartException,
       IllegalArgumentException
```

Description

Start the timer with the specified PhasingPolicy[44].

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[45].

IllegalArgumentException when the start time of this timer is not an absolute time, or phasingPolicy is null.

Available since RTSJ 2.0

start(boolean, PhasingPolicy)

Signature

```
public void
start(boolean disabled,
      PhasingPolicy phasingPolicy)
```

[43]Section 6.3.3.6
[44]Section 5.3.1.1
[45]Section 5.3.1.1.1

throws LateStartException,
IllegalArgumentException

Description

Start the timer with the specified PhasingPolicy[46] and the specified disabled state.

Parameters

disabled determine the mode of start: true for enabled and false for disabled for consistency with Timer.start(boolean)[47].

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[48].

IllegalArgumentException when the start time of this timer is not an absolute time, or phasingPolicy is null.

Available since RTSJ 2.0

getClock

Signature

public javax.realtime.Clock
getClock()
throws IllegalStateException

Description

Each instance can only be associated with a single clock, which this method can obtain.

Throws

IllegalStateException when this has been destroyed.

Returns

the instance of Clock[49] that is associated with this.

Available since RTSJ 1.0.1

[46] Section 5.3.1.1
[47] Section 10.3.2.6.2
[48] Section 5.3.1.1.1
[49] Section 10.3.2.1

createReleaseParameters

Signature

public javax.realtime.ReleaseParameters<?>
createReleaseParameters()

Description

Create a release parameters object with new objects containing copies of the values corresponding to this timer. When the PeriodicTimer interval is greater than 0, create a PeriodicParameters[50] 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, create an AperiodicParameters[51] object, since in this case the timer behaves like a OneShotTimer[52].

When this timer is active, then the start time is the next firing (or skipping) time returned as an AbsoluteTime[53]. Otherwise, the start time is the initial firing (or skipping) time, as set by the last call to Timer.reschedule[54], or when there was no such call, by the constructor of this timer.

Throws

IllegalStateException 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, return a new instance of PeriodicParameters[55]. When the interval is zero return a new instance of AperiodicParameters[56].

getFireTime

Signature

public javax.realtime.AbsoluteTime
getFireTime()
throws ArithmeticException,
IllegalStateException

[50] Section 6.3.3.6
[51] Section 6.3.3.2
[52] Section 10.3.2.2
[53] Section 9.3.1.1
[54] Section 10.3.2.6.2
[55] Section 6.3.3.6
[56] Section 6.3.3.2

Description

Get 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 of the firing. When the PeriodicTimer is *not-active* it throws IllegalStateException.

Throws

ArithmeticException when the result does not fit in the normalized format.

IllegalStateException 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[57] object. When the timer has been created or rescheduled (see Timer.reschedule(HighResolutionTime)[58]) 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

Get 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 of the firing. When the PeriodicTimer is *not-active* it throws IllegalStateException.

Parameters

dest The instance of AbsoluteTime[59] 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.

IllegalStateException when this Timer has been *destroyed*, or when it is *not-active*.

[57] Section 9.3.1.1
[58] Section 10.3.2.6.2
[59] Section 9.3.1.1

Returns

The instance of AbsoluteTime[60] 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)[61]) 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.

Available since RTSJ 1.0.1

getInterval

Signature

public javax.realtime.RelativeTime
getInterval()

Description

Gets the interval of this Timer.

Throws

IllegalStateException when this Timer has been *destroyed*.

Returns

The RelativeTime instance assigned as this periodic timer's interval by the constructor or setInterval(RelativeTime)[62].

setInterval(RelativeTime)

Signature

public javax.realtime.PeriodicTimer
setInterval(RelativeTime interval)

Description

Reset the interval value of this.

[60] Section 9.3.1.1
[61] Section 10.3.2.6.2
[62] Section 10.3.2.3.2

Parameters

interval A RelativeTime[63] 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 effects future fire (or skip) times after the next.

Throws

IllegalArgumentException 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.

IllegalStateException 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 rescheduled itself. Otherwise it does nothing.

Available since RTSJ 2.0 moved here from Timer, since OneShotTimer and PeriodicTimer have slightly different semantics.

10.3.2.4 TimeDispatcher

Inheritance

[63] Section 9.3.1.3

java.lang.Object
javax.realtime.ActiveEventDispatcher
javax.realtime.TimeDispatcher

Description

A dispatcher for time events: Timer[64] and RealtimeThread.sleep[65].

Available since RTSJ 2.0

10.3.2.4.1 Constructors

TimeDispatcher(SchedulingParameters, SchedulingGroup)

Signature

public
TimeDispatcher(SchedulingParameters schedule,
SchedulingGroup group)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

schedule give the parameters for scheduling this dispatcher

TimeDispatcher(SchedulingParameters)

Signature

public
TimeDispatcher(SchedulingParameters schedule)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

[64] Section 10.3.2.6
[65] Section 5.3.2.2.2

Parameters
schedule give the parameters for scheduling this dispatcher

10.3.2.4.2 Methods

register(Timable)

Signature

```
public void
register(Timable target)
throws RegistrationException,
       IllegalStateException,
       IllegalArgumentException
```

Description

Register a AsyncTimable[66] with this dispatcher.

Parameters
target to register
Throws
RegistrationException when target is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when target is not stopped.

deregister(Timable)

Signature

```
public void
deregister(Timable target)
throws DeregistrationException,
       IllegalStateException,
       IllegalArgumentException
```

Description

Deregister a AsyncTimable[67] from this dispatcher.

[66] Section 10.3.1.1
[67] Section 10.3.1.1

Parameters
target to deregister
Throws
DeregistrationException when target is not already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when target is not stopped.

destroy

Signature

public void
destroy()
throws IllegalStateException

Description

Release all resources thereby making the dispatcher unusable.

Throws
IllegalStateException when called on a dispatcher that has one or more registered AsyncTimable[68] objects.

10.3.2.5 TimeDispatcher.Runner

Inheritance
java.lang.Object
  java.lang.Thread
    javax.realtime.RealtimeThread
      javax.realtime.TimeDispatcher.Runner
Description

10.3.2.5.1 Methods

---

[68] Section 10.3.1.1

run

Signature

public void
run()

Description

10.3.2.6 Timer

Inheritance

java.lang.Object
javax.realtime.AsyncBaseEvent
javax.realtime.AsyncEvent
javax.realtime.Timer

Interfaces

javax.realtime.AsyncTimable
javax.realtime.ActiveEvent

Description

A *timer* is a timed event that measures time according to a given Clock[69]. This class defines basic functionality available to all timers. Applications will generally use either PeriodicTimer[70] to create an event that is fired repeatedly at regular intervals, or OneShotTimer[71] for an event that just fires once at a specific time. A timer is always associated with at least one Clock[72], 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.

10.3.2.6.1 Constructors

---

[69] Section 10.3.2.1
[70] Section 10.3.2.3
[71] Section 10.3.2.2
[72] Section 10.3.2.1

Timer(HighResolutionTime, TimeDispatcher)

Signature

protected
Timer(javax.realtime.HighResolutionTime<?> time,
TimeDispatcher dispatcher)
throws IllegalArgumentException,
UnsupportedOperationException,
IllegalAssignmentError

Description

Create a timer that fires according to the given time based on the Clock[73] associated with time and is dispatched by the specified dispatcher.

Available since version 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

IllegalArgumentException when time is a negative RelativeTime value.

UnsupportedOperationException when time has a Chronograph[74] is not a clock.

IllegalAssignmentError when this Timer cannot hold references to handler and clock.

Timer(HighResolutionTime)

Signature

protected
Timer(javax.realtime.HighResolutionTime<?> time)

[73]Section 10.3.2.1
[74]Section 10.3.1.2

throws IllegalArgumentException,
UnsupportedOperationException,
IllegalAssignmentError

Description

Create a timer that fires according to the given time based on the Clock[75] associated with time and is dispatched by the system default dispatcher.

This is equivalent to Timer(time, null).

Available since version 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().

Throws

IllegalArgumentException when time is a negative RelativeTime value.

UnsupportedOperationException when time has a Chronograph[76] is not a clock.

IllegalAssignmentError when this Timer cannot hold references to handler and clock.

Timer(HighResolutionTime, Clock, AsyncEventHandler)

Signature

protected
Timer(javax.realtime.HighResolutionTime<?> time,
Clock clock,
AsyncEventHandler handler)
throws IllegalArgumentException,
UnsupportedOperationException,
IllegalAssignmentError

Description

Create a timer that fires according to the given time, which must be based on the supplied Clock[77] clock (if any), and is handled by the specified AsyncEvent-

[75] Section 10.3.2.1
[76] Section 10.3.1.2
[77] Section 10.3.2.1

Handler[78] 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 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().

clock The clock on which to base this timer. When null, the clock associated with time 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

IllegalArgumentException when time is a negative RelativeTime value or the supplied clock is not the Clock associated with time.

UnsupportedOperationException when time has a Chronograph[79] that is not an instance of Clock.

IllegalAssignmentError when this Timer cannot hold references to handler and clock.

10.3.2.6.2 Methods

---

getClock

Signature

public javax.realtime.Clock
getClock()
throws IllegalStateException

Description

Return the instance of Clock[80] on which this timer is based.

Throws

[78] Section 8.3.3.5
[79] Section 10.3.1.2
[80] Section 10.3.2.1

IllegalStateException when this Timer has been *destroyed*.

Returns
The instance of Clock[81] associated with this Timer.

getStart

Signature

```
public javax.realtime.HighResolutionTime<?>
getStart()
```

Description

Get 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 effect 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 IllegalStateException,
       ArithmeticException
```

Description

Return a newly-created time representing the time the timer actually started, or when the timer has been rescheduled, the effective start time after the reschedule.

Throws
IllegalStateException 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.

Available since RTSJ 2.0

[81] Section 10.3.2.1

getEffectiveStartTime(AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
getEffectiveStartTime(AbsoluteTime dest)
throws IllegalStateException,
ArithmeticException

Description

Update dest to represent the time the timer actually started, or when the timer has been rescheduled, the effective start time after the reschedule. When dest is null, behave as if getEffectiveStartTime()[82] had been called.

Parameters

dest a place to store the time this actually started.

Throws

IllegalStateException when the timer is not active or has been destroyed.

ArithmeticException when the result does not fit in the normalized format.

Returns

The time the timer actually started, or when it has been rescheduled, the effective start time after the reschedule.

Available since RTSJ 2.0

getLastReleaseTime

Signature

public final javax.realtime.AbsoluteTime
getLastReleaseTime()

Description

Get the last release time of this timer.

Throws

IllegalStateException when this timer has not been released since it was last started.

Returns

[82] Section 10.3.2.6.2

a reference to a newly-created AbsoluteTime[83] object representing this timer's last release time. When the timer has not been released since it was last started, throw an exception.

Available since RTSJ 2.0

getLastReleaseTime(AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
getLastReleaseTime(AbsoluteTime dest)

Description

Returns

When dest is null, return a reference to a newly-created AbsoluteTime[84] object representing this timer's last release time. When dest is non-null, set dest to this timer's last release time. When the timer has not been released, return null. Since RTSJ 2.0

getFireTime

Signature

public javax.realtime.AbsoluteTime
getFireTime()
throws IllegalStateException,
ArithmeticException

Description

Get the time at which this Timer is expected to fire. When the Timer is *disabled*, the returned time is that of the skipping of the firing. When the Timer is *not-active* it throws IllegalStateException.

Throws

ArithmeticException when the result does not fit in the normalized format.

IllegalStateException when this Timer has been *destroyed*, or when it is *not-active*.

[83] Section 9.3.1.1
[84] Section 9.3.1.1

Returns

The absolute time at which this is expected to fire (release handlers or skip), in a newly allocated AbsoluteTime[85] object. When the timer has been created or re-scheduled (see Timer.reschedule[86]) 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 IllegalStateException,
       ArithmeticException
```

Description

Get the time at which this Timer is expected to fire. When the Timer is *disabled*, the returned time is that of the skipping of the firing. When the Timer is *not-active* it throws IllegalStateException.

Parameters

dest The instance of AbsoluteTime[87] 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.

IllegalStateException when this Timer has been *destroyed*, or when it is *not-active*.

Returns

The instance of AbsoluteTime[88] 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[89]) using an instance of RelativeTime for its time parameter then it will return the sum of the current time and the RelativeTime remaining time

[85] Section 9.3.1.1
[86] Section 10.3.2.6.2
[87] Section 9.3.1.1
[88] Section 9.3.1.1
[89] Section 10.3.2.6.2

before the timer is expected to fire. The clock association of the returned time is the clock on which this timer is based.

Available since RTSJ 1.0.1

getDispatcher

Signature

public javax.realtime.TimeDispatcher
getDispatcher()

Description

Get the dispatcher associated with this Timable.

Available since RTSJ 2.0

isActive

Signature

public boolean
isActive()

Description

Determine the activation state of this happening, i.e., it has been started.

Returns

true when active, false otherwise.

isRunning

Signature

public boolean
isRunning()
throws IllegalStateException

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 answer the question *"Is firing expected?"*.

Throws
IllegalStateException when this Timer has been *destroyed*.

Returns
true when the timer is *active* and *enabled*; oyherwise 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 IllegalStateException

Description
Replaced by AsyncBaseEvent.handledBy(AsyncBaseEventHandler)[90]

Parameters
handler to add to the Timer
Throws
IllegalStateException when this Timer has been *destroyed*.

Returns
true when handler is associated with this, otherwise false.

Available since RTSJ 1.0.1

createReleaseParameters

Signature
public javax.realtime.ReleaseParameters<?>
createReleaseParameters()
throws IllegalStateException

Description
Create a ReleaseParameters[91] object appropriate to the timing characteristics of this event. The default is the most pessimistic: AperiodicParameters[92]. This is

[90] Section 8.3.3.2.1
[91] Section 6.3.3.10
[92] Section 6.3.3.2

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
IllegalStateException when this Timer has been *destroyed*.

Returns
A newly created ReleaseParameters[93] object.

enable

Signature

public void
enable()
throws IllegalStateException

Description

Re-enable this timer after it has been *disabled*. (See Timer.disable()[94].) When the Timer is already *enabled*, this method does nothing. When the Timer is *not-active*, this method does nothing.

Throws
IllegalStateException when this Timer has been *destroyed*.

disable

Signature

public void
disable()
throws IllegalStateException

Description

Disable 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

[93] Section 6.3.3.10
[94] Section 10.3.2.6.2

subsequently re-*enabled* before its fire time and 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
IllegalStateException when this Timer has been *destroyed*.

start

Signature
public void
start()
throws IllegalStateException

Description

Start this timer. A timer starts measuring time from when it is started; this method makes the timer *active* and *enabled*.

Throws
IllegalStateException when this Timer has been *destroyed*, or when this timer is already *active*.

start(boolean)

Signature
public void
start(boolean disabled)
throws IllegalStateException

Description

Start this timer. A timer starts measuring time from when it is started. When disabled is true start 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

IllegalStateException when this Timer has been *destroyed*, or when this timer is *active*.

Available since RTSJ 1.0.1

stop

Signature

public boolean
stop()
throws IllegalStateException

Description

Stops a timer when it is *active* and changes its state to *inactive* and *disabled*.

Throws

IllegalStateException when this Timer has been *destroyed*.

Returns

true when this was *enabled* and false otherwise.

reschedule(HighResolutionTime)

Signature

public void
reschedule(javax.realtime.HighResolutionTime<?> time)
throws IllegalStateException,
IllegalArgumentException

Description

Change 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

IllegalArgumentException when time is a negative RelativeTime value.

IllegalStateException 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 unusual, but it enables the accommodation of difference kinds of clocks and as a possible resource allocation strategy. Consider a realtime system where the natural events of the system have different tolerances for jitter. Assume the system functions properly if event A is triggered within plus or minus 100 seconds of the actual time it should occur but event B must be triggered within 100 microseconds of its actual time. Further assume, without loss of generality, that events A and B are periodic. An application could then create two instances of PeriodicTimer based on two clocks. The timer for event B should be based on a Clock which checks its queue at least every 100 microseconds but the timer for event A could be based on a Clock that checked its queue only every 100 seconds. This use of two clocks reduces the queue size of the accurate clock and thus queue management overhead is reduced.

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: getDrivePrecission() and getQueryPrecission 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. For most realtime systems, a single heap with a deterministic garbage collector is usually also sufficient. For 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 is managing the allocation area that will be used when the thread/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.

Stacked Memory

RTSJ 2.0, 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.

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 a 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.

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. 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 instances that is active,
3. it contains a firable asynchronous event handlers[1],
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

[1]Defined in Section 8.1

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.

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.

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.

Scope Stack — A sequence of the memory areas the 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.

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 3.2.2.3 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 the class description and the constructor, method, and field detail sections further on.

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. The linear time attribute requires that, ignoring performance variations due to hardware caches or similar optimizations and ignoring execution time of any static initializers, the execution time of new must 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.

3. 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.
4. 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.
5. 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*.
6. 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.
7. 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 schedulables, 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.
8. The scope stack is accessible through a set of static methods on RealtimeThread. These methods allow outer allocation contexts to be accessed by their index number. Memory areas on a scope stack may be referred to as *inner* or *outer* relative to other entries in that scope stack. An "outer scope" is further from the current allocation context on the current scope stack and has a lower index.
9. The executeInArea, newInstance and newArray methods, when invoked on

an instance of ScopedMemory require that instance to be an outer allocation context on the current schedulable object's current scope stack.

10. An instance of ScopedMemory is said to be *in use* if it has a positive reference count as defined by semantic 17 below.

11.2.3 The Parent Scope

The following requirements apply to a scope's parent.

11. 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.
12. Instances of ScopedMemory must satisfy the *single parent rule*, which requires that each scoped memory has a unique parent as defined in semantic 11.

11.2.4 Memory Areas and Schedulables

The following requirements govern the relationship between memory and execution.

13. Pushing a scoped memory onto a scope stack is always subject to the single parent rule.
14. 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.
15. 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.
16. 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 15 applies even during execution of these methods.

11.2.5 Scoped Memory Reference Counting

The following requirements apply to references to scoped memory.

17. 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 contexts* or more exactly, the reference count is the number of causes for memory area to be an execution context.
18. 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).
19. 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.
20. 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 19 above applies.

21. 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.
22. 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.
23. 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.
24. 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.

11.2.6 Immortal Memory

The following requirements apply to immortal memory.

25. 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.
26. 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.
27. 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.

28. 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.

11.2.7 Maintaining Referential Integrity

The following rules apply to references to objects in scoped memory.

29. 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. For this table, ImmortalMemory and ImmortalPhysicalMemory are equivalent, and all subclasses of ScopedMemory are equivalent.

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**
Heap	Permit	Permit	Forbid	Permit
Immortal	Permit	Permit	Forbid	Permit
Scoped	Permit	Permit	Permit from same or less deeply nested scope	Permit
Local Variable	Permit	Permit	Permit	Permit

30. 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.

11.2.8 Object Initialization

The following requirements apply to object initialization.

31. 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.

11.2.9 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 static method getOuterMemoryArea(int) on RealtimeThread.

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 allocation 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 $A \rightarrow B \rightarrow C \rightarrow D$.

   Note that in the last case, when the initial memory area is a scope already in a scoped stack created by adding the initial memory area to the current stack of the handler at the time the release happend, a ScopedCycleException will be thrown at release time and the code in the handler will not be executed for that release.
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 object 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, m, is entered by calling m's executeInArea method or one of the m.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.

11.2.10 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
```

11.2.11 The executeInArea or newInstance Methods

For ma.executeInArea(logic), ma.newInstance(), or ma.newArray():

```
1  when ma is an instance of heap immortal or ImmortalPhysicalMemory,
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
```

11.2.12 Constructor Methods for Schedulables

For construction of a schedulable in memory area cma with initial memory area of ima:

```
1  if cma is heap, immortal or ImmortalPhysicalMemory,
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.

11.2.13 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., was entered from ImmortalMemory or Heap, 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.

Except for the primordial scope, which represents heap, immortal and immortal physical memory, 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 "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.

11.2.14 Scope Tree Maintenance

The single parent rule is enforced effectively as if there were a tree with the primordial scope (representing heap, immortal, and immortal physical memory) at its root, and other nodes corresponding to every scoped memory area that is currently on any schedulable's scope 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 realtime thread 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 is in a scope stack. Since it is possible for more than one schedulable to have the same explicit initial memory area, the memory are must behave as if a reference count for reservation is also maintained.

11.2.14.1 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 scope stack do 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
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   if s is an instance of scopedMemory
5   return s return primordial scope
6 }
```

11.2.14.2 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 = noParent
```

11.2.14.3 Reservation Management

Reservation management is separate from managing the scope stack for a task. When a realtime thread with an explicit initial scoped memory area (EISMA) is created or an ASEH with an EISMA is added to an ASE, 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 or an ASEH is removed from an ASE, 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.
```

11.2.15 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 distict 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 their 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 their 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 12.2.1).
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[2] or from some property file read at program initialization time.

[2]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/

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).

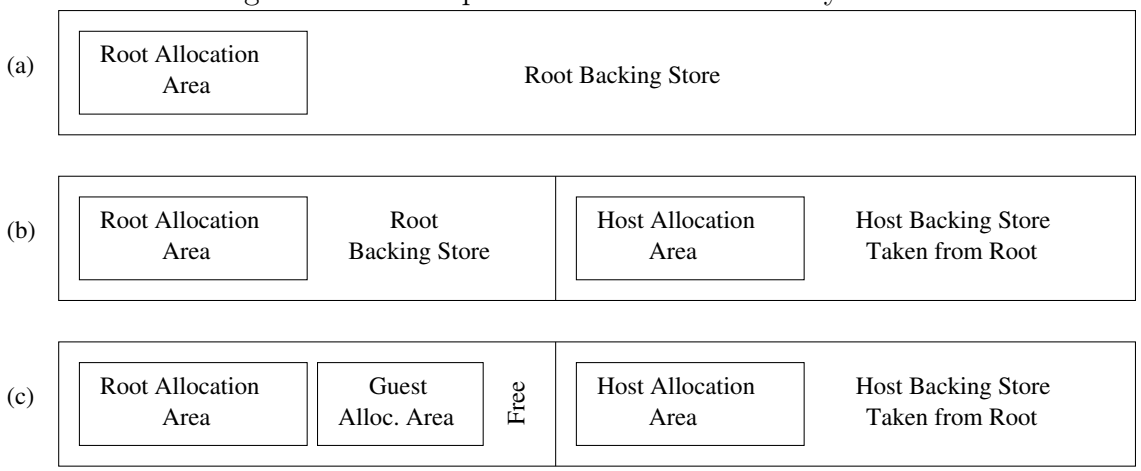
11.2.16 Stacked Memory

A StackedMemory area represents both an *allocation area* providing ScopedMemory semantics and an explicit *backing store* from which the 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.

StackedMemory backing stores are explicitly created and sized, and have well-defined lifetimes similar to objects in a ScopedMemory area. A StackedMemory object can be created as either a *host*, which has its own backing store, or a *guest*, which draws its allocation area directly from its parent's backing store. When a StackedMemory object is created in an allocation context other than StackedMemory, it is necessarily a host and is called a *root* StackedMemory. In this case, its backing store is drawn from a notional global backing store. 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 if this occurs. When a StackedMemory object is created in another StackedMemory's allocation context, it may be created as either a host or guest, as illustrated in Figure 11.1. When it is created as a host, its backing store is drawn from its parent area's backing store, and its allocation area is created in the newly-divided backing store. When it is created as a guest, its allocation area is created in its parent's backing store.

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

Figure 11.1: Manipulation of StackedMemory Areas



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 re-partitioned 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

1. a nonroot 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 StackedMemory area may have at most one direct child in the scope stack that is a guest StackedMemory area;
3. a guest StackedMemory area may not have a direct child area that is a host StackedMemory area;
4. a host StackedMemory object cannot be created from another StackedMemory allocation context unless its backing store is allocated from that area's backing store; and
5. a StackedMemory's allocation area cannot be resized if there are unfinalized guest StackedMemory allocation areas placed after it in the same backing store.

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. (Implementations may require a constant amount of

overhead, drawn from the backing store, for each StackedMemory area created in the store.)

```
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 notional 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.

11.3 javax.realtime

11.3.1 Interfaces

11.3.1.1 MemoryAreaVisitor

Description

This interface is used to visit memory areas. For example, the method MemoryArea.visitNestedMemory[3] uses this visitor to process all memory areas nested the area upon which it is called.

11.3.1.1.1 Methods

---

visit(MemoryArea)

Signature

public R
visit(MemoryArea memory)

Description

Visit the members of a collection of memory areas. It provides a means of accessing all live scopes contained in a memory area, even those to which no reference exits, such a javax.realtime.memory.PinnableMemory[4] that is pinned or another 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.

Parameters

memory The memory area being visited.

Returns

Any object declared by the application or null. When visit returns an object, no more memory areas are visited and the MemoryArea.visitNestedMemory[5] method returns the object returned by visit(MemoryArea)[6].

[3]Section 11.3.3.3.2
[4]Section 11.4.3.5
[5]Section 11.3.3.3.2
[6]Section 11.3.1.1.1

11.3.2 Exceptions

11.3.2.1 ConstructorCheckedException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.ReflectiveOperationException
        java.lang.InstantiationException
          javax.realtime.ConstructorCheckedException

Description

To throw when MemoryArea.newInstance[7] causes the constructor of the new instance to throw a checked exception.

Available since RTSJ 2.0

11.3.2.1.1 Constructors

ConstructorCheckedException(Throwable)

Signature

public
ConstructorCheckedException(Throwable cause)

Description

A constructor that can carry the original checked exception

Parameters

cause is the original checked exception.

[7] Section 11.3.3.3.2

11.3.3 Classes

11.3.3.1 HeapMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.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.

11.3.3.1.1 Methods

---

enter

Signature

public void
enter()

Description

Associate 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[8]) or the enter method exits.

Throws

IllegalThreadStateException when the caller is a Java thread.

IllegalArgumentException IllegalArgumentException 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.

[8]Section 11.3.3.1.1

enter(Runnable)

Signature

public void
enter(Runnable logic)

Description

Associate 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[9]) 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.

IllegalThreadStateException IllegalThreadStateException when the caller is a Java thread.

IllegalArgumentException IllegalArgumentException 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[10] representing the Java heap. The singleton instance of this class shall be allocated in the ImmortalMemory[11] area.

Returns

The singleton HeapMemory[12] object.

[9] Section 11.3.3.1.1
[10] Section 11.3.3.1
[11] Section 11.3.3.2
[12] Section 11.3.3.1

executeInArea(Runnable)

Signature

public void
executeInArea(Runnable logic)

Description

Execute 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

IllegalArgumentException 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

Allocate an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

type 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 number The number of elements in the new array.

Throws

MemoryAccessError when caller is a schedulable which may not use the heap.

IllegalArgumentException IllegalArgumentException when number is less than zero, type is null, or type is java.lang.Void.TYPE.

OutOfMemoryError OutOfMemoryError 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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters
type type The class of which to create a new instance.
Throws
MemoryAccessError when caller is a schedulable which may not use the heap.
IllegalAccessException IllegalAccessException The class or initializer is inaccessible.
IllegalArgumentException IllegalArgumentException when type is null.
ExceptionInInitializerError ExceptionInInitializerError when an unexpected exception has occurred in a static initializer.
OutOfMemoryError OutOfMemoryError when space in the memory area is exhausted.
InstantiationException 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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

c Tc The constructor for the new instance.

args args An array of arguments to pass to the constructor.

Throws

MemoryAccessError when caller is a schedulable which may not use the heap.

IllegalAccessException IllegalAccessException when the class or initializer is inaccessible under Java access control.

InstantiationException InstantiationException when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

OutOfMemoryError OutOfMemoryError when space in the memory area is exhausted.

IllegalArgumentException IllegalArgumentException 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 InvocationTargetException when the underlying constructor throws an exception.

Returns

A new instance of the object constructed by c.

visitNestedMemory(MemoryAreaVisitor)

Signature

public R
visitNestedMemory(javax.realtime.MemoryAreaVisitor<R> visitor)

Description

Visit each scoped memory area who's parent is the primordial scope and was created in heap memory.

Parameters

visitor invoke the MemoryAreaVisitor.visit(MemoryArea)[13] method for each member of the set of scoped memory areas that was created in heap memory and has the primordial scope as its parent.

Throws

IllegalArgumentException IllegalArgumentException when visitor is null.

Returns

null when all elements where visited and some object of type R when the visit is forced to terminate at the end of visiting that element.

11.3.3.2 ImmortalMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.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[14], javax.realtime.memory.StackedMemory[15], or javax.realtime.memory.PinnableMemory[16].

Objects in immortal 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.

11.3.3.2.1 Methods

---

[13] Section 11.3.1.1.1
[14] Section 11.4.3.1
[15] Section 11.4.3.7
[16] Section 11.4.3.5

instance

Signature

public static javax.realtime.ImmortalMemory
instance()

Description

Returns a pointer to the singleton ImmortalMemory[17] object.

Returns

The singleton ImmortalMemory[18] object.

executeInArea(Runnable)

Signature

public void
executeInArea(Runnable logic)

Description

Execute 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

IllegalArgumentException when logic is null.

visitNestedMemory(MemoryAreaVisitor)

Signature

public R
visitNestedMemory(javax.realtime.MemoryAreaVisitor<R> visitor)

Description

Visit each scoped memory area who's parent is the primordial scope and was created in this memory area.

[17] Section 11.3.3.2
[18] Section 11.3.3.2

Parameters

visitor invoke the MemoryAreaVisitor.visit(MemoryArea)[19] method for each member of the set of scoped memory areas that was created in this immortal memory area and has the primordial scope as its parent.

Throws

IllegalArgumentException IllegalArgumentException when visitor is null.

Returns

null when all elements where visited and some object of type R when the visit is forced to terminate at the end of visiting that element.

11.3.3.3 MemoryArea

Inheritance

java.lang.Object
  javax.realtime.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.

11.3.3.3.1 Constructors

MemoryArea(long, Runnable)

Signature

```
protected
MemoryArea(long size,
           Runnable logic)
```

[19] Section 11.3.1.1.1

throws IllegalArgumentException,
OutOfMemoryError,
IllegalAssignmentError

Description

Create an instance of MemoryArea.

Parameters

size The size of MemoryArea to allocate, in bytes.

logic The run() method of this object will be called whenever enter()[20] is called. When logic is null, this constructor is equivalent to MemoryArea(long size).

Throws

IllegalArgumentException when the size parameter is less than zero.

OutOfMemoryError when there is insufficient memory for the MemoryArea object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

MemoryArea(SizeEstimator, Runnable)

Signature

protected
MemoryArea(SizeEstimator size,
Runnable logic)
throws IllegalArgumentException,
OutOfMemoryError,
IllegalAssignmentError

Description

Equivalent to MemoryArea(long, Runnable)[21] with the argument list (size.getEstimate(), logic).

Parameters

size A SizeEstimator object which indicates the amount of memory required by this MemoryArea.

[20] Section 11.3.3.3.2
[21] Section 11.3.3.3.1

logic The run() method of this object will be called whenever enter()[22] is called. When logic is null, this constructor is equivalent to MemoryArea(SizeEstimator size).

Throws

IllegalArgumentException when size is null or size.getEstimate() is negative.

OutOfMemoryError when there is insufficient memory for the MemoryArea object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

MemoryArea(long)

Signature

protected
MemoryArea(long size)
throws IllegalArgumentException,
OutOfMemoryError

Description

Equivalent to MemoryArea(long, Runnable)[23] with the argument list (size, null).

Parameters

size The size of MemoryArea to allocate, in bytes.

Throws

IllegalArgumentException when size is less than zero.

OutOfMemoryError when there is insufficient memory for the MemoryArea object or for the backing memory.

MemoryArea(SizeEstimator)

Signature

protected
MemoryArea(SizeEstimator size)

[22]Section 11.3.3.3.2
[23]Section 11.3.3.3.1

throws IllegalArgumentException,
OutOfMemoryError

Description

Equivalent to MemoryArea(long, Runnable)[24] with the argument list (size.getEstimate(), null).

Parameters

size A SizeEstimator[25] object which indicates the amount of memory required by this MemoryArea.

Throws

IllegalArgumentException when the size parameter is null, or size.getEstimate() is negative.

OutOfMemoryError when there is insufficient memory for the MemoryArea object or for the backing memory.

11.3.3.3.2 Methods

---

enter

Signature

public void
enter()
throws IllegalArgumentException,
OutOfMemoryError,
IllegalAssignmentError,
MemoryAccessError

Description

Associate 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[26]) or the enter method exits.

[24] Section 11.3.3.3.1
[25] Section 11.3.3.5
[26] Section 11.3.3.3.2

Throws

IllegalThreadStateException when the caller is a Java thread.

IllegalArgumentException 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[27], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[28] instance is preallocated by the VM to avoid cascading creation of ThrowBoundaryError[29].

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

Associate 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[30]) or the enter method exits.

Parameters

logic The Runnable object whose run() method should be invoked.

Throws

IllegalThreadStateException when the caller is a Java thread.

IllegalArgumentException 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[31], so

[27] Section 15.2.3.2
[28] Section 15.2.3.8
[29] Section 15.2.3.8
[30] Section 11.3.3.3.2
[31] Section 15.2.3.2

the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[32] 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)[33] except that the executed method is called get and an object is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

enter(BooleanSupplier)

Signature

public boolean
enter(BooleanSupplier logic)

Description

Same as enter(Runnable)[34] except that the executed method is called get and a boolean is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

[32]Section 15.2.3.8
[33]Section 11.3.3.3.2
[34]Section 11.3.3.3.2

enter(IntSupplier)

Signature

public int
enter(IntSupplier logic)

Description

Same as enter(Runnable)[35] except that the executed method is called get and an int is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

enter(LongSupplier)

Signature

public long
enter(LongSupplier logic)

Description

Same as enter(Runnable)[36] except that the executed method is called get and a long is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

enter(DoubleSupplier)

Signature

public double
enter(DoubleSupplier logic)

Description

[35] Section 11.3.3.3.2
[36] Section 11.3.3.3.2

Same as enter(Runnable)[37] except that the executed method is called get and a double is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

getMemoryArea(Object)

Signature

public static javax.realtime.MemoryArea
getMemoryArea(Object object)

Description

Gets the MemoryArea in which the given object is located.

Throws
IllegalArgumentException 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.

[37] Section 11.3.3.3.2

memoryRemaining

Signature

public long
memoryRemaining()

Description

An approximation to 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 IllegalArgumentException,
OutOfMemoryError,
SecurityException

Description

Allocate 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 when number is less than zero, type is null, or type is java.lang.Void.TYPE.

OutOfMemoryError when space in the memory area is exhausted.

SecurityException when the caller does not have permission to create a new instance.

Returns

A new array of class type, of number elements.

newInstance(Class)

Signature

public T
newInstance(java.lang.Class<T> type)
throws IllegalAccessException,
IllegalArgumentException,
InstantiationException,
OutOfMemoryError,
ExceptionInInitializerError,
SecurityException

Description

Allocate 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 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.

OutOfMemoryError when space in the memory area is exhausted.

ExceptionInInitializerError when an unexpected exception has occurred in a static initializer.

SecurityException 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,
IllegalArgumentException,
InstantiationException,
InvocationTargetException,
OutOfMemoryError,
SecurityException

Description

Allocate 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.

IllegalArgumentException 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.

OutOfMemoryError when space in the memory area is exhausted.

SecurityException 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

Query 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 IllegalArgumentException

Description

Execute 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
IllegalArgumentException when logic is null.

executeInArea(Supplier)

Signature

public T
executeInArea(java.util.function.Supplier<T> logic)

Description

Same as executeInArea(Runnable)[38] except that the executed method is called get and an object is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

[38]Section 11.3.3.3.2

executeInArea(BooleanSupplier)

Signature

public boolean
executeInArea(BooleanSupplier logic)

Description

Same as executeInArea(Runnable)[39] except that the executed method is called get and a boolean is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

executeInArea(IntSupplier)

Signature

public int
executeInArea(IntSupplier logic)

Description

Same as executeInArea(Runnable)[40] except that the executed method is called get and an int is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

executeInArea(LongSupplier)

Signature

public long
executeInArea(LongSupplier logic)

Description

[39] Section 11.3.3.3.2
[40] Section 11.3.3.3.2

Same as executeInArea(Runnable)[41] except that the executed method is called get and a long is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

executeInArea(DoubleSupplier)

Signature

public double
executeInArea(DoubleSupplier logic)

Description

Same as executeInArea(Runnable)[42] except that the executed method is called get and a double is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

visitNestedMemory(MemoryAreaVisitor)

Signature

public R
visitNestedMemory(javax.realtime.MemoryAreaVisitor<R> visitor)
throws IllegalArgumentException

Description

A means of accessing all live nested memory areas contained in this memory area, even those to which no reference exits, such a javax.realtime.memory.PinnableMemory[43] 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 guarantees even when the set is disturbed by other tasks:

[41] Section 11.3.3.3.2
[42] Section 11.3.3.3.2
[43] Section 11.4.3.5

- 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.

Perform an action on all children scopes of this memory area, so long as the MemoryAreaVisitor.visit(MemoryArea)[44] method returns null. When that method returns an object, the visit is terminated and that object is returned by this method,

When execution of the visitor's visit method 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
IllegalArgumentException when visitor is null.

Returns
null when all elements where visited and some object of type R when the visit is forced to terminate at the end of visiting that element.

mayHoldReferenceTo

Signature

public boolean
mayHoldReferenceTo()

Description

Determine 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.

mayHoldReferenceTo(Object)

Signature

[44]Section 11.3.1.1.1

public boolean
mayHoldReferenceTo(Object value)

Description

Determine whether an object A allocated in the memory area represented by this can hold a reference to the object value.

Parameters
value is the object to test.
Returns
true when value can be assigned to a field of A, otherwise false.

11.3.3.4 MemoryParameters

Inheritance
java.lang.Object
javax.realtime.MemoryParameters
Interfaces
Cloneable
Serializable
Description

Memory parameters can be given on the constructor of RealtimeThread[45] and AsyncEventHandler[46]. These can be used both for the purposes of admission control by the scheduler and for the purposes of pacing the garbage collector (if any) to satisfy all of the schedulable memory allocation rates.

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 object allocation throws an OutOfMemoryError.

When a reference to a MemoryParameters object is given as a parameter to a constructor, the MemoryParameters object becomes bound to the object being created. Changes to the values in the MemoryParameters object affect the constructed object. When given to more than one constructor, then changes to the values in the MemoryParameters object affect *all* of the associated objects. Note that this is a one-to-many relationship and *not* a many-to-many.

[45]Section 5.3.2.2
[46]Section 8.3.3.5

A MemoryParameters object may be shared, 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.

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

11.3.3.4.1 Fields

NO_MAX

public static final NO_MAX

Description

Specifies no maximum limit.

11.3.3.4.2 Constructors

MemoryParameters(long, long, boolean)

Signature

public
MemoryParameters(long maxMemoryArea,
long maxImmortal,
boolean mayUseHeap)

Description

Create a MemoryParameters object with the given values.

Available since RTSJ 2.0

Parameters

maxMemoryArea A limit on the amount of memory the schedulable may allocate in its initial memory area. Units are in bytes. When zero, no allocation allowed in the memory area. To specify no limit, use NO_MAX.

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 NO_MAX.

mayUseHeap indicates whether or not the schedulable may use the heap. The default is true when an instance of this class is not provided.

Throws

IllegalArgumentException when any value other than positive. zero, or NO_MAX is passed as the value of maxMemoryArea or maxImmortal.

MemoryParameters(long, long, long)

Signature

public
MemoryParameters(long maxMemoryArea,
long maxImmortal,
long allocationRate)

Description

Create a MemoryParameters object with the given values and mayUseHeap[47] returns true.

Parameters

maxMemoryArea A limit on the amount of memory the schedulable may allocate in its initial memory area. Units are in bytes. When zero, no allocation allowed in the memory area. To specify no limit, use NO_MAX.

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 NO_MAX.

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 NO_MAX. 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 non-zero allocation rate limits as NO_MAX.

Throws

IllegalArgumentException when any value other than positive. zero, or NO_MAX is passed as the value of maxMemoryArea or maxImmortal, or allocationRate.

[47] Section 11.3.3.4.3

MemoryParameters(long, long)

Signature

public
MemoryParameters(long maxMemoryArea,
long maxImmortal)

Description

Create a MemoryParameters object with the given values and mayUseHeap[48] returns false.

Parameters

maxMemoryArea A limit on the amount of memory the schedulable may allocate in its initial memory area. Units are in bytes. When zero, no allocation allowed in the memory area. To specify no limit, use NO_MAX.

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 NO_MAX.

Throws

IllegalArgumentException when any value other than positive. zero, or NO_MAX is passed as the value of maxMemoryArea or maxImmortal.

MemoryParameters(boolean)

Signature

public
MemoryParameters(boolean mayUseHeap)

Description

Create a MemoryParameters object with the given values.

Available since RTSJ 2.0

Parameters

mayUseHeap indicates whether or not the schedulable may use the heap. The default is true when an instance of this class is not provided.

[48] Section 11.3.3.4.3

11.3.3.4.3 Methods

clone

Signature

public java.lang.Object
clone()

Description

Return 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.
-

Available since RTSJ 1.0.1

getAllocationRate

Signature

public long
getAllocationRate()

Description

Gets 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 NO_MAX[49] then the allocation rate on the heap is uncontrolled.

getMaxImmortal

Signature

[49] Section 11.3.3.4.1

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 NO_MAX[50] then there is no limit for allocation in immortal memory.

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[51] then there is no limit for allocation in the initial memory area.

mayUseHeap

Signature

public boolean
mayUseHeap()

Description

Determine whether or not this parameter object specifies that the heap may be used.

Returns

true when heap may be used and false otherwise.

[50] Section 11.3.3.4.1
[51] Section 11.3.3.4.1

setAllocationRate(long)

Signature

public javax.realtime.MemoryParameters
setAllocationRate(long allocationRate)

Description

Sets the limit on the rate of allocation in the heap.

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

IllegalArgumentException when any value other than positive, zero, or NO_MAX is passed as the value of allocationRate.

Returns

this

11.3.3.5 SizeEstimator

Inheritance

java.lang.Object
javax.realtime.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)

See Section LTMemory.LTMemory(SizeEstimator)

11.3.3.5.1 Constructors

SizeEstimator

Signature

public
SizeEstimator()

Description

11.3.3.5.2 Methods

reserve(Class, int)

Signature

public void
reserve(java.lang.Class<?> c,
int number)

Description

Take into account additional number instances of Class c when estimating the size of the MemoryArea[52].

Parameters

[52] Section 11.3.3.3

c The class to take into account.

number The number of instances of c to estimate.

Throws

IllegalArgumentException when c is null.

Open issue 11.3.1

The 1.0.2 TCK allows a negative number of elements, but gives no indication of what effect it should have.

End of issue 11.3.1

reserve(SizeEstimator, int)

Signature

public void
reserve(SizeEstimator estimator,
int number)

Description

Take into account additional number instances of SizeEstimator size when estimating the size of the MemoryArea[53].

Parameters

estimator The given instance of SizeEstimator[54].

number The number of times to reserve the size denoted by estimator.

Throws

IllegalArgumentException when estimator is null.

reserve(SizeEstimator)

Signature

public void
reserve(SizeEstimator size)

Description

Take into account an additional instance of SizeEstimator size when estimating the size of the MemoryArea[55].

Parameters

[53]Section 11.3.3.3
[54]Section 11.3.3.5
[55]Section 11.3.3.3

size The given instance of SizeEstimator.
Throws
IllegalArgumentException when size is null.

reserveArray(int)

Signature

public void
reserveArray(int length)

Description

Take into account an additional instance of an array of length reference values when estimating the size of the MemoryArea[56].

Parameters
length The number of entries in the array.
Throws
IllegalArgumentException when length is negative.

Available since RTSJ 1.0.1

reserveArray(int, Class)

Signature

public void
reserveArray(int length,
java.lang.Class<?> type)

Description

Take into account an additional instance of an array of length primitive values when estimating the size of the MemoryArea[57].

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.

[56]Section 11.3.3.3
[57]Section 11.3.3.3

Throws

IllegalArgumentException when length is negative, or type does not represent a primitive type.

Available since RTSJ 1.0.1

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.

11.4 javax.realtime.memory

11.4.1 Interfaces

11.4.1.1 PhysicalMemoryCharacteristic

Description

A tagging interface used to identify physical memory characteristics. Applications can give names to regions of memory that are described by PhysicalMemoryRegion[58]. The names are defined by creating instances of this interface. For example, final static PhysicalMemoryCharacteristic STATIC_RAM = ...;

Available since RTSJ 2.0

11.4.2 Enumerations

11.4.2.1 PhysicalMemorySelector.CachingBehavior

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.memory.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.

11.4.2.1.1 Enumeration Constants

DISABLED

public static final DISABLED

Description

[58] Section 11.4.3.3

WRITE_THROUGH

public static final WRITE_THROUGH

Description

WRITE_BACK

public static final WRITE_BACK

Description

11.4.2.1.2 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

11.4.2.2 PhysicalMemorySelector.PagingBehavior

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.memory.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.

11.4.2.2.1 Enumeration Constants

DIRECT

public static final DIRECT

Description

FIXED

public static final FIXED

Description

SWAPPABLE

public static final SWAPPABLE

Description

11.4.2.2.2 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

11.4.3 Classes

11.4.3.1 LTMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.memory.ScopedMemory
      javax.realtime.memory.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 *initial* size. Execution time for allocation is allowed to vary when memory consumption is between the initial size and the maximum size for the area. Furthermore, the underlying system is not required to guarantee that memory between initial and maximum will always be available.

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[59]

[59] Section 6.3.1.3

instance which may not use the javax.realtime.HeapMemory[60] or to enter the memory area using the ScopedMemory.enter[61] method within such an instance.

Enough memory must be committed by the completion of the constructor to satisfy the initial memory requirement. (Committed means that this memory must always be available for allocation). The initial 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.

Note, to ensure that all requested memory is available set initial and maximum to the same value.

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

Available since RTSJ 2.0 moved to this package.

11.4.3.1.1 Constructors

LTMemory(long, Runnable)

Signature

```
public
LTMemory(long size,
         Runnable logic)
```

Description

[60] Section 11.3.3.1
[61] Section 11.4.3.6.1

Create a scoped memory of the given size and with the give logic to run upon entry when no other logic is given.

Available 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)[62].

Throws

IllegalArgumentException when size is less than zero.

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

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)[63] with argument list (size.getEstimate(), runnable).

Available since RTSJ 1.0.1

Parameters

size An instance of javax.realtime.SizeEstimator[64] used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

[62] Section 11.4.3.1.1
[63] Section 11.4.3.1.1
[64] Section 11.3.3.5

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)[65].

Throws

IllegalArgumentException when size is null.

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

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)[66] with the argument list ((size, null).

Available 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.

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

LTMemory(SizeEstimator)

Signature

public
LTMemory(SizeEstimator size)

[65] Section 11.4.3.1.1
[66] Section 11.4.3.1.1

Description

Equivalent to LTMemory(long, Runnable)[67] with argument list (size.getEstimate(), null).

Available since RTSJ 1.0.1

Parameters

size An instance of javax.realtime.SizeEstimator[68] 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.

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

11.4.3.1.2 Methods

---

toString

Signature

public java.lang.String
toString()

Description

Create a string representation of this object. The string is of the form
(LTMemory) Scoped memory # num
where num uniquely identifies the LTMemory area.

Returns

A string representing the value of this.

11.4.3.2 PhysicalMemoryFactory

Inheritance

[67] Section 11.4.3.1.1
[68] Section 11.3.3.5

java.lang.Object
javax.realtime.memory.PhysicalMemoryFactory

Description

Both associate memory ranges, in the form of PhysicalMemoryRegion[69] instances with physical memory characteristics in the form of PhysicalMemoryCharacteristic[70] instances, and create memory areas in those modules.

Each physical memory module can have more than one 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 create.

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 are may not span more than one physical memory module. To find a memory range that supports PMC A and PMC B uses set intersection modules(A) $
cap$ modules(B)

Available since RTSJ 2.0

11.4.3.2.1 Constructors

PhysicalMemoryFactory

Signature

public
PhysicalMemoryFactory()

Description

Create an empty factory, but when only one factor is required, use getDefault[71] instead.

[69] Section 11.4.3.3
[70] Section 11.4.1.1
[71] Section 11.4.3.2.2

11.4.3.2.2 Methods

getDefault

Signature

public static javax.realtime.memory.PhysicalMemoryFactory
getDefault()

Description

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

public void
associate(PhysicalMemoryCharacteristic name,
PhysicalMemoryRegion module)
throws IllegalArgumentException,
IllegalStateException

Description

Associates a programmer-defined name with a physical address range.

Parameters

name is the physical memory characteristic. e.g STATIC_RAM.

module is the object representing a range of contiguous physical addresses

Throws

IllegalArgumentException when either name or module is null

IllegalStateException when module overlaps a previously associated PhysicalMemoryRegion instance.

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

public void
associate(javax.realtime.memory.PhysicalMemoryCharacteristic[] names,
PhysicalMemoryRegion module)
throws IllegalArgumentException,
IllegalStateException

Description

Associates am array of programmer-defined names with a physical address range.

Parameters

names is the array of physical memory characteristics. e.g { STATIC_RAM }.

module is the object representing a range of contiguous physical addresses

Throws

IllegalArgumentException when either names or module is null

IllegalStateException when module overlaps a previously associated PhysicalMemoryRegion instance.

associate(PhysicalMemoryCharacteristic, PhysicalMemoryRegion)

Signature

public static void
associate(PhysicalMemoryCharacteristic name,
javax.realtime.memory.PhysicalMemoryRegion[] modules)
throws IllegalArgumentException,
IllegalStateException

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

IllegalArgumentException when either name or modules is null

IllegalStateException when module overlaps a previously associated PhysicalMemoryRegion instance.

createImmortalMemory(PhysicalMemorySelector, long, Runnable)

Signature

public javax.realtime.ImmortalMemory
createImmortalMemory(PhysicalMemorySelector selector,
long size,
Runnable logic)
throws SecurityException,
SizeOutOfBoundsException,
UnsupportedPhysicalMemoryException,
MemoryTypeConflictException,
IllegalArgumentException

Description

Instantiate a javax.realtime.ImmortalMemory[72] object in a PhysicalMemoryRegion[73] matching the PhysicalMemoryCharacteristic[74] in selector and then with virtual memory parameters of selector applied.

Parameters

selector to use to choose the memory module and set the virtual mapping

size is the size of memory to be taken out of the selected module

logic the logic to execute on entry (may be null

Throws

SecurityException 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[75] 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.

IllegalArgumentException when size is less than zero.

Returns

[72]Section 11.3.3.2
[73]Section 11.4.3.3
[74]Section 11.4.1.1
[75]Section 11.4.1.1

the new memory area

createLTMemory(PhysicalMemorySelector, long, Runnable)

Signature

```
public javax.realtime.memory.PinnableMemory
createLTMemory(PhysicalMemorySelector selector,
               long size,
               Runnable logic)
throws SecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       IllegalArgumentException
```

Description

Instantiate a LTMemory[76] object in a PhysicalMemoryRegion[77] matching the PhysicalMemoryCharacteristic[78] in selector and then with virtual memory parameters of selector applied.

Parameters

selector to use to choose the memory module and set the virtual mapping

size is the size of memory to be taken out of the selected module

logic the logic to execute on entry (may be null

Throws

SecurityException 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[79] 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.

[76] Section 11.4.3.1
[77] Section 11.4.3.3
[78] Section 11.4.1.1
[79] Section 11.4.1.1

IllegalArgumentException 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 SecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       IllegalArgumentException
```

Description

Instantiate a PinnableMemory[80] object in a PhysicalMemoryRegion[81] matching the PhysicalMemoryCharacteristic[82] in selector and then with virtual memory parameters of selector applied.

Parameters
selector to use to choose the memory module and set the virtual mapping

size is the size of memory to be taken out of the selected module

logic the logic to execute on entry (may be null

Throws
SecurityException 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[83] has been registered with this PhysicalMemoryFactory.

[80] Section 11.4.3.5
[81] Section 11.4.3.3
[82] Section 11.4.1.1
[83] Section 11.4.1.1

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.

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 SecurityException,
       SizeOutOfBoundsException,
       UnsupportedPhysicalMemoryException,
       MemoryTypeConflictException,
       IllegalArgumentException
```

Description

Instantiate a StackedMemory[84] object in a PhysicalMemoryRegion[85] matching the PhysicalMemoryCharacteristic[86] in selector and then with virtual memory parameters of selector applied.

Parameters

selector to use to choose the memory module and set the virtual mapping

scopeSize is the size of the scope to be created

backingSize is the size of the backing store to take out of the selected module

logic the logic to execute on entry (may be null

Throws

SecurityException when the application does not have permissions to access physical memory or the given range of memory.

[84] Section 11.4.3.7
[85] Section 11.4.3.3
[86] Section 11.4.1.1

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[87] 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.

IllegalArgumentException when scopeSize or backingSize is less than zero.

Returns
the new memory area

11.4.3.3 PhysicalMemoryRegion

Inheritance
java.lang.Object
javax.realtime.memory.PhysicalMemoryRegion
Description

Enable an application to define a range of physical memory addresses.

Available since RTSJ 2.0

11.4.3.3.1 Constructors

PhysicalMemoryRegion(long, long)

Signature

```
public
PhysicalMemoryRegion(long base,
                     long length)
```

Description

[87] Section 11.4.1.1

Creates an instance representing a range of contiguous physical memory.

Parameters
base is a physical address
length is size of contiguous memory from that base
Throws
IllegalArgumentException when length is less than or equal to 0, or when base is less than 0 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

11.4.3.3.2 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

11.4.3.4 PhysicalMemorySelector

Inheritance

java.lang.Object
  javax.realtime.memory.PhysicalMemorySelector

Description

Provides both 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.

Available since RTSJ 2.0

11.4.3.4.1 Constructors

PhysicalMemorySelector(PhysicalMemoryCharacteristic, PhysicalMemoryCharacteristic, CachingBehavior, PagingBehavior)

Signature

```
public
PhysicalMemorySelector(javax.realtime.memory.PhysicalMemoryCharacteristic[] request,
                       javax.realtime.memory.PhysicalMemoryCharacteristic[] reject,
                       PhysicalMemorySelector.CachingBehavior caching,
                       PhysicalMemorySelector.PagingBehavior paging)
```

Description

11.4.3.4.2 Methods

---

getSupportedCachingBehavior

Signature

public static javax.realtime.memory.PhysicalMemorySelector.CachingBehavior[] getSupportedCachingBehavior()

Description

Get 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

Get 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

getPagingPagingBehavior

Signature

public javax.realtime.memory.PhysicalMemorySelector.PagingBehavior
getPagingPagingBehavior()

Description

A getter for the PagingBehavior to be requested

Returns

the PagingBehavior

11.4.3.5 PinnableMemory

Inheritance
java.lang.Object
javax.realtime.MemoryArea
javax.realtime.memory.ScopedMemory
javax.realtime.memory.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.

Available since RTSJ 2.0

11.4.3.5.1 Constructors

PinnableMemory(long)

Signature

```
public
PinnableMemory(long size)
throws IllegalArgumentException,
       StaticOutOfMemoryError
```

Description

Create a scoped memory of fixed size that can be held open when no javax.realtime.Schedulable[88] has it on its scoped memory stack.

Parameters
size is the number of bytes in the memory area.
Throws
IllegalArgumentException when size is less than zero.

[88] Section 6.3.1.3

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the PinnalbeMemory object or for its backing memory.

PinnableMemory(SizeEstimator)

Signature

public
PinnableMemory(SizeEstimator size)
throws IllegalArgumentException,
StaticOutOfMemoryError

Description

Equivalent to PinnableMemory(long)[89] with size.getEstimate() as its argument.

Parameters

size is an estimator for determining the number of bytes in the memory area.

Throws

IllegalArgumentException when size is null.

javax.realtime.StaticOutOfMemoryError when there is insufficient memory for the PinnalbeMemory object or for its backing memory.

11.4.3.5.2 Methods

pin

Signature

public void
pin()

Description

Prevent the contents from being freed.

[89] Section 11.4.3.5.1

unpin

Signature

public void
unpin()

Description

Allow the contents to be freed the next time no javax.realtime.Schedulable[90] is active within the scope.

isPinned

Signature

public boolean
isPinned()

Description

Determine whether the scope may be cleared on last exit.

Returns

true when yes, otherwise false.

getPinCount

Signature

public int
getPinCount()

Description

Find out how many times the scope has been pinned, but not unpinned.

Returns

the number of outstanding pins.

[90] Section 6.3.1.3

joinPinned

Signature

public void
joinPinned()
throws InterruptedException

Description

Wait until the scope has been cleared and then pin it.

Throws

InterruptedException When this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[91] or javax.realtime.AsynchronouslyInterruptedException.fire()[92] while waiting for the reference count to go to zero.

joinPinned(HighResolutionTime)

Signature

public void
joinPinned(javax.realtime.HighResolutionTime<T> limit)
throws InterruptedException

Description

Wait until the scope has been cleared and then pin it, within a specified time frame.

Parameters

limit is the maximum time to wait

Throws

InterruptedException when this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[93] or javax.realtime.AsynchronouslyInterruptedException.fire()[94] while waiting for the reference count to go to zero.

[91] Section 6.3.1.3.1
[92] Section 8.3.2.1.2
[93] Section 6.3.1.3.1
[94] Section 8.3.2.1.2

joinPinnedAndEnter(Runnable)

Signature

public void
joinPinnedAndEnter(Runnable logic)
throws InterruptedException,
ScopedCycleException

Description

Wait until the scope has been cleared and then pin it and enter it.

Parameters

logic is the logic to execute upon entry

Throws

InterruptedException When this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[95] or javax.realtime.AsynchronouslyInterruptedException.fire()[96] 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.

joinPinnedAndEnter(Runnable, HighResolutionTime)

Signature

public void
joinPinnedAndEnter(Runnable logic,
javax.realtime.HighResolutionTime<T> limit)
throws InterruptedException,
ScopedCycleException

Description

Wait until the scope has been cleared and then pin it and enter it, within a specified time frame.

Parameters

logic is the logic to execute upon entry

limit is the maximum time to wait.

Throws

[95] Section 6.3.1.3.1
[96] Section 8.3.2.1.2

InterruptedException When this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[97] or javax.realtime.AsynchronouslyInterruptedException.fire()[98] 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.

joinPinnedAndEnter

Signature

public void
joinPinnedAndEnter()
throws InterruptedException,
IllegalSchedulableStateException,
ThrowBoundaryError,
ScopedCycleException,
MemoryAccessError

Description

Wait until the scope has been cleared and then pin it and enter it.

Throws

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[99], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[100] 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.

InterruptedException When this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[101] or javax.realtime.AsynchronouslyInterruptedException.fire()[102] while waiting for the reference count to go to zero.

IllegalSchedulableStateException when the caller is a Java thread, or when this method is invoked during finalization of objects in scoped memory and enter-

[97] Section 6.3.1.3.1
[98] Section 8.3.2.1.2
[99] Section 15.2.3.2
[100] Section 15.2.3.8
[101] Section 6.3.1.3.1
[102] Section 8.3.2.1.2

ing 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.

MemoryAccessError when calling schedulable may not use the heap and this memory area's logic value is allocated in heap memory.

joinPinnedAndEnter(HighResolutionTime)

Signature

public void
joinPinnedAndEnter(javax.realtime.HighResolutionTime<T> limit)
throws InterruptedException,
IllegalSchedulableStateException,
IllegalArgumentException,
UnsupportedOperationException,
ThrowBoundaryError,
ScopedCycleException,
MemoryAccessError

Description

Wait until the scope has been cleared and then pin it and enter it, within a specified time frame.

Parameters

limit is the maximum time to wait.

Throws

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[103], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[104] 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.

InterruptedException When this schedulable is interrupted by javax.realtime.Schedulable.interrupt()[105] or javax.realtime.AsynchronouslyInterruptedException.fire()[106]

[103]Section 15.2.3.2
[104]Section 15.2.3.8
[105]Section 6.3.1.3.1
[106]Section 8.3.2.1.2

while waiting for the reference count to go to zero.

IllegalSchedulableStateException 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 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.

UnsupportedOperationException when the wait operation is not supported using the clock associated with time.

11.4.3.6 ScopedMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.memory.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 object 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 (it's 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[107] method of ScopedMemory is one mechanism used to make a memory area the current allocation context. The other mechanism

[107]Section 11.4.3.6.1

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 a 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.

11.4.3.6.1 Methods

enter

Signature

public void
enter()

Description

Associate 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[108]) or the enter method exits.

Throws

javax.realtime.ScopedCycleException when this invocation would break the single parent rule.

[108] Section 11.4.3.6.1

javax.realtime.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[109], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[110] 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 IllegalArgumentException when the caller is a schedulable and a null value for logic was supplied when the memory area was constructed.

MemoryAccessError 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

Associate 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[111]) or the enter method exits.

Parameters

logic logic The Runnable object whose run() method should be invoked.

Throws

javax.realtime.ScopedCycleException when this invocation would break the single parent rule.

javax.realtime.ThrowBoundaryError Thrown when the JVM needs to propagate an exception allocated in this scope to (or through) the memory area of the

[109] Section 15.2.3.2
[110] Section 15.2.3.8
[111] Section 11.4.3.6.1

caller. Storing a reference to that exception would cause an javax.realtime.IllegalAssignmentError[112], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[113] 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 IllegalArgumentException when the caller is a schedulable and logic is null.

enter(Supplier)

Signature

public T
enter(java.util.function.Supplier<T> logic)

Description

Same as enter(Runnable)[114] except that the executed method is called get and an object is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

enter(BooleanSupplier)

Signature

public boolean
enter(BooleanSupplier logic)

Description

Same as enter(Runnable)[115] except that the executed method is called get and a boolean is returned.

[112] Section 15.2.3.2
[113] Section 15.2.3.8
[114] Section 11.4.3.6.1
[115] Section 11.4.3.6.1

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

enter(IntSupplier)

Signature

public int
enter(IntSupplier logic)

Description

Same as enter(Runnable)[116] except that the executed method is called get and an int is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

enter(LongSupplier)

Signature

public long
enter(LongSupplier logic)

Description

Same as enter(Runnable)[117] except that the executed method is called get and a long is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

[116]Section 11.4.3.6.1
[117]Section 11.4.3.6.1

enter(DoubleSupplier)

Signature

public double
enter(DoubleSupplier logic)

Description

Same as enter(Runnable)[118] except that the executed method is called get and a double is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

executeInArea(Runnable)

Signature

public void
executeInArea(Runnable logic)

Description

Execute 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 is a Java thread.

InaccessibleAreaException when the memory area is not in the schedulable's scope stack.

IllegalArgumentException when the caller is a schedulable and logic is null.

executeInArea(Supplier)

Signature

[118] Section 11.4.3.6.1

public T
executeInArea(java.util.function.Supplier<T> logic)

Description

Same as executeInArea(Runnable)[119] except that the executed method is called get and an object is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

executeInArea(BooleanSupplier)

Signature

public boolean
executeInArea(BooleanSupplier logic)

Description

Same as executeInArea(Runnable)[120] except that the executed method is called get and a boolean is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

executeInArea(IntSupplier)

Signature

public int
executeInArea(IntSupplier logic)

Description

Same as executeInArea(Runnable)[121] except that the executed method is called get and an int is returned.

[119] Section 11.4.3.6.1
[120] Section 11.4.3.6.1
[121] Section 11.4.3.6.1

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

executeInArea(LongSupplier)

Signature

public long
executeInArea(LongSupplier logic)

Description

Same as executeInArea(Runnable)[122] except that the executed method is called get and a long is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

executeInArea(DoubleSupplier)

Signature

public double
executeInArea(DoubleSupplier logic)

Description

Same as executeInArea(Runnable)[123] except that the executed method is called get and a double is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

[122]Section 11.4.3.6.1
[123]Section 11.4.3.6.1

getPortal

Signature

public java.lang.Object
getPortal()

Description

Return 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 this is "inner" relative to the current allocation context or not on the caller's scope stack.

IllegalThreadStateException when the caller is a Java thread.

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, 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

Wait until the reference count of this ScopedMemory goes down to zero. Return immediately when the memory is unreferenced.

Throws

InterruptedException When this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt()[124] or javax.realtime.AsynchronouslyInterruptedException.fire()[125] while waiting for the reference count to go to zero.

IllegalThreadStateException when the caller is a Java thread.

join(HighResolutionTime)

Signature

public void
join(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException

Description

Wait at most until the time designated by the time parameter for the reference count of this ScopedMemory to drop to zero. Return immediately when the memory area is unreferenced.

Since the time is expressed as a javax.realtime.HighResolutionTime[126], 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

[124]Section 5.3.2.2.2
[125]Section 8.3.2.1.2
[126]Section 9.3.1.2

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

InterruptedException When this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt()[127] or javax.realtime.AsynchronouslyInterruptedException.fire()[128] while waiting for the reference count to go to zero.

IllegalThreadStateException when the caller is a Java thread.

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

[127] Section 5.3.2.2.2
[128] Section 8.3.2.1.2

InterruptedException When this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt()[129] or javax.realtime.AsynchronouslyInterruptedException.fire()[130] 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.

javax.realtime.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[131], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[132] 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.

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(javax.realtime.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

[129]Section 5.3.2.2.2
[130]Section 8.3.2.1.2
[131]Section 15.2.3.2
[132]Section 15.2.3.8

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 javax.realtime.HighResolutionTime[133], 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[134].

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 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[135], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[136] is allocated in the current allocation context and contains information about the exception it replaces.

InterruptedException When this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt()[137] or javax.realtime.AsynchronouslyInterruptedException.fire()[138] 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.

[133]Section 9.3.1.2
[134]Section 11.4.3.6.1
[135]Section 15.2.3.2
[136]Section 15.2.3.8
[137]Section 5.3.2.2.2
[138]Section 8.3.2.1.2

javax.realtime.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 no non-null logic value was supplied to the memory area's constructor.

UnsupportedOperationException when the wait operation is not supported using the clock associated with time.

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

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 javax.realtime.RealtimeThread.interrupt()[139] or javax.realtime.AsynchronouslyInterruptedException.fire()[140] while waiting for the reference count to go to zero.

[139]Section 5.3.2.2.2
[140]Section 8.3.2.1.2

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.

javax.realtime.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[141], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[142] 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.

IllegalArgumentException when the caller is a schedulable and logic is null.

joinAndEnter(Supplier)

Signature

public T
joinAndEnter(java.util.function.Supplier<T> logic)

Description

Same as joinAndEnter(Runnable)[143] except that the executed method is called get and an object is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

joinAndEnter(BooleanSupplier)

Signature

public boolean
joinAndEnter(BooleanSupplier logic)

[141] Section 15.2.3.2
[142] Section 15.2.3.8
[143] Section 11.4.3.6.1

Description

Same as joinAndEnter(Runnable)[144] except that the executed method is called get and a boolean is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

joinAndEnter(IntSupplier)

Signature

public int
joinAndEnter(IntSupplier logic)

Description

Same as joinAndEnter(Runnable)[145] except that the executed method is called get and an int is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

joinAndEnter(LongSupplier)

Signature

public long
joinAndEnter(LongSupplier logic)

Description

Same as joinAndEnter(Runnable)[146] except that the executed method is called get and a long is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

[144] Section 11.4.3.6.1
[145] Section 11.4.3.6.1
[146] Section 11.4.3.6.1

joinAndEnter(DoubleSupplier)

Signature

public double
joinAndEnter(DoubleSupplier logic)

Description

Same as joinAndEnter(Runnable)[147] except that the executed method is called get and a double is returned.

Parameters

logic the object who's get method will be executed.

Returns

a result from the computation.

joinAndEnter(Runnable, HighResolutionTime)

Signature

public void
joinAndEnter(Runnable logic,
javax.realtime.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 javax.realtime.HighResolutionTime[148], 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)[149].

[147] Section 11.4.3.6.1
[148] Section 9.3.1.2
[149] Section 11.4.3.6.1

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 javax.realtime.RealtimeThread.interrupt()[150] or javax.realtime.AsynchronouslyInterruptedException.fire()[151] 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.

javax.realtime.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 a javax.realtime.IllegalAssignmentError[152], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[153] is preallocated and saves information about the exception it replaces.

javax.realtime.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.

joinAndEnter(Supplier, HighResolutionTime)

Signature

public P

[150]Section 5.3.2.2.2
[151]Section 8.3.2.1.2
[152]Section 15.2.3.2
[153]Section 15.2.3.8

joinAndEnter(java.util.function.Supplier<P> logic,
javax.realtime.HighResolutionTime<?> time)

Description

Same as joinAndEnter(Runnable, HighResolutionTime)[154] except that the executed method is called get and an object is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

joinAndEnter(BooleanSupplier, HighResolutionTime)

Signature

public boolean
joinAndEnter(BooleanSupplier logic,
javax.realtime.HighResolutionTime<?> time)

Description

Same as joinAndEnter(Runnable, HighResolutionTime)[155] except that the executed method is called get and a boolean is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

joinAndEnter(IntSupplier, HighResolutionTime)

Signature

public int
joinAndEnter(IntSupplier logic,
javax.realtime.HighResolutionTime<?> time)

Description

[154]Section 11.4.3.6.1
[155]Section 11.4.3.6.1

Same as joinAndEnter(Runnable, HighResolutionTime)[156] except that the executed method is called get and an int is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

joinAndEnter(LongSupplier, HighResolutionTime)

Signature

```
public long
joinAndEnter(LongSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
```

Description

Same as joinAndEnter(Runnable, HighResolutionTime)[157] except that the executed method is called get and a long is returned.

Parameters
logic the object who's get method will be executed.
Returns
a result from the computation.

joinAndEnter(DoubleSupplier, HighResolutionTime)

Signature

```
public double
joinAndEnter(DoubleSupplier logic,
             javax.realtime.HighResolutionTime<?> time)
```

Description

Same as joinAndEnter(Runnable, HighResolutionTime)[158] except that the executed method is called get and a double is returned.

Parameters
logic the object who's get method will be executed.

[156] Section 11.4.3.6.1
[157] Section 11.4.3.6.1
[158] Section 11.4.3.6.1

Returns
a result from the computation.

getParent

Signature
public javax.realtime.MemoryArea
getParent()

Description

Return a reference to this scopes 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, return a reference to this.
- When there is no outer scoped memory and the primordial parent is immortal, or when this is unreferenced and unpinned, return 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.*

Available since RTSJ 2.0

visitNestedMemory(MemoryAreaVisitor)

Signature
public R
visitNestedMemory(javax.realtime.MemoryAreaVisitor<R> visitor)

Description

A means of accessing all live nested memory areas contained in this memory area, even those to which no reference exits, such a javax.realtime.memory.PinnableMemory[159] 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 guarantees 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.

Perform an action on all children scopes of this memory area, so long as the MemoryAreaVisitor.visit(MemoryArea)[160] method returns null. When that method returns an object, the visit is terminated and that object is returned by this method,

When execution of the visitor's visit method terminated abruptly by throwing an exception, then execution of visitScopedChildren also terminates abruptly by throwing the same exception.

Throws

IllegalArgumentException when visitor is null.

newArray(Class, int)

Signature

```
public java.lang.Object
newArray(java.lang.Class<?> type,
         int number)
```

Description

Allocate an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

type 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 number The number of elements in the new array.

[159] Section 11.4.3.5

[160] Section 11.3.1.1.1

Throws

IllegalArgumentException IllegalArgumentException when number is less than zero, type is null, or type is java.lang.Void.TYPE.

javax.realtime.StaticOutOfMemoryError null

IllegalThreadStateException when the caller is a Java thread.

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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

type type The class of which to create a new instance.

Throws

IllegalAccessException IllegalAccessException The class or initializer is inaccessible.

IllegalArgumentException IllegalArgumentException when type is null.

ExceptionInInitializerError ExceptionInInitializerError when an unexpected exception has occurred in a static initializer.

javax.realtime.StaticOutOfMemoryError null

InstantiationException 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 is a Java thread.

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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

c T c The constructor for the new instance.

args args An array of arguments to pass to the constructor.

Throws

IllegalAccessException IllegalAccessException when the class or initializer is inaccessible under Java access control.

InstantiationException 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

IllegalArgumentException IllegalArgumentException 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.

IllegalThreadStateException when the caller is a Java thread.

InvocationTargetException 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 javax.realtime.memory.ScopedMemory
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 is a Java Thread.

javax.realtime.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.

Returns

this

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

11.4.3.7 StackedMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.memory.ScopedMemory
      javax.realtime.memory.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 which case it is returned to its enclosing scope's backing store when the object is finalized. Implementations are not required to 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 objects, *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.

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 manipu-

lation:

- 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 cannot 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 cannot 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.

Available since RTSJ 2.0

11.4.3.7.1 Constructors

StackedMemory(long, long, Runnable)

Signature

```
public
StackedMemory(long scopeSize,
              long backingSize,
              Runnable logic)
```

Description

Create 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

backingSize Size of the total backing store

logic Runnable to be entered using this as its current memory area when enter()[161] is called.

Throws

IllegalArgumentException 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.

StackedMemory(SizeEstimator, SizeEstimator, Runnable)

Signature

```
public
StackedMemory(SizeEstimator scopeSize,
              SizeEstimator backingSize,
              Runnable logic)
```

Description

Equivalent to StackedMemory(long, long, Runnable)[162] with argument list (scopeSize.getEstimate(), backingSize.getEstimate(), runnable).

Parameters

scopeSize SizeEstimator indicating the size of the object allocation area

backingSize SizeEstimator indicating the size of the total backing store

logic Runnable to be entered using this as its current memory area when enter()[163] is called.

Throws

[161] Section 11.4.3.7.2
[162] Section 11.4.3.7.1
[163] Section 11.4.3.7.2

IllegalArgumentException 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.

StackedMemory(long, long)

Signature

public
StackedMemory(long scopeSize,
long backingSize)

Description

Equivalent to StackedMemory(long, long, Runnable)[164] with argument list (scopeSize, backingSize, null).

Parameters

scopeSize Size of the allocation area

backingSize Size of the total backing store

Throws

IllegalArgumentException 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.

StackedMemory(SizeEstimator, SizeEstimator)

Signature

public
StackedMemory(SizeEstimator scopeSize,
SizeEstimator backingSize)

Description

[164] Section 11.4.3.7.1

Equivalent to StackedMemory(long, long, Runnable)[165] with argument list (scopeSize.getEstimate(), backingSize.getEstimate(), null).

Parameters

scopeSize SizeEstimator indicating the size of the object allocation area

backingSize SizeEstimator indicating the size of the total backing store

Throws

IllegalArgumentException 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.

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

logic Runnable to be entered using this as its current memory area when enter()[166] is called.

Throws

IllegalStateException when the parent memory area is not a StackedMemory, or when the parent StackedMemory already has a child that is also a guest StackedMemory.

IllegalArgumentException when scopeSize is less than zero.

[165] Section 11.4.3.7.1

[166] Section 11.4.3.7.2

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.

StackedMemory(SizeEstimator, Runnable)

Signature

public
StackedMemory(SizeEstimator scopeSize,
Runnable logic)

Description

Equivalent to StackedMemory(long, Runnable)[167] with argument list (scopeSize.getEstimate(), runnable).

Parameters

scopeSize SizeEstimator indicating the size of the object allocation area

logic Runnable to be entered using this as its current memory area when enter()[168] is called.

Throws

IllegalStateException when the parent memory area is not a StackedMemory, or when the parent StackedMemory already has a child that is also a guest StackedMemory.

IllegalArgumentException 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.

StackedMemory(long)

Signature

public
StackedMemory(long scopeSize)

Description

[167] Section 11.4.3.7.1
[168] Section 11.4.3.7.2

Equivalent to StackedMemory(long, Runnable)[169] with argument list (scopeSize, null).

Parameters

scopeSize Size of the allocation area

Throws

IllegalStateException when the parent memory area is not a StackedMemory, or when the parent StackedMemory already has a child that is also a guest StackedMemory.

IllegalArgumentException 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.

StackedMemory(SizeEstimator)

Signature

public
StackedMemory(SizeEstimator scopeSize)

Description

Equivalent to StackedMemory(long, Runnable)[170] with argument list (scopeSize. getEstimate(), null).

Parameters

scopeSize SizeEstimator indicating the size of the object allocation area

Throws

IllegalStateException when the parent memory area is not a StackedMemory, or when the parent StackedMemory already has a child that is also a guest StackedMemory.

IllegalArgumentException 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.

[169] Section 11.4.3.7.1
[170] Section 11.4.3.7.1

11.4.3.7.2 Methods

resize(long)

Signature

public void
resize(long scopeSize)

Description

Change 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 shrink the allocation area down to 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

IllegalStateException when the caller is not permitted to perform the requested adjustment or 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.

getMaximumSize

Signature

public long
getMaximumSize()

Description

Get 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)[171] without triggering an OutOfMemoryException.

[171] Section 11.4.3.7.2

Returns
The maximum size attainable.

enter

Signature
public void
enter()

Description

Associate 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
IllegalStateException 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 null

IllegalThreadStateException 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.

MemoryAccessError MemoryAccessError 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

Associate 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

IllegalStateException 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 null

IllegalThreadStateException 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.

MemoryAccessError null

See Section ScopedMemory.enter(Runnable)

joinAndEnter

Signature

public void
joinAndEnter()

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 javax.realtime.RealtimeThread.interrupt()[172] or javax.realtime.AsynchronouslyInterruptedException.fire()[173] 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.

javax.realtime.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[174], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[175] 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.

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(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException

Description

[172]Section 5.3.2.2.2
[173]Section 8.3.2.1.2
[174]Section 15.2.3.2
[175]Section 15.2.3.8

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 javax.realtime.HighResolutionTime[176], 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[177].

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 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[178], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[179] is allocated in the current allocation context and contains information about the exception it replaces.

InterruptedException When this schedulable is interrupted by javax.realtime.RealtimeThread.interrupt()[180] or javax.realtime.AsynchronouslyInterruptedException.fire()[181] while waiting for the reference count to go to zero.

IllegalThreadStateException when the caller is a Java thread, or when this method is

[176]Section 9.3.1.2
[177]Section 11.4.3.7.2
[178]Section 15.2.3.2
[179]Section 15.2.3.8
[180]Section 5.3.2.2.2
[181]Section 8.3.2.1.2

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.

javax.realtime.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 no non-null logic value was supplied to the memory area's constructor.

UnsupportedOperationException when the wait operation is not supported using the clock associated with time.

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

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 javax.realtime.RealtimeThread.interrupt()[182] or javax.realtime.AsynchronouslyInterruptedException.fire()[183] 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.

javax.realtime.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[184], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[185] 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.

IllegalArgumentException when the caller is a schedulable and logic is null.

joinAndEnter(Runnable, HighResolutionTime)

Signature

```
public void
joinAndEnter(Runnable logic,
             javax.realtime.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 javax.realtime.HighResolutionTime[186], this method is an accurate timer with nanosecond granularity. The actual resolution

[182]Section 5.3.2.2.2
[183]Section 8.3.2.1.2
[184]Section 15.2.3.2
[185]Section 15.2.3.8
[186]Section 9.3.1.2

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)[187].

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 javax.realtime.RealtimeThread.interrupt()[188] or javax.realtime.AsynchronouslyInterruptedException.fire()[189] 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.

javax.realtime.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 a javax.realtime.IllegalAssignmentError[190], so the JVM cannot be permitted to deliver the exception. The javax.realtime.ThrowBoundaryError[191] is preallocated and saves information about the exception it replaces.

javax.realtime.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.

[187]Section 11.4.3.7.2
[188]Section 5.3.2.2.2
[189]Section 8.3.2.1.2
[190]Section 15.2.3.2
[191]Section 15.2.3.8

UnsupportedOperationException when the wait operation is not supported using the clock associated with time.

11.5 The Rationale

11.5.1 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 nondeterminacy 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 it realtime thread is constructed or its ASEH becomes firable, but its reference count is not incremented until the thread is started or the async 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 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 affect on EISMA finalization. Only another execution context can prevent finalization by the handler at release end.

11.5.2 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 costs per byte. SRAM has faster access times and is more expensive. Both DRAM and SRAM are example 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 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 lookaside 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 100 ms or so. To exploit this, the objects used by each phase of our 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 12.2.1). 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[192]. 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.

11.5.2.1 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

[192]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.

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 can interact in order 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 PMM. However, the programming of filters is difficult for the following reasons.

1. Physical memory type filters included a memory allocation function that must respond to allocation requests with whether a requested range of physical memory is free and when it was 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.

11.5.2.2 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. It, therefore, 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 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 can be used any objects store 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 be accessed via the RTSJ Raw Memory facilities (see Section 12.2.1).
2. Any API must delegates 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[193] 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 PhysicalMemoryFactory. This factory can then be used with new constructors on the physical memory classes. For example,

[193] 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/

```
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.

11.5.2.3 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.

11.5.2.3.1 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 PhysicalMemory-Region class to represent the physical memory module memory modules to represent

```
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 now create a selector with the required properties. In this case, it is for some SRAM that 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.

11.5.2.3.2 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, 0x1000);
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 mememoy factory has no knowledge of what these names mean; it is merely providing a look-up service.

Chapter 12

Devices and Triggering

Interacting with the external environment in a timely manner is an important requirement for realtime, embedded systems. From an embedded systems' 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 defined 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.

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 execution environments 2, 3, and 4, the 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 implementers.

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.

12.1 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 bit of code that is executed when an interrupt happens. This code runs above the normal priorites and can only be interrupted by another interrupt.

Raw Memory — An 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 arbirary 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 messured 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 12.1.1 (elb)

Pull in some relevant definitions from the JMM.

End of issue 12.1.1

12.2 Semantics

The classes in this Chapter are part of the Device Module introduced in Section 3.2.2.3 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 interal active events.

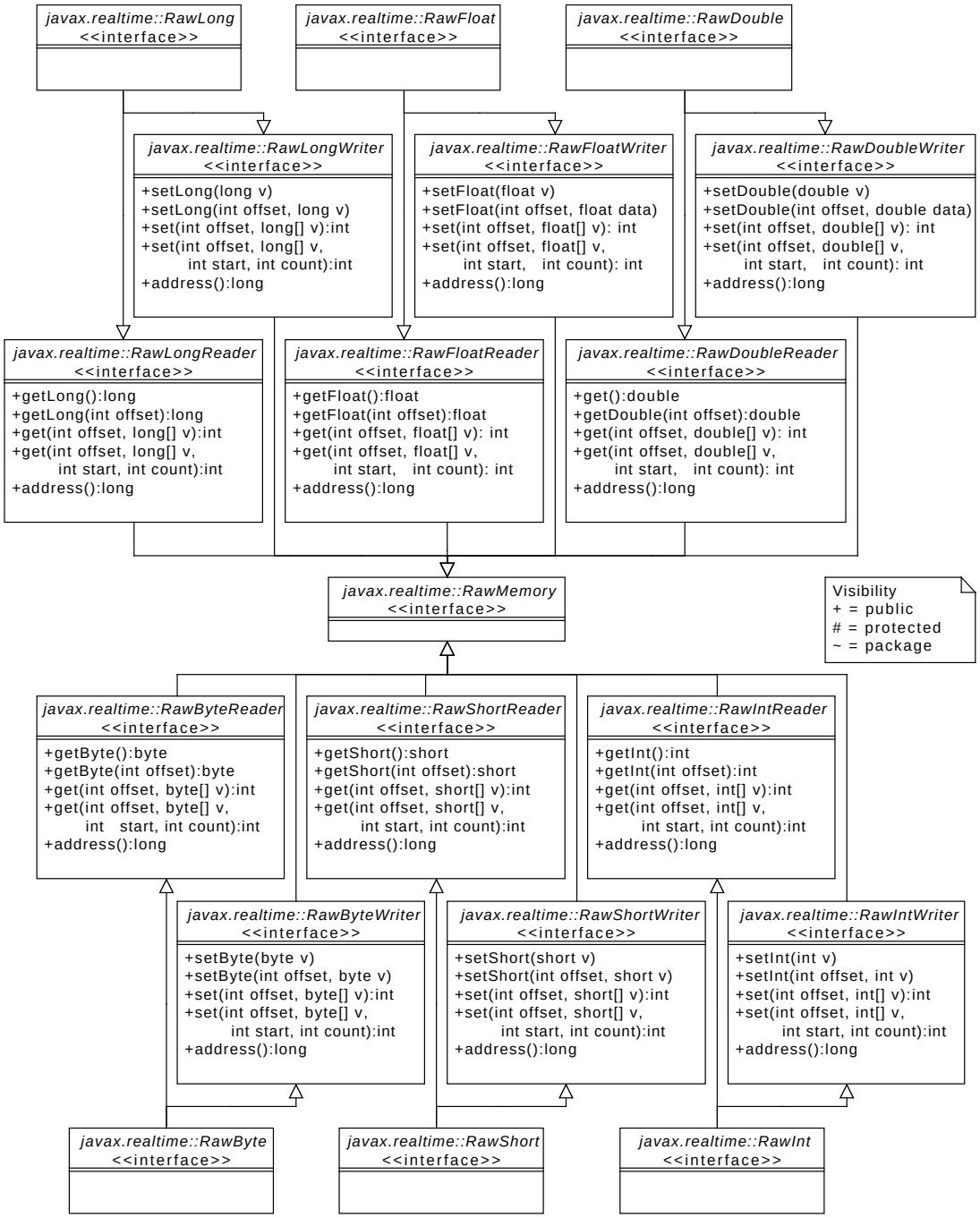
12.2.1 Raw Memory

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 location 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.

Figure 12.1: Raw Memory Interface

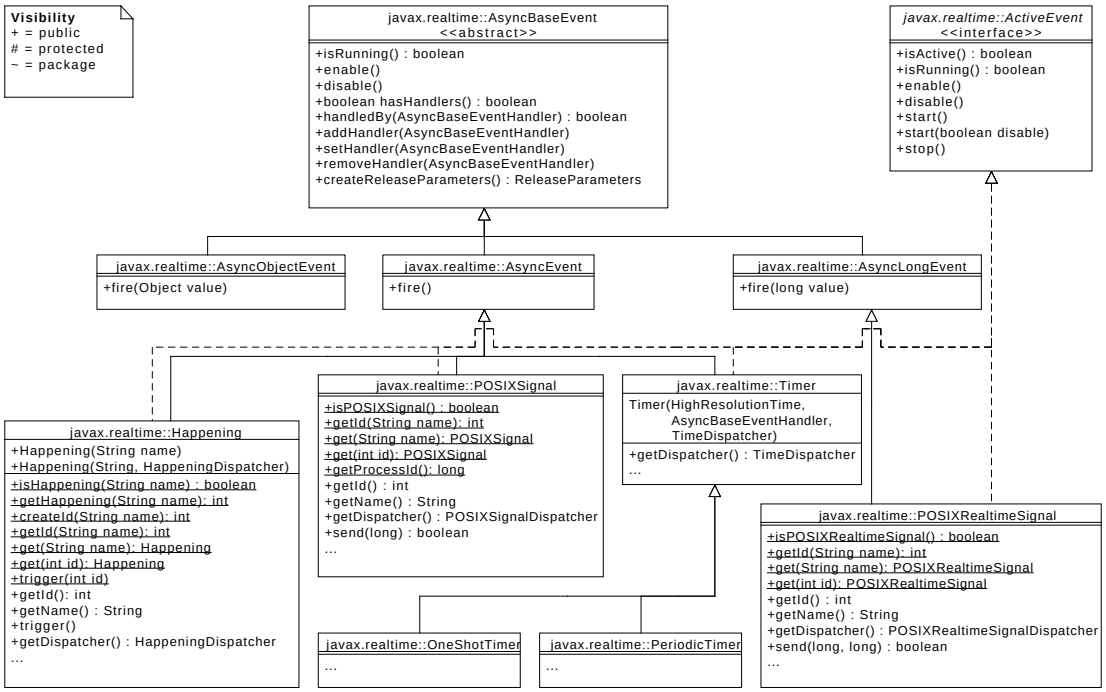


(b) The raw memory region RawMemoryFactory.IO_PORT_MAPPED_REGION facilitates access to locations that are outside the main memory used by the JVM. It is used to access input and output device registers when such registers are port-based and can only be accessed by special hardware instructions.

(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.
3. The RawMemoryFactory class defines the applications programmers interface to the raw memory facilities.
4. The RawMemoryRegionFactory interface defines the interface that all factories must support for creating accessor objects.

Figure 12.2: Event Classes



12.2.1.1 Raw Memory Region

Raw memory is designed to support arbitrary I/O address spaces. The simplest is through the processor address space and is accessible via standard memory access instructions, such as load and store. This provide access to memory mapped I/O devices, but there are others 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 support it.

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 emulated 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_REGI for memory mapped devices and RawMemoryFactory.IO_PORT_MAPPED_REGION for port mapped devices for processors that have instructions for reading and writing an I/O bus directly. The instances are used to get accessors of a region instead of using a RawMemoryRegionFactory directly.

12.2.1.2 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.

12.2.1.3 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.

12.2.2 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 form 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 is a bit different than for other java.nio mechanisms.

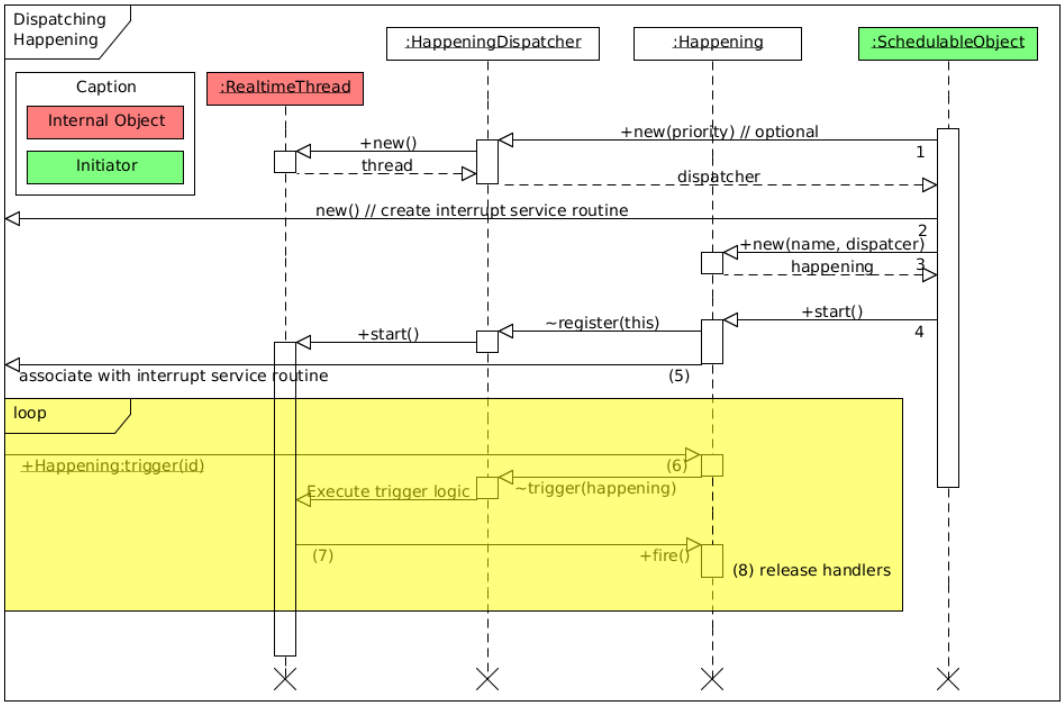
These differences are covered with a special byte buffer factory: DMABufferFactory. An instance of this factory can produce direct byte buffers within a given memory range. This range can be chosen by the programmer to be within the range of a given DMA controller. The factory also provides methods for 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 DMABufferFactory class also provides static methods for ensuring that Java-generated changes to DMA-mapped memory buffers are visible to native code, and vice-versa.

12.2.3 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 handler 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, as well as 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 12.3: Happening State Transition Diagram



12.2.3.1 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 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 have 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 12.3 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 it 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).

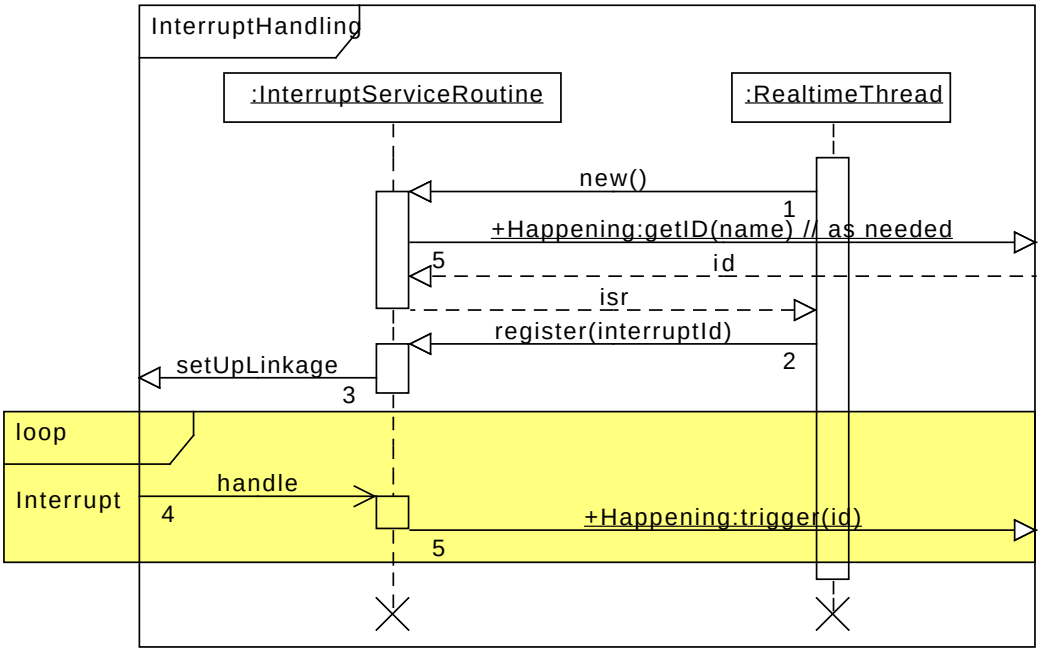
There are three main differences between this mechanism and the string based API.

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, a native code function that permits native application code to trigger the happening.
3. Finally, Happening is a subclass of AsyncEvent just as with Timer instead of having a happening attached to an AsyncEvent.

12.2.4 Interrupt Service Routines

In Java-based systems, JNI is typically used to transfer control between the assembler/C *interrupt service routine* (ISR) and the program. 2.0 of the RTSJ supports the possibility of the ISR containing 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.

Figure 12.4: Interrupt servicing



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 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 occurrence is inhibited, all occurrences of that interrupt shall be prevented from being delivered. Whether such occurrences remain pending or are lost is imple-

mentation 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 method must be synchronized with a priority high enough to lock out the requisite interrupts. This synchronized uses priority ceiling emulation to inhibit the corresponding interrupt (and all lower priority interrupts). The default allocation context of the handle method is the memory area passed during construction.
   Any exception propagated from the handle method shall be caught by the JVM and ignored.
9. Code running in the context of an ISR may only attempt to acquire a lock that has priority ceiling emulation as its monitor control policy. The behavior is undefined, when an ISR attempt to acquire a lock that has a monitor control policy other than priority ceiling emulation.

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 interrupt priority;
3. associated with the interrupt lines is a (logical) interrupt vector that contains the addresses of the ISRs;
4. the processor has instructions that allow interrupts from a particular line to be disabled/masked irrespective of whether (or the type of) device attached;
5. disabling interrupts from a specific line may disables the interrupts from lines of lower priority;
6. a device can be connected to an arbitrary interrupt line;
7. when an interrupt is signalled 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);

8. on return from the ISR, interrupts are automatically re-enabled.

For each of the interrupt, the RTSJ has an associated hardware priority that can be used to set the ceiling of an ISR object. The RTSJ virtual machine may use this to disable the interrupts from the associated interrupt line and lower priority interrupts, when it is executing a synchronized method of the interrupt-handling object. On a multicore system, the situation is more complex, since there may be other cores available to handle other interrupts, even at lower priorities, 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 real-time JVM may place restrictions of the code that can be written in this method. The process is illustrated in Figure 12.4, and is described below.

1. The ISR is created by some application real-time thread.
2. The created ISR is registered with the JVM, the interrupt id is passed as a parameter.
3. As part of the registration process, some internal interface is used to set up the code that will set the underlying interrupt vectors to some C/assembler code that will provide the necessary linkage to allow the callback to 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 happening or fire an event.

Typically 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 non inhibitable 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.

12.3 javax.realtime.device

12.3.1 Interfaces

12.3.1.1 RawByte

Interfaces
javax.realtime.device.RawByteReader
javax.realtime.device.RawByteWriter
Description

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.2 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 transfered in a single atomic operation. Groups of bytes may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawByteReader[1] and RawMemoryFactory.createRawByte[2]. Each object references a range of elements in the RawMemoryRegion[3] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

[1] Section 12.3.2.6.3
[2] Section 12.3.2.6.3
[3] Section 12.3.2.7

Available since RTSJ 2.0

12.3.1.2.1 Methods

---

getByte

Signature

public byte
getByte()

Description

Get 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

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters

offset of the first byte in the memory region to transfere

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 actuall transferred to values

get(int, byte, int, int)

Signature

```
public int
get(int offset,
    byte[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first byte in the memory region to transfere

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 transfered.

12.3.1.3 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 transfered in a single atomic operation. Groups of bytes may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawByteWriter[4] and RawMemoryFactory.createRawByte[5]. Each object references a range of elements in the RawMemoryRegion[6] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

[4]Section 12.3.2.6.3
[5]Section 12.3.2.6.3
[6]Section 12.3.2.7

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.

Available since RTSJ 2.0

12.3.1.3.1 Methods

---

setByte(byte)

Signature

public void
setByte(byte value)

Description

Set 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 is the new value for the element.

setByte(int, byte)

Signature

public void
setByte(int offset,
byte value)
throws OffsetOutOfBoundsException

Description

Set 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 transfered.

Parameters

offset of byte in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the bytes in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first byte in the memory region to be set.

values is 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,
NullPointerException

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.1.4 RawDouble

Interfaces

javax.realtime.device.RawDoubleReader
javax.realtime.device.RawDoubleWriter

Description

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.5 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 transfered in a single atomic operation. Groups of doubles may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawDoubleReader[7] and RawMemoryFactory.createRawDouble[8]. Each object references a range of elements in the RawMemoryRegion[9] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.5.1 Methods

getDouble

Signature

public double
getDouble()

Description

Get 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.

[7] Section 12.3.2.6.3
[8] Section 12.3.2.6.3
[9] Section 12.3.2.7

Returns
the value at the *base address*.

getDouble(int)

Signature

```
public double
getDouble(int offset)
throws OffsetOutOfBoundsException
```

Description

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters

offset of the first double in the memory region to transfere

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 actuall transferred to values

get(int, double, int, int)

Signature

```
public int
get(int offset,
    double[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first double in the memory region to transfere

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 transfered.

12.3.1.6 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 transfered in a single atomic operation. Groups of doubles may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawDoubleWriter[10] and RawMemoryFactory.createRawDouble[11]. Each object references a range of elements in the RawMemoryRegion[12] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.6.1 Methods

---

setDouble(double)

Signature

public void
setDouble(double value)

[10] Section 12.3.2.6.3
[11] Section 12.3.2.6.3
[12] Section 12.3.2.7

Description

Set 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 is the new value for the element.

setDouble(int, double)

Signature

```
public void
setDouble(int offset,
          double value)
throws OffsetOutOfBoundsException
```

Description

Set 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 transfered.

Parameters

offset of double in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the doubles in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first double in the memory region to be set.

values is 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,
       NullPointerException
```

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.1.7 RawFloat

Interfaces

javax.realtime.device.RawFloatReader
javax.realtime.device.RawFloatWriter

Description

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.8 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 transfered in a single atomic operation. Groups of floats may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawFloatReader[13] and RawMemoryFactory.createRawFloat[14]. Each object references a range of

[13] Section 12.3.2.6.3
[14] Section 12.3.2.6.3

elements in the RawMemoryRegion[15] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.8.1 Methods

---

getFloat

Signature

public float
getFloat()

Description

Get 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

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

[15] Section 12.3.2.7

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters
offset of the first float in the memory region to transfere
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 actuall transferred to values

get(int, float, int, int)

Signature

```
public int
get(int offset,
    float[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first float in the memory region to transfere

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 transfered.

12.3.1.9 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 transfered in a single atomic operation. Groups of floats may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawFloatWriter[16] and RawMemoryFactory.createRawFloat[17]. Each object references a range of elements in the RawMemoryRegion[18] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.9.1 Methods

---

setFloat(float)

Signature

public void
setFloat(float value)

Description

Set 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 is the new value for the element.

setFloat(int, float)

Signature

[16] Section 12.3.2.6.3
[17] Section 12.3.2.6.3
[18] Section 12.3.2.7

```
public void
setFloat(int offset,
         float value)
throws OffsetOutOfBoundsException
```

Description

Set 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 transfered.

Parameters

offset of float in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the floats in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first float in the memory region to be set.

values is 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,
       NullPointerException
```

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.1.10 RawInt

Interfaces
javax.realtime.device.RawIntReader
javax.realtime.device.RawIntWriter
Description

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.11 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 transfered in a single atomic operation. Groups of ints may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawIntReader[19] and RawMemoryFactory.createRawInt[20]. Each object references a range of elements in the RawMemoryRegion[21] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

[19] Section 12.3.2.6.3
[20] Section 12.3.2.6.3
[21] Section 12.3.2.7

12.3.1.11.1 Methods

getInt

Signature

public int
getInt()

Description

Get 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

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters

offset of the first int in the memory region to transfere

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 actuall transferred to values

get(int, int, int, int)

Signature

```
public int
get(int offset,
    int[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first int in the memory region to transfere

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 transfered.

12.3.1.12 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 transfered in a single atomic operation. Groups of ints may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawIntWriter[22] and RawMemoryFactory.createRawInt[23]. Each object references a range of elements in the RawMemoryRegion[24] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

[22]Section 12.3.2.6.3
[23]Section 12.3.2.6.3
[24]Section 12.3.2.7

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.

Available since RTSJ 2.0

12.3.1.12.1 Methods

---

setInt(int)

Signature

public void
setInt(int value)

Description

Set 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 is the new value for the element.

setInt(int, int)

Signature

public void
setInt(int offset,
int value)
throws OffsetOutOfBoundsException

Description

Set 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 transfered.

Parameters

offset of int in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the ints in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first int in the memory region to be set.

values is 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,
NullPointerException

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.1.13 RawLong

Interfaces

javax.realtime.device.RawLongReader
javax.realtime.device.RawLongWriter

Description

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.14 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 transfered in a single atomic operation. Groups of longs may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawLongReader[25] and RawMemoryFactory.createRawLong[26]. Each object references a range of elements in the RawMemoryRegion[27] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.14.1 Methods

getLong

Signature

public long
getLong()

Description

Get 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.

[25] Section 12.3.2.6.3
[26] Section 12.3.2.6.3
[27] Section 12.3.2.7

Returns
the value at the *base address*.

getLong(int)

Signature

```
public long
getLong(int offset)
throws OffsetOutOfBoundsException
```

Description

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters

offset of the first long in the memory region to transfere

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 actuall transferred to values

get(int, long, int, int)

Signature

```
public int
get(int offset,
    long[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first long in the memory region to transfere

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 transfered.

12.3.1.15 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 transfered in a single atomic operation. Groups of longs may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawLongWriter[28] and RawMemoryFactory.createRawLong[29]. Each object references a range of elements in the RawMemoryRegion[30] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.15.1 Methods

---

setLong(long)

Signature

public void
setLong(long value)

[28] Section 12.3.2.6.3
[29] Section 12.3.2.6.3
[30] Section 12.3.2.7

Description

Set 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 is the new value for the element.

setLong(int, long)

Signature

```
public void
setLong(int offset,
        long value)
throws OffsetOutOfBoundsException
```

Description

Set 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 transfered.

Parameters

offset of long in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the longs in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first long in the memory region to be set.

values is 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,
       NullPointerException
```

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.1.16 RawMemory

Description

A marker for all raw memory accessor objects.

Available since RTSJ 2.0

12.3.1.16.1 Methods

---

getAddress

Signature

public long
getAddress()

Description

Get the base physical address of this object.

Returns

the first physical address this raw memory object can access.

getSize

Signature

public int
getSize()

Description

Get the number of bytes that this object spans.

Returns

the size of this raw memory

getStride

Signature

public int
getStride()

Description

Get the distance between elements in multiples of element size.

Returns

the span between elements of this raw memory

12.3.1.17 RawMemoryRegionFactory

Description

A class to give an application the ability to provide support for a RawMemoryRegion[31] that is not already provided by the standard. An instance of this call can be registered with a RawMemoryFactory[32] and provides the object that that factory should return for 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.

Available since RTSJ 2.0

12.3.1.17.1 Methods

---

[31] Section 12.3.2.7
[32] Section 12.3.2.6

getRegion

Signature

public javax.realtime.device.RawMemoryRegion
getRegion()

Description

Determine for what region this factory creates raw memory objects.

Returns

the region of this factory.

getName

Signature

public java.lang.String
getName()

Description

Determine 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawByte[33] and accesses memory of getRegion[34] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawByte[35] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawByteReader(long, int, int)

Signature

```
public javax.realtime.device.RawByteReader
createRawByteReader(long base,
                    int count,
                    int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
```

[33]Section 12.3.1.1
[34]Section 12.3.1.17.1
[35]Section 12.3.1.1

UnsupportedRawMemoryRegionException,
MemoryTypeConflictException

Description

Create an instance of a class that implements RawByteReader[36] and accesses memory of getRegion[37] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawByteReader[38] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawByteWriter(long, int, int)

Signature

public javax.realtime.device.RawByteWriter
createRawByteWriter(long base,

[36]Section 12.3.1.2
[37]Section 12.3.1.17.1
[38]Section 12.3.1.2

```
                        int count,
                        int stride)
    throws SecurityException,
           OffsetOutOfBoundsException,
           SizeOutOfBoundsException,
           UnsupportedRawMemoryRegionException,
           MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawByteWriter[39] and accesses memory of getRegion[40] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawByteWriter[41] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

[39] Section 12.3.1.3
[40] Section 12.3.1.17.1
[41] Section 12.3.1.3

createRawShort(long, int, int)

Signature

public javax.realtime.device.RawShort
createRawShort(long base,
int count,
int stride)
throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
UnsupportedRawMemoryRegionException,
MemoryTypeConflictException

Description

Create an instance of a class that implements RawShort[42] and accesses memory of getRegion[43] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawShort[44] and supports access to the specified range in the memory region.

[42]Section 12.3.1.18
[43]Section 12.3.1.17.1
[44]Section 12.3.1.18

Available since RTSJ 2.0

createRawShortReader(long, int, int)

Signature

```
public javax.realtime.device.RawShortReader
createRawShortReader(long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawShortReader[45] and accesses memory of getRegion[46] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

[45] Section 12.3.1.19
[46] Section 12.3.1.17.1

Returns

an object that implements RawShortReader[47] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawShortWriter(long, int, int)

Signature

```
public javax.realtime.device.RawShortWriter
createRawShortWriter(long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawShortWriter[48] and accesses memory of getRegion[49] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

[47] Section 12.3.1.19
[48] Section 12.3.1.20
[49] Section 12.3.1.17.1

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawShortWriter[50] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawInt(long, int, int)

Signature

```
public javax.realtime.device.RawInt
createRawInt(long base,
             int count,
             int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawInt[51] and accesses memory of getRegion[52] 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

[50] Section 12.3.1.20
[51] Section 12.3.1.10
[52] Section 12.3.1.17.1

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawInt[53] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawIntReader(long, int, int)

Signature

```
public javax.realtime.device.RawIntReader
createRawIntReader(long base,
                   int count,
                   int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawIntReader[54] and accesses memory of getRegion[55] 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

[53] Section 12.3.1.10
[54] Section 12.3.1.11
[55] Section 12.3.1.17.1

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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawIntReader[56] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawIntWriter(long, int, int)

Signature

```
public javax.realtime.device.RawIntWriter
createRawIntWriter(long base,
                   int count,
                   int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawIntWriter[57] and accesses memory of getRegion[58] in the address range described by base, stride, and count.

[56] Section 12.3.1.11
[57] Section 12.3.1.12
[58] Section 12.3.1.17.1

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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawIntWriter[59] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawLong(long, int, int)

Signature

```
public javax.realtime.device.RawLong
createRawLong(long base,
              int count,
              int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

[59] Section 12.3.1.12

Description

Create an instance of a class that implements RawLong[60] and accesses memory of getRegion[61] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawLong[62] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawLongReader(long, int, int)

Signature

```
public javax.realtime.device.RawLongReader
createRawLongReader(long base,
                    int count,
                    int stride)
```

[60] Section 12.3.1.13
[61] Section 12.3.1.17.1
[62] Section 12.3.1.13

throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
UnsupportedRawMemoryRegionException,
MemoryTypeConflictException

Description

Create an instance of a class that implements RawLongReader[63] and accesses memory of getRegion[64] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawLongReader[65] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawLongWriter(long, int, int)

[63]Section 12.3.1.14
[64]Section 12.3.1.17.1
[65]Section 12.3.1.14

Signature

```
public javax.realtime.device.RawLongWriter
createRawLongWriter(long base,
                    int count,
                    int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawLongWriter[66] and accesses memory of getRegion[67] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawLongWriter[68] and supports access to the specified range in the memory region.

[66] Section 12.3.1.15
[67] Section 12.3.1.17.1
[68] Section 12.3.1.15

Available since RTSJ 2.0

createRawFloat(long, int, int)

Signature

public javax.realtime.device.RawFloat
createRawFloat(long base,
int count,
int stride)
throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
UnsupportedRawMemoryRegionException,
MemoryTypeConflictException

Description

Create an instance of a class that implements RawFloat[69] and accesses memory of getRegion[70] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

[69] Section 12.3.1.7
[70] Section 12.3.1.17.1

Returns

an object that implements RawFloat[71] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawFloatReader(long, int, int)

Signature

```
public javax.realtime.device.RawFloatReader
createRawFloatReader(long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawFloatReader[72] and accesses memory of getRegion[73] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

[71] Section 12.3.1.7
[72] Section 12.3.1.8
[73] Section 12.3.1.17.1

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawFloatReader[74] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawFloatWriter(long, int, int)

Signature

```
public javax.realtime.device.RawFloatWriter
createRawFloatWriter(long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawFloatWriter[75] and accesses memory of getRegion[76] 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.

[74] Section 12.3.1.8
[75] Section 12.3.1.9
[76] Section 12.3.1.17.1

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawFloatWriter[77] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawDouble(long, int, int)

Signature

```
public javax.realtime.device.RawDouble
createRawDouble(long base,
                int count,
                int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawDouble[78] and accesses memory of getRegion[79] 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

[77] Section 12.3.1.9
[78] Section 12.3.1.4
[79] Section 12.3.1.17.1

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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawDouble[80] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawDoubleReader(long, int, int)

Signature

```
public javax.realtime.device.RawDoubleReader
createRawDoubleReader(long base,
                      int count,
                      int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

Description

Create an instance of a class that implements RawDoubleReader[81] and accesses memory of getRegion[82] in the address range described by base, stride, and count.

[80] Section 12.3.1.4
[81] Section 12.3.1.5
[82] Section 12.3.1.17.1

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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawDoubleReader[83] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

createRawDoubleWriter(long, int, int)

Signature

```
public javax.realtime.device.RawDoubleWriter
createRawDoubleWriter(long base,
                      int count,
                      int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       UnsupportedRawMemoryRegionException,
       MemoryTypeConflictException
```

[83] Section 12.3.1.5

Description

Create an instance of a class that implements RawDoubleWriter[84] and accesses memory of getRegion[85] 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

IllegalArgumentException when base is negative, count is not greater than zero, or stride is not greater than zero.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to memory that matches the type served by this factory.

Returns

an object that implements RawDoubleWriter[86] and supports access to the specified range in the memory region.

Available since RTSJ 2.0

12.3.1.18 RawShort

Interfaces

javax.realtime.device.RawShortReader
javax.realtime.device.RawShortWriter

Description

[84]Section 12.3.1.6
[85]Section 12.3.1.17.1
[86]Section 12.3.1.6

A marker for an object that can be used to access to 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.

Available since RTSJ 2.0

12.3.1.19 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 transfered in a single atomic operation. Groups of shorts may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawShortReader[87] and RawMemoryFactory.createRawShort[88]. Each object references a range of elements in the RawMemoryRegion[89] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.19.1 Methods

---

getShort

Signature

[87] Section 12.3.2.6.3
[88] Section 12.3.2.6.3
[89] Section 12.3.2.7

public short
getShort()

Description

Get 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

Get the value at the address: base address + offset x stride x element size in bytes. When an exception is thrown, no data is transfered.

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

Fill values with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x 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 transfered. When an exception is thrown, no data is transfered.

Parameters

offset of the first short in the memory region to transfere

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 actuall transferred to values

get(int, short, int, int)

Signature

```
public int
get(int offset,
    short[] values,
    int start,
    int count)
throws OffsetOutOfBoundsException,
       ArrayIndexOutOfBoundsException,
       NullPointerException
```

Description

Fill values from index start with elements from this instance, where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. The number of bytes transfered 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 transfered.

Parameters

offset of the first short in the memory region to transfere

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 transfered.

12.3.1.20 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 transfered in a single atomic operation. Groups of shorts may be transfered together; however, this is not required.

Objects of this type are created with the method RawMemoryFactory.createRawShortWriter[90] and RawMemoryFactory.createRawShort[91]. Each object references a range of elements in the RawMemoryRegion[92] starting at the *base address* provided to the factory method. The size provided to the factor method determines the number of elements accessable.

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.

Available since RTSJ 2.0

12.3.1.20.1 Methods

---

[90] Section 12.3.2.6.3
[91] Section 12.3.2.6.3
[92] Section 12.3.2.7

setShort(short)

Signature

public void
setShort(short value)

Description

Set 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 is the new value for the element.

setShort(int, short)

Signature

public void
setShort(int offset,
short value)
throws OffsetOutOfBoundsException

Description

Set 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 transfered.

Parameters

offset of short in the memory region.

value is 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

Copy from values to the memory region from index start,to elements where the nth element is at the address: base address + (offset+n) x stride x element size in bytes. Only the shorts in the intersection of values and the end of the memory region are transfered. When an exception is thrown, no data is transfered.

Parameters

offset of first short in the memory region to be set.

values is 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,
       NullPointerException
```

Description

Copy 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 transfered 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 transfered.

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 transfered.

12.3.2 Classes

12.3.2.1 DMABufferFactory

Inheritance

java.lang.Object
  javax.realtime.device.DMABufferFactory

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 DMABufferFactory instance may overlap that of another DMABufferFactory instance.

12.3.2.1.1 Constructors

DMABufferFactory(DMARegion, long, long)

Signature

public
DMABufferFactory(DMARegion region,
long base,
long size)
throws MemoryInUseException

Description

Create a factory for allocating buffers in a particular address range. Whether the address is physical or virtual is system dependent.

Parameters

region is the area of memory a DMA controller can reference, from which this factory takes its memory.

base is the base address of a memory range in region for buffer allocation

size is the number of bytes in the memory range

Throws

MemoryInUseException when the memory area provide is already in use by or reserved for a javax.realtime.MemoryArea[93], program code, or other sytem or VM structure.

12.3.2.1.2 Methods

---

allocateDirectByteBuffer(int)

Signature

public java.nio.ByteBuffer
allocateDirectByteBuffer(int capacity)

Description

Create 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.

[93] Section 11.3.3.3

free(ByteBuffer)

Signature

public void
free(ByteBuffer buffer)

Description

Free the memory associated with the given ByteBuffer instance. The capacity and limit of the buffer are both set to zero, so data can no longer be transfered with the buffer. The buffer range can then be safely reallocated.

Parameters

buffer is the ByteBuffer to free.

Throws

IllegalArgumentException when buffer was not allocated from this factory.

IllegalStateException when buffer has already been freed.

Open issue 12.3.1

Should we have our own buffer class with this methods defined there instead of here?

End of issue 12.3.1

inRange(ByteBuffer)

Signature

public boolean
inRange(ByteBuffer buffer)

Description

Check to see if the buffer's data area is within the range of this factory.

Parameters

buffer to check

Returns

true when and only when buffer's data area is within the range of this factory; otherwise false

addressOf(ByteBuffer)

Signature

public long
addressOf(ByteBuffer buffer)

Description

Give the location of this buffers data in memory. The address shall be in the address space of the DMA controller.

Parameters
buffer of which to get the address
Returns
the start address of the data range of this buffer

writeFence(ByteBuffer)

Signature
public static void
writeFence(ByteBuffer buffer)

Description

Ensures that all changes to the DirectByteBuffer buffer 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(ByteBuffer)

Signature
public static void
readFence(ByteBuffer buffer)

Description

Ensures that any previous changes to the memory represented by the given DirectByteBuffer 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(ByteBuffer)[94] or its native equivalent on the buffer's memory.

Parameters
buffer the byte buffer which will be updated

12.3.2.2 DMARegion

Inheritance
java.lang.Object
javax.realtime.device.DMARegion
Description

Define the reachable memory for a given DMA controller in terms of the physical address space of the system.

12.3.2.2.1 Constructors

DMARegion(long, long)

Signature

```
public
DMARegion(long start,
          long size)
throws IllegalArgumentException
```

Description

Create a DMA memory definition.

Parameters

[94] Section 12.3.1

start address of the DMA address space in the physical address address space of the main processor.

size is the number of bytes in the DMA address space

Throws

IllegalArgumentException when start is less than zero or start + size is larger than the physical memory of the system.

12.3.2.2.2 Methods

---

regionAddressOf(long)

Signature

public long
regionAddressOf(long address)
throws IllegalArgumentException

Description

Translate a physical address into a DMA region address.

Parameters

address to translate

Throws

IllegalArgumentException when the results is outside the DMA space.

Returns

the equivalent address in DMA space.

physicalAddressOf(long)

Signature

public long
physicalAddressOf(long address)
throws IllegalArgumentException

Description

Translate a DMA space address into a physical address.

Parameters

address to translate

Throws

IllegalArgumentException when the input is outside the DMA space.

Returns

the corresponding physical address

12.3.2.3 Happening

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncEvent
      javax.realtime.device.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[95] 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 provide by the system which is a string beginning with @.

Available since RTSJ 2.0

12.3.2.3.1 Constructors

Happening(String, HappeningDispatcher)

Signature

public
Happening(String name,
HappeningDispatcher dispatcher)

[95] Section 12.3.2.5

throws IllegalArgumentException

Description

Create a Happening with the given name.

Parameters

name of the happening.

dispatcher to use when being triggered.

Throws

IllegalArgumentException 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 IllegalArgumentException

Description

Create a Happening with the given name and the default dispatcher.

Parameters

name of the happening.

Throws

IllegalArgumentException 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.

12.3.2.3.2 Methods

---

getHappening(String)

Signature

public static javax.realtime.device.Happening
getHappening(String name)

Description

Find an active happening by its name.

Parameters
name of the happening to get.
Throws
IllegalArgumentException when name is null.

Returns
a reference to the happening with name name, or null if no happening is found.

isHappening(String)

Signature
public static boolean
isHappening(String name)

Description

Is there an active happening with name name?

Parameters
name A string that might name an active happening.
Throws
IllegalArgumentException when name is null.

Returns
True only when there is a registered happening with the name name.

createId(String)

Signature
public static int
createId(String name)
throws IllegalStateException

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[96] 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 is a happing name string.
Throws
IllegalStateException when name is already registered.
IllegalArgumentException when name is null.

Returns
an ID assigned by the system

getId(String)

Signature
public static int
getId(String name)

Description

Return 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 is a happening name string.
Throws
IllegalArgumentException when name is null.

Returns
The id, or -1 when no happening is found with that name.

get(int)

Signature

[96]Section 12.3.2.5

public static javax.realtime.device.Happening
get(int id)

Description

Get the external event corresponding to a given id.

Parameters
id of a registered signal
Returns
the signal corresponding to id.

get(String)

Signature

public static javax.realtime.device.Happening
get(String name)

Description

Get the external event corresponding to a given name.

Parameters
name of a registered signal
Throws
IllegalArgumentException 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[97] method.

[97] Section 12.3.2.5.2

trigger() and any native code analog to it interact with other javax.realtime.ActiveEvent[98] 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 if a happening with id happeningId was found, false otherwise.

getId

Signature

public final int
getId()

Description

Get the number of this happening.

Returns
the happening number or -1, when not registered.

getName

Signature

public java.lang.String
getName()

Description

Get the name of this happening.

Returns
the name of this happening.

[98] Section 8.3.1.1

start

Signature

public void
start()
throws IllegalStateException

Description

Start this Happening, i.e., change to the active and enabled state. 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

IllegalStateException 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 IllegalStateException

Description

Start this Happening, but leave 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

IllegalStateException when this Happening has already been started.

See Section stop()

stop

Signature

public boolean
stop()
throws IllegalStateException

Description

Stop this happening from responding to the fire and trigger methods.

Throws
IllegalStateException when this Happening is not active.

Returns
true when this is in the *enabled* state false otherwise.

isActive

Signature
public boolean
isActive()

Description

Determine the activation state of this happening, i.e., it has been started.

Returns
true when active, false otherwise.

isRunning

Signature
public boolean
isRunning()

Description

Determine whether or not this Happening is both active an enabled.

Returns
true when this Happening is both active and enabled, 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[99] method.

This method must execute in constant time.

getDispatcher

Signature

public javax.realtime.device.HappeningDispatcher
getDispatcher()

Description

Obtain the dispatcher for this.

Returns

that dispatcher.

12.3.2.4 HappeningDispatcher

Inheritance

java.lang.Object
  javax.realtime.ActiveEventDispatcher
    javax.realtime.device.HappeningDispatcher

Description

This class provides a means of dispatching a set of Happening[100].

12.3.2.4.1 Constructors

---

[99] Section 12.3.2.5.2
[100] Section 12.3.2.3

HappeningDispatcher(SchedulingParameters, SchedulingGroup)

Signature

public
HappeningDispatcher(SchedulingParameters schedule,
SchedulingGroup group)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

schedule give the parameters for scheduling this dispatcher

HappeningDispatcher(SchedulingParameters)

Signature

public
HappeningDispatcher(SchedulingParameters schedule)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

schedule give the parameters for scheduling this dispatcher

12.3.2.4.2 Methods

---

register(Happening)

Signature

public synchronized void
register(Happening happening)

throws RegistrationException,
IllegalStateException,
IllegalArgumentException

Description

Register a Happening[101] with this dispatcher.

Parameters

happening to register

Throws

RegistrationException when happening is already registered.

IllegalStateException when this object has been destroyed.

IllegalArgumentException when happening is not stopped.

deregister(Happening)

Signature

public synchronized void
deregister(Happening happening)
throws DeregistrationException,
IllegalStateException,
IllegalArgumentException

Description

Unregister a Happening[102] from this dispatcher.

Parameters

happening to unregister

Throws

DeregistrationException when happening is not already registered.

IllegalStateException when this object has been destroyed.

IllegalArgumentException when happening is not stopped.

destroy

Signature

[101] Section 12.3.2.3
[102] Section 12.3.2.3

public void
destroy()
throws IllegalStateException

Description

Release all reasources thereby making the dispatcher unusable.

Throws

IllegalStateException when called on a dispatcher that has one or more registered Happening[103] objects.

12.3.2.5 InterruptServiceRoutine

Inheritance

java.lang.Object
javax.realtime.device.InterruptServiceRoutine

Interfaces

javax.realtime.RealtimeExecutionContext

Description

A class for defining a first level interrupt handler. The implementation must override the handle[104] 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.

12.3.2.5.1 Constructors

InterruptServiceRoutine(MemoryArea)

Signature

public
InterruptServiceRoutine(MemoryArea area)

[103] Section 12.3.2.3
[104] Section 12.3.2.5.2

throws NullPointerException,
IllegalArgumentException

Description

Create an interrupt service routine with a particular memory area.

Parameters

area the allocation context in which the handle[105] method runs.

Throws

NullPointerException when area is null.

IllegalArgumentException when area is a memory are that cannot be accessed from an ISR.

12.3.2.5.2 Methods

---

validInterruptIds

Signature

public static int[]
validInterruptIds()

Description

Determine which interrupt identifiers are valid.

Returns

an ordered array of integers representing the valid interrupts in the system. On a machine that does not support any interrupts, a zero length array is returned.

getHandler(int)

Signature

public static javax.realtime.device.InterruptServiceRoutine
getHandler(int interrupt)

Description

Find the InterruptServiceRoutine that is handling a given interrupt.

[105] Section 12.3.2.5.2

Parameters
interrupt for which to find the InterruptServiceRoutine
Returns
the InterruptServiceRoutine registered to the given interrupt. Null is returned when nothing is registered for that interrupt.

getMaximumInterruptPriority

Signature
public static int
getMaximumInterruptPriority()

Description
Retrieve the maximum interrupt priority. It must be greater than or equal to the result of getMinimumInterruptPriority[106].

Returns
the maximum interrupt priority.

getMinimumInterruptPriority

Signature
public static int
getMinimumInterruptPriority()

Description
Retrieve the minimum interrupt priority. It must be higher than all other priorities provided by the system.

Returns
the minimum interrupt priority.

getInterruptPriority(int)

Signature
public static int
getInterruptPriority(int interruptId)

[106]Section 12.3.2.5.2

throws IllegalArgumentException

Description
Get the interrupt priority of a given interrupt.

Throws
IllegalArgumentException when there is no interrupt corresponding to interruptId

Returns
the priority at which the handle[107] method is involked. The returned value is always greater than javax.realtime.PriorityScheduler.getMaxPriority()[108].

isRegistered

Signature
public final boolean
isRegistered()

Description
A predicate for the registration state.

Returns
true when registered, otherwise false.

register(int)

Signature
public void
register(int interrupt)
throws RegistrationException

Description
Register this interrupt service routine with the system so that it can be triggered.

Parameters
interrupt a system dependent identifier for the interrupt.

Throws
RegistrationException when this is already registered or some other InterruptServiceRoutine[109] is registered for interrupt.

[107] Section 12.3.2.5.2
[108] Section 6.3.3.8.3
[109] Section 12.3.2.5

unregister

Signature

public void
unregister()
throws DeregistrationException

Description

Deregister this interrupt service routine with the system so that it can no longer be triggered.

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[110] classes may be used to access the associated device registers and a Happening[111] may be triggered for second level interrupt handling.

The code used to implement this method should not block itself for an unbounded amount of time or induce a context switch, e.g., sleeping. 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 Object.wait() should not be called.

Unless the overridden method is synchronized, the infrastructure shall provide no synchronization for the execution of this method. When the javax.realtime.MemoryArea[112] provided at creation is a javax.realtime.memory.ScopedMemory[113], its count is incremented on entry to this method and decremented on exit.

Open issue 12.3.2

[110] Section 12.3.1.16
[111] Section 12.3.2.3
[112] Section 11.3.3.3
[113] Section 11.4.3.6

What is the ISR handle method allowed to do and how are errors handled? Should there be an error handler?
End of issue 12.3.2

12.3.2.6 RawMemoryFactory

Inheritance
java.lang.Object
javax.realtime.device.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)[114] 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)[115] method returns a reference to an object that implements the RawByte[116] 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.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[117]) which can create

[114]Section 12.3.2.6.3
[115]Section 12.3.2.6.3
[116]Section 12.3.1.1
[117]Section 12.3.1.17

objects to access memory in that region.

A raw memory region factory is identified by a RawMemoryRegion[118] that is used by each create method, e.g., createRawByte(RawMemoryRegion, long, int, int)[119], to locate the appropriate factory. The name is provided to register(RawMemoryRegionFactory)[120] through the factory's RawMemoryRegionFactory.getName[121] method.

The register(RawMemoryRegionFactory)[122] method is only used when by application code when it needs to add support for a new type of raw memory.

Whether a give 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[123] static byte variable in class javax.realtime.RealtimeSystem[124], the start address of the object, and 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.

[118] Section 12.3.2.7
[119] Section 12.3.2.6.3
[120] Section 12.3.2.6.3
[121] Section 12.3.1.17.1
[122] Section 12.3.2.6.3
[123] Section 14.2.2.3.1
[124] Section 14.2.2.3

This class need not support unaligned access to data; but if it does, it is not require 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 schedulable objects. A raw memory region could be updated by another schedulable object, 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 represent 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 dimension are

Table 12.1: 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 *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 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.

Available since RTSJ 2.0

12.3.2.6.1 Fields

MEMORY_MAPPED_REGION

public static final MEMORY_MAPPED_REGION

Description

This raw memory region is predefined for request access to memory mapped I/O devices.

IO_PORT_MAPPED_REGION

public static final 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.

12.3.2.6.2 Constructors

RawMemoryFactory

Signature

public
RawMemoryFactory()

Description

Create an empty factory. For a factory with support for the platform defined regions, use getDefaultFactory[125] instead.

12.3.2.6.3 Methods

---

getDefaultFactory

Signature

public static javax.realtime.device.RawMemoryFactory
getDefaultFactory()

Description

Get the factory with support for the platform defined regions.

Returns

the platform defined factory

register(RawMemoryRegionFactory)

Signature

public void
register(RawMemoryRegionFactory factory)
throws RegistrationException

Description

Add support for a new memory region

Parameters

factory is the RawMemoryRegionFactory[126] to use for creating RawMemory[127] objects for the RawMemoryRegion[128]s it makes available.

Throws

RegistrationException when the factory already is already registered.

[125] Section 12.3.2.6.3
[126] Section 12.3.1.17
[127] Section 12.3.1.16
[128] Section 12.3.2.7

deregister(RawMemoryRegionFactory)

Signature

public void
deregister(RawMemoryRegionFactory factory)
throws DeregistrationException

Description

Remove support for a new memory region

Parameters

factory is the RawMemoryRegionFactory[129] to make unavailable.

Throws

RegistrationException when the factory is not registered.

createRawByte(RawMemoryRegion, long, int, int)

Signature

public javax.realtime.device.RawByte
createRawByte(RawMemoryRegion region,
long base,
int count,
int stride)
throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
MemoryTypeConflictException,
UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawByte[130] 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.

[129] Section 12.3.1.17
[130] Section 12.3.1.1

count The number of memory elements accessible through the returned instance.

stride The distance to the next element as a mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawByte[131] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawByteReader[132] 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.

[131] Section 12.3.1.1
[132] Section 12.3.1.2

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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawByteReader[133] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawByteWriter[134] and accesses

[133] Section 12.3.1.2

[134] Section 12.3.1.3

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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawByteWriter[135] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
```

[135] Section 12.3.1.3

UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawShort[136] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawShort[137] 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)
```

[136] Section 12.3.1.18
[137] Section 12.3.1.18

throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
MemoryTypeConflictException,
UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawShortReader[138] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawShortReader[139] and supports access to the specified range in the memory region.

createRawShortWriter(RawMemoryRegion, long, int, int)

Signature

[138] Section 12.3.1.19
[139] Section 12.3.1.19

```
public javax.realtime.device.RawShortWriter
createRawShortWriter(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawShortWriter[140] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawShortWriter[141] and supports access to the specified range in the memory region.

[140] Section 12.3.1.20
[141] Section 12.3.1.20

createRawInt(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawInt
createRawInt(RawMemoryRegion region,
             long base,
             int count,
             int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawInt[142] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

[142] Section 12.3.1.10

an object that implements RawInt[143] 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,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
MemoryTypeConflictException,
UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawIntReader[144] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

[143]Section 12.3.1.10
[144]Section 12.3.1.11

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawIntReader[145] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawIntWriter[146] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

[145] Section 12.3.1.11
[146] Section 12.3.1.12

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawIntWriter[147] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawLong[148] 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.

[147] Section 12.3.1.12
[148] Section 12.3.1.13

stride The distance to the next element as a mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawLong[149] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawLongReader[150] 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.

[149]Section 12.3.1.13
[150]Section 12.3.1.14

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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawLongReader[151] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawLongWriter[152] and accesses

[151] Section 12.3.1.14

[152] Section 12.3.1.15

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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawLongWriter[153] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
```

[153] Section 12.3.1.15

UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawFloat[154] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawFloat[155] 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)
```

[154]Section 12.3.1.7
[155]Section 12.3.1.7

throws SecurityException,
OffsetOutOfBoundsException,
SizeOutOfBoundsException,
MemoryTypeConflictException,
UnsupportedRawMemoryRegionException

Description

Create an instance of a class that implements RawFloatReader[156] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawFloatReader[157] and supports access to the specified range in the memory region.

createRawFloatWriter(RawMemoryRegion, long, int, int)

Signature

[156]Section 12.3.1.8
[157]Section 12.3.1.8

```
public javax.realtime.device.RawFloatWriter
createRawFloatWriter(RawMemoryRegion region,
                     long base,
                     int count,
                     int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawFloatWriter[158] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawFloatWriter[159] and supports access to the specified range in the memory region.

[158] Section 12.3.1.9
[159] Section 12.3.1.9

createRawDouble(RawMemoryRegion, long, int, int)

Signature

```
public javax.realtime.device.RawDouble
createRawDouble(RawMemoryRegion region,
                long base,
                int count,
                int stride)
throws SecurityException,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawDouble[160] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

[160] Section 12.3.1.4

an object that implements RawDouble[161] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawDoubleReader[162] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

[161] Section 12.3.1.4
[162] Section 12.3.1.5

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawDoubleReader[163] 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,
       OffsetOutOfBoundsException,
       SizeOutOfBoundsException,
       MemoryTypeConflictException,
       UnsupportedRawMemoryRegionException
```

Description

Create an instance of a class that implements RawDoubleWriter[164] 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 mulitple of element size, where 1 means the elements are adjacent in memory.

Throws

[163] Section 12.3.1.5

[164] Section 12.3.1.6

IllegalArgumentException when base is negative, count is not greater than zero, or stride is less than one.

SecurityException when the caller does not have permissions to access the given memory region or the specified range of addresses.

OffsetOutOfBoundsException when base is invalid.

SizeOutOfBoundsException when the memory addressed by the object would extend into an invalid range of memory.

MemoryTypeConflictException when base does not point to a memory that matches the type served by this factory.

Returns

an object that implements RawDoubleWriter[165] and supports access to the specified range in the memory region.

12.3.2.7 RawMemoryRegion

Inheritance

java.lang.Object
javax.realtime.device.RawMemoryRegion

Description

RawMemoryRegion is a class for typing raw memory regions. It is returned by the RawMemoryRegionFactory.getRegion[166] methods of the raw memory region factory classes, and it is used with methods such as RawMemoryFactory.createRawByte(RawMemoryRegion, long, int, int)[167] and RawMemoryFactory.createRawDouble(RawMemoryRegion, long, int, int)[168] methods to identify the region from which the application wants to get an accessor instance.

Available since RTSJ 2.0

12.3.2.7.1 Methods

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[165] Section 12.3.1.6
[166] Section 12.3.1.17.1
[167] Section 12.3.2.6.3
[168] Section 12.3.2.6.3

getRegion(String)

Signature

public static javax.realtime.device.RawMemoryRegion
getRegion(String name)

Description

Get a region type when it already exists or creates a new one.

Parameters
name of the region
Returns
the region type object.

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.

12.4 Rationale

12.4.1 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.

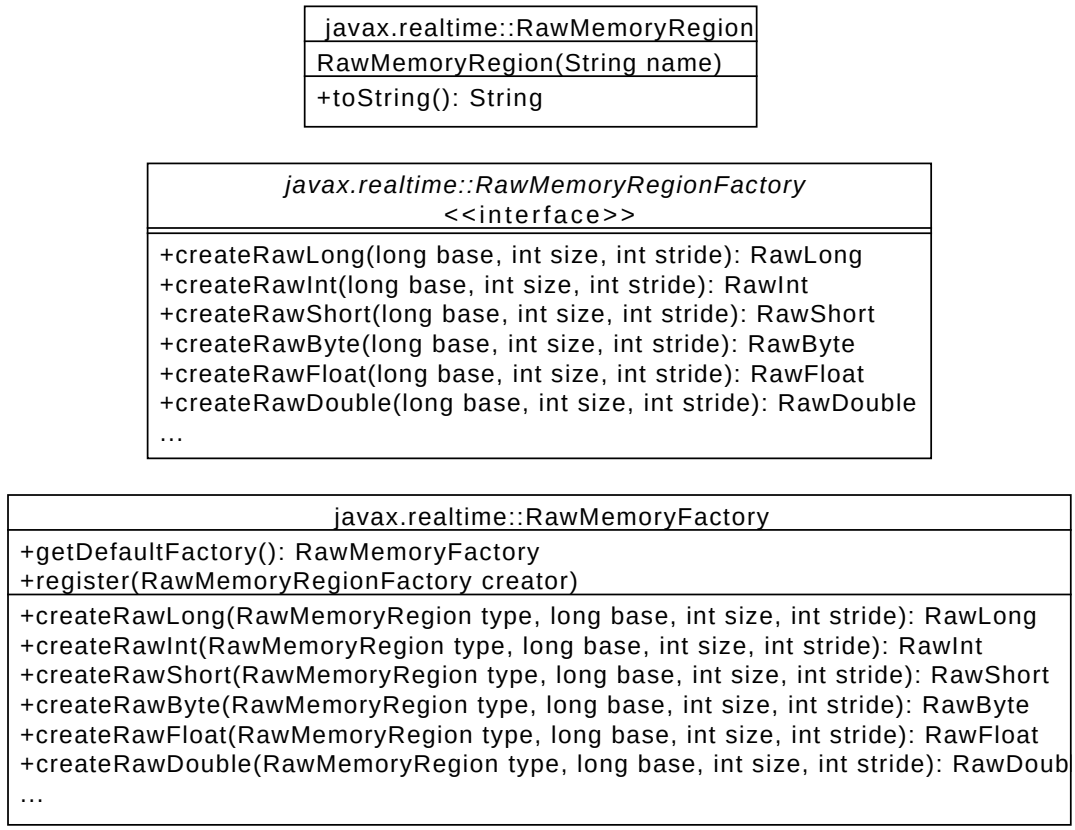
Each of these categories of memory is represented by an instance of RawMemoryRegion. In addition, the application can define other regions outside these two, either for accessing devices registers in some other address space or for other purposes, such as emulating device access.

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 encapsulates the access protocol to the raw memory.

Control over all these objects is managed by the RawMemoryFactory class that provides a set of static methods, as shown in Figure 12.5. There are two groups of methods, those that

1. enable a factory to be registered, and
2. request the creation of *accessor* object for a particular memory type at a particular address.

Figure 12.5: Creating Raw Memory Accessors



The latter consists of methods to create Java-primitive-type accessor objets, 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 a 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 supports 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 allows it only to be accessed as a raw memory device. An example of this will be given in Section 12.4.3.

12.4.1.1 Direct memory access

DMA requires access to memory out side 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.

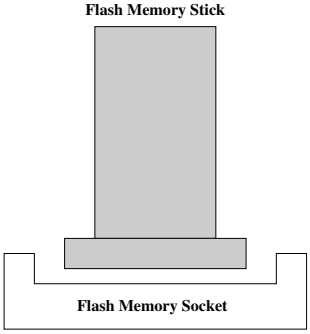
1. The RTSJ does not address issues of persistent objects; so the input and output of Java objects to devices (other than by using the Java serialization mechanism) is not supported.

2. The RTSJ requires that RTSJ programs can be compiled by regular Java compilers. Different bytecode compilers (and their supporting JVM) 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 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 DMARegion 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 DMARegion 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.

Figure 12.6: Flash memory device



12.4.2 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[169]. 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 usually be used to determine the worst-case stack usage of all interrupt handlers. If stack is borrowed from the executing thread then 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]).

[169] See http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0375a/Cegbfjhf.html

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.
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.

12.4.3 An Illustrative Example

Consider an embedded system that has a simple flash memory device that supports a single type of removable flash memory stick, as illustrated in Figure 12.6.

When the memory stick is inserted or removed, an interrupt is generated. This interrupt is known to the realtime JVM. The interrupt is also generated when operations requested on the device are completed. For simplicity, it is assumed that the application has associated this interrupt to an happening called FlashHappening with a default happening dispatcher.

The example illustrates how

1. a programmer can use the RTSJ facilities to write a device handler,
2. a factory class can be constructed and how the accessor objects police the access,
3. removable memory can be handled.

The flash memory device is accessed via several associated registers, which are shown in Table 12.2. These have all been memory mapped to the indicated locations.

12.4.3.1 Software architecture

There are many ways in which the software architecture for the example could be constructed. Here, for simplicity of representation, an architecture is chosen with

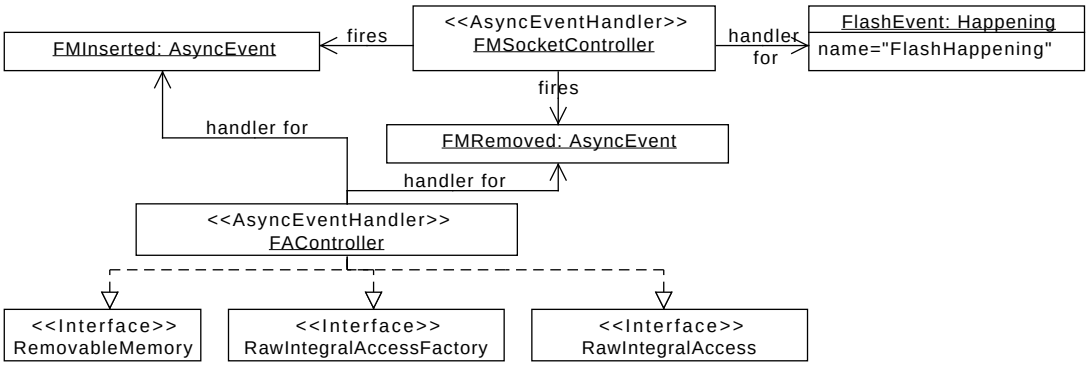
Table 12.2: Device registers

Register	Location	Bit Positions	Values
Command	0x20	0	0 = Disable device, 1 = Enable device
		4	0 = Disable interrupts, 1 = Enable interrupts
		5-8	1 = Read byte, 2 = Write byte
			3 = Read short, 4 = Write short
			5 = Read int, 6 = Write int
			7 = Read long, 8 = Write long
		9	0 = DMA Read, 1 = DMA
		31-63	Offset into flash memory
Data	0x28	0-63	Simple data or memory address if DMA
Length	0x30	0-31	Length of data transfer
Status	0x38	0	1 = Device enabled
		3	1 = Interrupts enabled
		4	1 = Device in error
		5	1 = Transfer complete
		6	1 = Memory stick present
			0 = Memory stick absent
		7	1 = Memory stick inserted
		8	0 = Memory stick removed

a minimal number of classes. It is illustrated in Figure 12.7. There are three key components.

1. FlashHappening—This is the happening that has been associated with the flash device's interrupt. The RTSJ will provide a default dispatcher, which will release any associated handler when the interrupt occurs and the happening is triggered.
2. FMSocketController—This is the object that encapsulates the access to the flash memory device. In essence, it is the device driver; it is also the handler for the FlashHappening and is responsibly for firing the FMInserted and FMRemoved asynchronous events.
3. FAController—This is the object that controls access to the flash memory, it
   (a) acts as the factory for the creating objects that will facilitate access to the flash memory itself (using the mechanisms provided by the FMSocketController),
   (b) is the asynchronous event handler that responds to the firing of the FMInserted and FMRemoved asynchronous events, and
   (c) also acts as the accessor object for the memory.

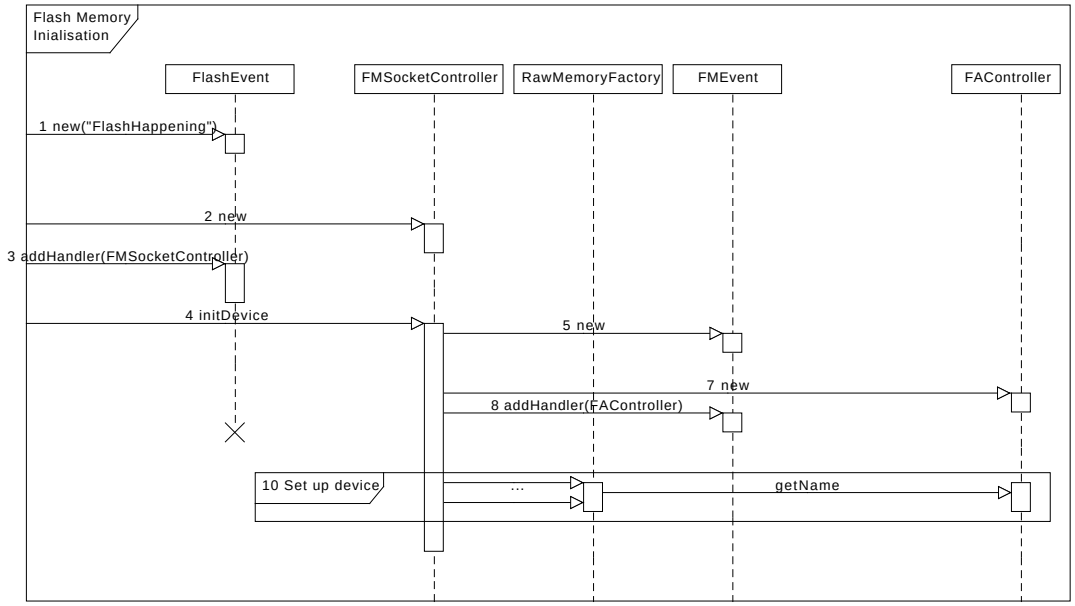
Figure 12.7: Flash memory classes



12.4.3.2 Device initialization

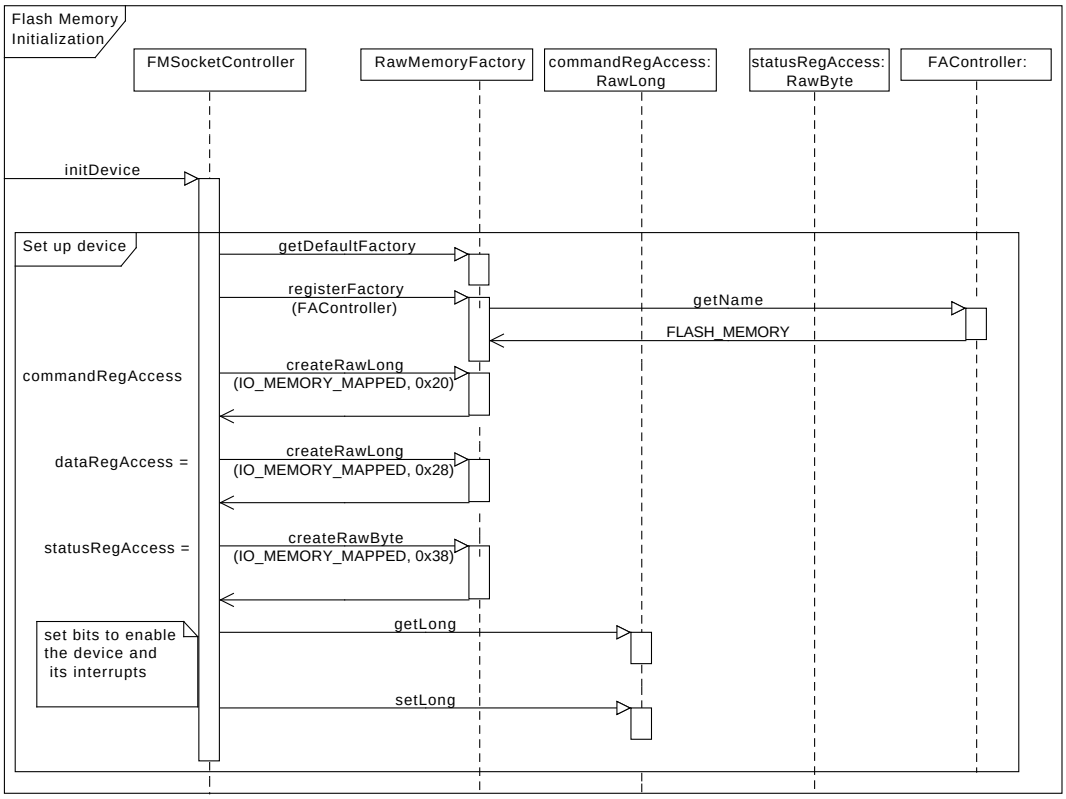
Figure 12.8 shows the sequence of operations that the program must perform to initialize the flash memory device. The main steps are as follows.

Figure 12.8: Sequence diagram showing initialization operations



1 The happening (FlashEvent) associated with the flash happening must be created.

Figure 12.9: Sequence diagrams showing operations to initialize the hardware device



2-3 The (FMSocketController) object is created and added as a handler for FlashEvent.

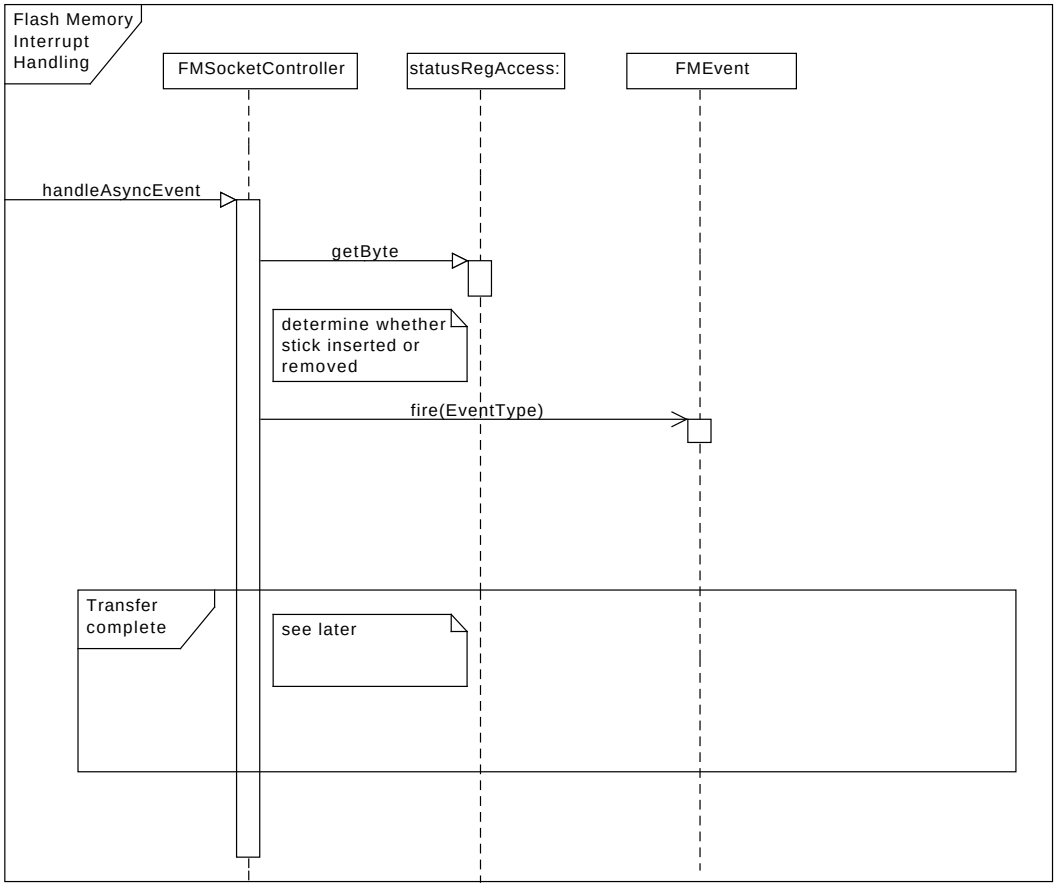
4 An initialization method is called (initDevice) to perform all the operations necessary to configure the infrastructure and initialize the hardware device.

5-6 Two new asynchronous events are created to represent insertion and removal of the flash memory stick.

7-9 The FAController class is created. It is added as the handler for the two events created in steps 5 and 6.

10 Setting up the device and registering the factory is shown in detail in Figure 12.9. It involves registering the FAController object via the static methods in the RawMemoryFactory class and creating and using the JVM-supplied factory to access the memory-mapped I/O registers.

Figure 12.10: The FMSocketController.handleAsync method



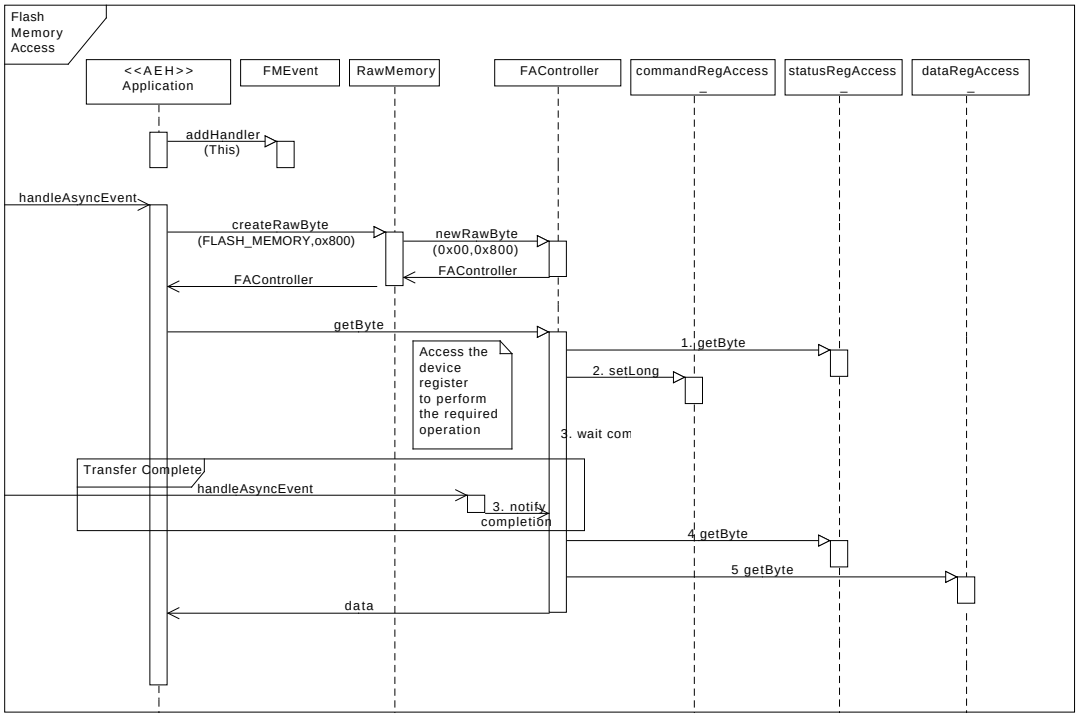
12.4.3.3 Responding to external happenings

In the example, interrupts are handled by the JVM, which turns them into an external happening. The application code that indirectly responds to the happening is provided in the handleAsyncEvent method in the FMSocketController object. Figure 12.10 illustrates the approach. In this example, the actions in response to the *memory stick inserted* and *memory stick removed* flash events is simply shown as the execution of the FMInserted and FMRemoved handlers. These will inform the application. The memory accessor classes themselves will ensure that the stick is present when performing the required application accesses.

12.4.3.4 Access to the flash controller's device registers

Figure 12.11 shows the sequence of events that the application follows. First it must register a handler with the FMInserted asynchronous event. Here, the application

Figure 12.11: Application usage



itself is an asynchronous event handler. When this is released, the memory has been inserted.

In this simple example, the application simply reads a byte from an offset within the memory stick. It, therefore, creates an accessor to access the data. When this has been returned (it is the FAController itself), the application can now call the getByte method (called *FA* getByte, in the following, for clarity). This method must implement the sequence of raw memory access on the device's registers to perform the operation. In Figure 12.11, they are as follows.

1. *FA* getByte calls the getByte method of the status register's accessor object. This can check to make sure that the flash memory is present (bit 6, as shown in Table 12.2). If it is not, an exception can be thrown.
2. Assuming the memory is present, it then sets the control register with the offset required (bits 31–63, as shown in Table 12.2) and sets the read byte request bit (bits 5-8, as shown in Table 12.2).
3. The *FA* getByte method must then wait for indication that the requested operation has been completed by the device. This is detected by the handleAsyncEvent method of the FMController, which performs the necessary notify.

4. Once notified of completion, the *FA* getByte method, again reads the status register to make sure there were no errors on the device (bit 4 in Table 12.2) and that the memory is still present
5. The *FA* getLong then reads the data register to get the requested data, which it returns.

Chapter 13

Interprocess Signalling

On many operating systems, it is possible for one process to signal another. POSIX provides a well defined means of signalling 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.

13.1 Definitions

Signal — A notification between two system 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.

13.2 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.

13.2.1 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.

13.2.2 POSIX Realtime Signals

The RealtimeSignal class represents POSIX realtime events. It is also implements ActiveEvent, but is 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 retrieves either by name or number using the RealtimeSignal.get(int) and RealtimeSignal.get(String) methods.

13.3 javax.realtime.posix

13.3.1 Classes

13.3.1.1 RealtimeSignal

Inheritance
java.lang.Object
javax.realtime.AsyncBaseEvent
javax.realtime.AsyncLongEvent
javax.realtime.posix.RealtimeSignal

Interfaces
javax.realtime.ActiveEvent

Description

A javax.realtime.ActiveEvent[1] subclass for defining a POSIX realtime signal.

Available since RTSJ 2.0

13.3.1.1.1 Methods

---

isPOSIXRealtimeSignal(String)

Signature

public static boolean
isPOSIXRealtimeSignal(String name)

Description

Determine if a signal with a given name is registered.

Parameters
name of the signal
Returns
true when a signal with the given name is registered

[1]Section 8.3.1.1

getId(String)

Signature
public static int
getId(String name)

Description
Get the ID of a registered signal.

Parameters
name of the signal for which to search
Returns
the ID of the signal named by name

get(String)

Signature
public static javax.realtime.posix.RealtimeSignal
get(String name)

Description
Get the registered realtime signal with the given name.

Parameters
name of the signal to get.
Returns
the registered signal with name or null.

get(int)

Signature
public static javax.realtime.posix.RealtimeSignal
get(int id)

Description
Get the realtime signal corresponding to a given id.

Parameters
id of a registered signal
Returns
the signal corresponding to id.

getId

Signature

public int
getId()

Description

Get the name of this realtime signal.

Returns

the ID of this signal.

getName

Signature

public final java.lang.String
getName()

Description

Get the name of this signal.

Returns

the name of this signal.

getDispatcher

Signature

public javax.realtime.posix.RealtimeSignalDispatcher
getDispatcher()

Description

Obtain the dispatcher for this.

Returns

that dispatcher.

isActive

Signature

public boolean
isActive()

Description

Determine the activation state of this signal, i.e., it has been started.

Returns

true when active, false otherwise.

isRunning

Signature

public boolean
isRunning()

Description

Determine the firing state (releasing or skipping) of this signal, i.e., it is active and enabled.

Returns

true when releasing, false when skipping.

start

Signature

public final synchronized void
start()
throws IllegalStateException

Description

Start this RealtimeSignal, i.e., change to a running state. A running realtime signal is a source of activation when in a scoped memory and is a member of the root set when in the heap. A running realtime signal can be triggered.

Throws

IllegalStateException when this RealtimeSignal has already been started.

See Section stop()

start(boolean)

Signature

public final synchronized void
start(boolean disabled)
throws IllegalStateException

Description

Start this RealtimeSignal, i.e., change to a running state. A running realtime signal is a source of activation when in a scoped memory and is a member of the root set when in the heap. A running realtime signal can be triggered.

Parameters

disabled true for starting in a disabled state.

Throws

IllegalStateException when this RealtimeSignal has already been started.

See Section stop()

stop

Signature

public final boolean
stop()
throws IllegalStateException

Description

Stop this RealtimeSignal. A stopped realtime signal ceases to be a source of activation and no longer cause any AE attached to it to be a source of activation.

Throws

IllegalStateException when this RealtimeSignal is not running.

Returns

true when this was *enabled* and false otherwise.

send(long, long)

Signature

```
public native boolean
send(long pid,
     long payload)
```

Description

Send this signal to another process

Parameters
pid of the process to which to send the signal
Returns
true when signal can be sent, otherwise false.

13.3.1.2 RealtimeSignalDispatcher

Inheritance
java.lang.Object
javax.realtime.ActiveEventDispatcher
javax.realtime.posix.RealtimeSignalDispatcher
Description

Provides a means of dispatching a set of RealtimeSignal[2]s. An application can provide its own dispatcher, providing the priority for the internal dispatching thread. This dispatching thread calls process() each time the signal is triggered.

Available since RTSJ 2.0

13.3.1.2.1 Constructors

RealtimeSignalDispatcher(SchedulingParameters, SchedulingGroup)

Signature

[2]Section 13.3.1.1

public
RealtimeSignalDispatcher(SchedulingParameters schedule,
SchedulingGroup group)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters
schedule give the parameters for scheduling this dispatcher

RealtimeSignalDispatcher(SchedulingParameters)

Signature
public
RealtimeSignalDispatcher(SchedulingParameters schedule)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters
schedule give the parameters for scheduling this dispatcher

13.3.1.1.2.2 Methods

---

register(RealtimeSignal)

Signature
public void
register(RealtimeSignal signal)
throws RegistrationException,
IllegalStateException,
IllegalArgumentException

Description

Register signal with this dispatcher.

Parameters
signal to register
Throws
RegistrationException when signal is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when signal is not stopped.

deregister(RealtimeSignal)

Signature

```
public void
deregister(RealtimeSignal signal)
throws DeregistrationException,
       IllegalStateException,
       IllegalArgumentException
```

Description

Deregister the signal form this dispatcher.

Parameters
signal to unregister
Throws
DeregistrationException when signal is not already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when signal is not stopped.

destroy

Signature

```
public void
destroy()
throws IllegalStateException
```

Description

Release all reasources thereby making the dispatcher unusable.

Throws

IllegalStateException when called on a dispatcher that has one or more registered RealtimeSignal[3] objects.

13.3.1.3 Signal

Inheritance

java.lang.Object
  javax.realtime.AsyncBaseEvent
    javax.realtime.AsyncEvent
      javax.realtime.posix.Signal

Interfaces

javax.realtime.ActiveEvent

Description

A javax.realtime.ActiveEvent[4] subclass for defining a POSIX signal.

Available since RTSJ 2.0

13.3.1.3.1 Fields

MAX_NUM_SIGNALS

public static final MAX_NUM_SIGNALS

Description

this number of signals can be processed.

13.3.1.3.2 Methods

---

[3]Section 13.3.1.1
[4]Section 8.3.1.1

isPOSIXSignal(String)

Signature
public static boolean
isPOSIXSignal(String name)

Description
Determine if a signal with a given name is registered.

Parameters
name of the signal
Returns
true when a signal with the given name is registered

getId(String)

Signature
public static int
getId(String name)

Description
Get the ID of a registered signal.

Parameters
name of the signal for which to search
Returns
the ID of the signal named by name

get(String)

Signature
public static javax.realtime.posix.Signal
get(String name)

Description
Get the registered signal with the given name.

Parameters
name of the signal to get.
Returns
the registered signal with name or null.

get(int)

Signature

public static javax.realtime.posix.Signal
get(int id)

Description

Get the signal corresponding to a given id.

Parameters
id of a registered signal
Returns
the signal corresponding to id or null.

getProcessId

Signature

public static long
getProcessId()

Description

Obtain 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 Signal.send(long)[5].

Returns
the OS process id.

getId

Signature

public int
getId()

Description

Get the number of this signal.

Returns
the signal number

[5]Section 13.3.1.3.2

getName

Signature

public java.lang.String
getName()

Description

Get the name of this signal.

Returns

the name of this signal.

getDispatcher

Signature

public javax.realtime.posix.SignalDispatcher
getDispatcher()

Description

Obtain the dispatcher for this.

Returns

that dispatcher.

isActive

Signature

public boolean
isActive()

Description

Determine the activation state of this signal, i.e., it has been started.

Returns

true when active, false otherwise.

isRunning

Signature

public boolean
isRunning()

Description

Determine the firing state (releasing or skipping) of this signal, i.e., it is active and enabled.

Returns

true when releasing, false when skipping.

start

Signature

public void
start()
throws IllegalStateException

Description

Start this Signal, i.e., change to a running state. A running signal is a source of activation when in a scoped memory and is a member of the root set when in the heap. A running signal can be triggered.

Throws

IllegalStateException when this Signal has already been started.

See Section stop()

start(boolean)

Signature

public void
start(boolean disabled)
throws IllegalStateException

Description

Start this Signal, i.e., change to a running state. A running signal is a source of activation when in a scoped memory and is a member of the root set when in the heap. A running signal can be triggered.

Parameters
disabled true for starting in a disabled state.
Throws
IllegalStateException when this Signal has already been started.

See Section stop()

stop

Signature

```
public boolean
stop()
throws IllegalStateException
```

Description

Stop this Signal. A stopped signal ceases to be a source of activation and no longer cause any AE attached to it to be a source of activation.

Throws
IllegalStateException when this Signal is not running.

Returns
true when this was *enabled* and false otherwise.

send(long)

Signature

```
public void
send(long pid)
throws POSIXInvalidSignalException,
       POSIXSignalPermissionException,
       POSIXInvalidTargetException
```

Description

Send 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

POSIXInvalidSignalException when the signal number is not valid.

POSIXSignalPermissionException when the process does not have permission to send the target.

POSIXInvalidTargetException when the target does not exist.

13.3.1.4 SignalDispatcher

Inheritance

java.lang.Object
  javax.realtime.ActiveEventDispatcher
    javax.realtime.posix.SignalDispatcher

Description

Provides a means of dispatching a set of Signal[6]s. An application can provide its own dispatcher, providing the priority for the internal dispatching thread. This dispatching thread calls process() each time the signal is triggered.

13.3.1.4.1 Constructors

---

[6]Section 13.3.1.3

SignalDispatcher(SchedulingParameters, SchedulingGroup)

Signature

public
SignalDispatcher(SchedulingParameters scheduling,
SchedulingGroup group)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

scheduling give the parameters for scheduling this dispatcher

SignalDispatcher(SchedulingParameters)

Signature

public
SignalDispatcher(SchedulingParameters scheduling)

Description

Create a new dispatcher, whose dispatching thread runs with the given scheduling parameters.

Parameters

scheduling give the parameters for scheduling this dispatcher

13.3.1.4.2 Methods

---

register(Signal)

Signature

public synchronized void
register(Signal signal)

throws RegistrationException,
IllegalStateException,
IllegalArgumentException

Description

Register a POSIX signal with this dispatcher.

Parameters
signal to register
Throws
RegistrationException when signal is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when signal is not stopped.

deregister(Signal)

Signature
public synchronized void
deregister(Signal signal)
throws DeregistrationException,
IllegalStateException,
IllegalArgumentException

Description

Deregister a POSIX Signal form this dispatcher. (This is a really naive implementation.)

Parameters
signal to deregister
Throws
DeregistrationException when signal not is already registered.
IllegalStateException when this object has been destroyed.
IllegalArgumentException when signal is not stopped.

destroy

Signature
public void
destroy()

throws IllegalStateException

Description

Release all reasources thereby making the dispatcher unusable.

Throws

IllegalStateException when called on a dispatcher that has one or more registered Signal[7] objects.

13.4 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 stictly POSIX compatible, one can implement this interface for encapsulating similar functionality in a common API.

[7] Section 13.3.1.3

Chapter 14

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. Even the ones that do vary in their degree of compliance. Also, the type of garbage collection provided may also vary from on implementation to another. The specification defines classes to help manage these differences 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.

14.1 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.

14.1.1 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.

14.1.2 RealtimeSecurity

The RealtimeSecurity class controls access to key realtime features. Particularly critical is access to memory outside the heap. Core RTSJ features also have security checks. This 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.

Open issue 14.1.1 (jjh)

Look at security closely. Try to make this a Java Security Manager if possible. Here is an initial list of methods that should have security checks.

End of issue 14.1.1

Open issue 14.1.2 (jjh)

Check Scheduler to see what security checks it needs.

End of issue 14.1.2

Open issue 14.1.3 (elb)

Check ThreadGroup/SchedulingGroup/ProcessingGroup to see what security checks they need.

End of issue 14.1.3

- Core Module
  - ActiveEvent.start
  - ActiveEvent.stop
  - ActiveEventDispatcher.register
  - ActiveEventDispatcher.deregister
  - Affinity.applyTo
  - Affinity.set
  - AsyncBaseEvent.enable
  - AsyncBaseEvent.disable
  - AsyncBaseEvent.addHandler
  - AsyncBaseEvent.removeHandler
  - AsyncBaseEvent.setHandler
  - Schedulable.setDaemon RealtimeSecurity.checkAEHSetDaemon
  - Clock.Clock
  - MemoryArea.executeInArea
  - MemoryArea.enter
  - MonitorControl.setMonitorControl RealtimeSecurity.checkSetMonitorControl
  - RealtimeThread.RealtimeThread RealtimeSecurity.checkCreateRealtimeThread
  - Scheduler.setDefaultScheduler RealtimeSecurity.checkSetScheduler
  - Timer.Timer RealtimeSecurity.checkCreateTimer

- POSIX Module
  - RealtimeSignal.get
  - RealtimeSignal.getId
  - RealtimeSignal.send
  - RealtimeSignal.getDispatcher
  - RealtimeSignal.start
  - RealtimeSignal.stop
  - Signal.get
  - Signal.getId
  - Signal.send
  - Signal.getDispatcher
  - Signal.start
  - Signal.stop
- Alternate Memory Module
  - PhysicalMemoryFactory.associate RealtimeSecurity.checkAccessPhysical RealtimeSecurity.checkAccessPhysicalRange
  - PhysicalMemoryFactory.createImmortalMemory
  - PhysicalMemoryFactory.createLTMemory
  - PhysicalMemoryFactory.createPinnableMemory
  - PhysicalMemoryFactory.createStackedMemory
  - LTMemory.LTMemory
  - PinnableMemory.PinnableMemory
  - StackedMemory.StackedMemory
- Device Module
  - DMABufferFactory.DMABufferFactory
  - Happening.createId
  - Happening.getHappening
  - Happening.get
  - Happening.createId
  - Happening.Happening
  - RawMemoryFactory.register
  - RawMemoryFactory.deregister
  - RawMemoryFactory.RawMemoryFactory
  - RawMemoryFactory.createRawByte
  - RawMemoryFactory.createRawByteReader
  - RawMemoryFactory.createRawByteWriter
  - ...
  - RawMemoryFactory.createRawDouble
  - RawMemoryFactory.createRawDoubleReader
  - RawMemoryFactory.createRawDoubleWriter

14.1.3 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.

14.1.4 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".

14.2 javax.realtime

14.2.1 Enumerations

14.2.1.1 RTSJModule

Inheritance

java.lang.Object
  java.lang.Enum
    javax.realtime.RTSJModule

Description

Modules an RTSJ implementation may provide.

14.2.1.1.1 Enumeration Constants

CORE

public static final CORE

Description

Indicates the presence of the core module.

DEVICE

public static final DEVICE

Description

Indicates the presence of the device access module.

MEMORY

public static final MEMORY

Description

Indicates the presence of the alternative memory areas module.

POSIX

public static final POSIX

Description

Indicates the presence of the POSIX module.

SCJ

public static final SCJ

Description

Indicates the presence of the Safety-Critical Java module.

14.2.1.1.2 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

Determine the nummeric 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, see 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.

14.2.2 Classes

14.2.2.1 GarbageCollector

Inheritance

java.lang.Object
javax.realtime.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 system. 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()[1].

14.2.2.1.1 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 preemption-safe point.

Schedulables which may not use the heap preempt garbage collection immediately, but other schedulables must wait until the collector reaches a preemption-safe point. For many garbage collectors the only preemption 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 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.

[1] Section 14.2.2.3.2

14.2.2.2 RealtimeSecurity

Inheritance

java.lang.Object
  javax.realtime.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[2]. 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.

14.2.2.2.1 Constructors

RealtimeSecurity

Signature

public
RealtimeSecurity()

Description

Create an RealtimeSecurity object.

14.2.2.2.2 Methods

---

[2]Section 14.2.2.3.2

checkAccessPhysical

Signature

public void
checkAccessPhysical()
throws SecurityException

Description

Check whether the application is allowed to access physical memory.

Throws

SecurityException The application doesn't have permission to access physical memory.

checkAccessPhysicalRange(long, long)

Signature

public void
checkAccessPhysicalRange(long base,
long size)
throws SecurityException

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

SecurityException The application doesn't have permission to access the memory in the given range.

checkSetFilter

Signature

public void
checkSetFilter()
throws SecurityException

Description

Checks whether the application is allowed to register PhysicalMemoryTypeFilter[3] objects with the PhysicalMemoryManager[4].

Throws

SecurityException The application doesn't have permission to register filter objects.

checkSetMonitorControl(MonitorControl)

Signature

public void
checkSetMonitorControl(MonitorControl policy)
throws SecurityException

Description

Checks whether the application is allowed to set the default monitor control policy.

Parameters

policy The new policy

Throws

SecurityException when the application doesn't have permission to change the default monitor control policy to policy.

Available since RTSJ 1.0.1

checkAEHSetDaemon

Signature

public void
checkAEHSetDaemon()
throws SecurityException

Description

Checks whether the application is allowed to set the daemon status of an AEH.

Throws

SecurityException when the application is not permitted to alter the daemon status.

[3]Section A.2.1.1
[4]Section A.2.3.20

Available since RTSJ 1.0.1

checkSetScheduler

Signature

public void
checkSetScheduler()
throws SecurityException

Description

Checks whether the application is allowed to set the scheduler.

Throws

SecurityException The application doesn't have permission to set the scheduler.

checkCreateRealtimeThread

Signature

public void
checkCreateRealtimeThread()
throws SecurityException

Description

Check if an application may create a realtime thread.

Throws

SecurityException when not allowed

Available since RTSJ 2.0

checkCreateTimer

Signature

public void
checkCreateTimer()
throws SecurityException

Description

Check if an application may create a Timer.

Throws
SecurityException when not allowed.

Available since RTSJ 2.0

checkPOSIXSendSignal(Signal, long)

Signature

```
public void
checkPOSIXSendSignal(Signal signal,
                     long pid)
throws SecurityException
```

Description

Check if the given signal can be sent to the given process id.

Parameters
signal is the signal being sent
pid is the id to which the signal is being set.
Throws
SecurityException when the operation is not allowed.

Available since RTSJ 2.0

14.2.2.3 RealtimeSystem

Inheritance
java.lang.Object
javax.realtime.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.

14.2.2.3.1 Fields

BIG_ENDIAN

public static final 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 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 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.

BYTE_ORDER

public static final BYTE_ORDER

Description

The byte ordering of the underlying hardware.

14.2.2.3.2 Methods

currentGC

Signature

public static javax.realtime.GarbageCollector
currentGC()

Description

Return a reference to the currently active garbage collector for the heap.

Returns

A GarbageCollector[5] 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, return -1. Note that when the number of concurrent locks is not tracked, the number of available concurrent locks is effectively unlimited.

getMaximumConcurrentLocks

Signature

[5]Section 14.2.2.1

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 give 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.

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[6] object representing the default realtime security manager.

setMaximumConcurrentLocks(int)

Signature

public static void
setMaximumConcurrentLocks(int numLocks)

Description

[6]Section 14.2.2.2

Sets the anticipated maximum number of locks that may be held or waited on concurrently. Provide 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()[7].

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. Provide 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()[8].

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[9] is thrown. When the system does not limit use of concurrent locks, this parameter is silently ignored.

setSecurityManager(RealtimeSecurity)

Signature

[7]Section 14.2.2.3.2
[8]Section 14.2.2.3.2
[9]Section 15.2.3.4

public static void
setSecurityManager(RealtimeSecurity manager)

Description

Sets a new realtime security manager.

Parameters
manager A RealtimeSecurity[10] object which will become the new security manager.
Throws
SecurityException 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.

Available since RTSJ 1.0.1

supports(RTSJModule)

Signature

public static boolean
supports(RTSJModule module)

Description

Determine if a particular module is supported.

Parameters
module of interest.
Returns
true when module is supported; otherwise false.

[10] Section 14.2.2.2

Available since RTSJ 2.0

modules

Signature
public static int
modules()

Description
The set of modules supported.

Returns
an integer representing all the modules supported.

Available since RTSJ 2.0

canEnforceCost

Signature
public static boolean
canEnforceCost()

Description
Determine whether or not hard cost enforcement is supported.

Returns
true when cost enforcement is supported, otherwise false.

Available since RTSJ 2.0

canEnforceAllocationRate

Signature
public static boolean
canEnforceAllocationRate()

Description
Determine whether or not allocation rate enforcement is supported.

Returns
true when allocation rate enforcement is supported, otherwise false.

Available since RTSJ 2.0

setDefaultConfiguration(ConfigurationParameters)

Signature
public static void
setDefaultConfiguration(ConfigurationParameters parameters)

Description
Set the default configuration used to by tasks that are not explicitly provided with one.

Parameters
parameters contains the new default configuration.
Available since RTSJ 2.0

getDefaultConfiguration

Signature
public static javax.realtime.ConfigurationParameters
getDefaultConfiguration()

Description
Determine the current configurations used by tasks that are not explicitly provided with one.

Returns
the current configurations.

Available since RTSJ 2.0

14.3 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 similarly 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 supports 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 15

Exceptions

As with other Java specifications, the RTSJ uses exceptions and errors to signal conditions that are abnormal, incorrect, or disallowed. In cases where these exceptional and error conditions are substantially the same as those defined in conventional Java, those 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 other cases, new exceptions are defined in the javax.realtime package. These 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 use too much memory to be useful.

15.1 Semantics

Except for how information associated with a Throwable is stored and managed, the semantics of the subclasses of Error, Exception, and RuntimeException 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, as opposed to those that are standard exceptions used without change by the specification, are statically allocated (and implement the StaticThrowable interface). 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 StaticThrowables 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 class defines an exception, it provides additional functionality for supporting ATC. This functionality is more closely related to asynchronous operation than to exception handling. For this reason, it is not included in this chapter, but rather in Chapter 8 on asynchrony.

15.2 javax.realtime

15.2.1 Interfaces

15.2.1.1 StaticThrowable

Description

A marker interface to indicate that a Throwable is intended to be created once and reused. Throwables that implement this interface kept their state in a RealtimeThread local 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 AsyncBaseEventHandler[1] always have some instance of RealtimeThread 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 initialize the stack backtrace. The message and cause should be cleared.

An application which throws a static exception should use the following paradigm:

throw LateStartException.get().initMessage("....").initCause(...);

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 static throwables should extend one of StaticError[2], StaticCheckedException[3], or StaticRuntimeException[4]

See Section ConfigurationParameters

Available since RTSJ 2.0

15.2.1.1.1 Methods

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[1] Section 8.3.3.3
[2] Section 15.2.3.5
[3] Section 15.2.2.21
[4] Section 15.2.2.22

initMessage(String)

Signature

public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters

message is the text to save.

getMessage

Signature

public java.lang.String
getMessage()

Description

get the message describing the problem from SO local memory.

Returns

the message given to the constructor or null when no message was set.

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

Initializes the cause to the given Throwable is SO local memory.

Parameters

causingThrowable the reason why this Throwable gets Thrown.

Throws

IllegalArgumentException when the cause is this Throwable itself.

Returns

the reference to this Throwable.

getCause

Signature

public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns

The cause or null.

fillInStackTrace

Signature

public java.lang.Throwable
fillInStackTrace()

Description

Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns

a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature

public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description

This method allows 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 replace be used.

Throws

NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[5]), 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.

[5] Section 11.3.3.3

Returns
array representing the stack trace, never null.

printStackTrace

Signature
public void
printStackTrace()

Description

Print 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

Print 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

Print 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.

15.2.2 Exceptions

15.2.2.1 ArrivalTimeQueueOverflowException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.EventQueueOverflowException
            javax.realtime.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.

Available since RTSJ 1.0.1 this is unchecked

Available since RTSJ 2.0 extends EventQueueOverflowException

Deprecated RTSJ 2.0 replaced by EventQueueOverflowException[6]

15.2.2.1.1 Constructors

---

[6] Section 8.3.2.2

ArrivalTimeQueueOverflowException

Signature

public
ArrivalTimeQueueOverflowException()

Description

The default constructor for ArrivalTimeQueueOverflowException, but user code should use get()[7] instead.

15.2.2.1.2 Methods

---

get

Signature

public static javax.realtime.ArrivalTimeQueueOverflowException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.2 CeilingViolationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException

[7] Section 15.2.2.1.2

java.lang.IllegalArgumentException
java.lang.IllegalThreadStateException
javax.realtime.IllegalSchedulableStateException
javax.realtime.CeilingViolationException

Interfaces

javax.realtime.StaticThrowable

Description

This exception is thrown when a schedulable or java.lang.Thread attempts to lock an object governed by an instance of PriorityCeilingEmulation[8] and the thread or SO's base priority exceeds the policy's ceiling.

Available since RTSJ 2.0 implements StaticThrowable

15.2.2.2.1 Methods

get

Signature

public static javax.realtime.CeilingViolationException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

getCeiling

Signature

public int
getCeiling()

[8] Section 7.3.1.2

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.

15.2.2.3 DeregistrationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.DeregistrationException

Description

An exception to throw when trying to deregister an ActiveEvent[9] from an ActiveEventDispatcher[10] to which it is not registered.

Available since RTSJ 2.0

[9] Section 8.3.1.1
[10] Section 8.3.3.1

15.2.2.3.1 Methods

get

Signature

public static javax.realtime.DeregistrationException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

15.2.2.4 IllegalSchedulableStateException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        java.lang.IllegalArgumentException
          java.lang.IllegalThreadStateException
            javax.realtime.IllegalSchedulableStateException

Interfaces

javax.realtime.StaticThrowable

Description

The exception thrown when a Schedulable[11] 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.

Available since RTSJ 2.0

[11] Section 6.3.1.3

15.2.2.4.1 Methods

get

Signature

public static javax.realtime.IllegalSchedulableStateException
get()

Description

Get the preallocated version of this Throwable. Allocation is done in memory that acts like ImmortalMemory[12]. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception

initMessage(String)

Signature

public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters

message is the text to save.

getMessage

Signature

public java.lang.String
getMessage()

Description

get the message describing the problem from SO local memory.

[12]Section 11.3.3.2

Returns
the message given to the constructor or null when no message was set.

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

Initializes the cause to the given Throwable is SO local memory.

Parameters
causingThrowable the reason why this Throwable gets Thrown.
Throws
IllegalArgumentException when the cause is this Throwable itself.

Returns
the reference to this Throwable.

getCause

Signature
public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns
The cause or null.

fillInStackTrace

Signature
public java.lang.Throwable
fillInStackTrace()

Description

Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns
a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description

This method allows 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 replace be used.
Throws
NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[13]), 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

array representing the stack trace, never null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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.

[13] Section 11.3.3.3

printStackTrace(PrintStream)

Signature

public void
printStackTrace(PrintStream stream)

Description

Print 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 writer)

Description

Print 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.

15.2.2.5 InaccessibleAreaException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException

javax.realtime.InaccessibleAreaException

Description

The specified memory area is not on the current thread's scope stack.

Available since RTSJ 1.0.1 Becomes unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.5.1 Constructors

InaccessibleAreaException

Signature

public
InaccessibleAreaException()

Description

A constructor for InaccessibleAreaException, but application code should use get()[14] instead.

InaccessibleAreaException(String)

Signature

public
InaccessibleAreaException(String description)

Description

A descriptive constructor for InaccessibleAreaException.

Deprecated since RTSJ 2.0; application code should use get()[15] instead.

Parameters

description Description of the error.

[14] Section 15.2.2.5.2
[15] Section 15.2.2.5.2

15.2.2.5.2 Methods

get

Signature

public static javax.realtime.InaccessibleAreaException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.6 LateStartException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.LateStartException

Description

Exception thrown when a periodic realtime thread or timer is started after its assigned, absolute, start time.

Available since RTSJ 2.0

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.6.1 Methods

get

Signature

public static javax.realtime.LateStartException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

15.2.2.7 MITViolationException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.MITViolationException

Description

Thrown by the AsyncEvent.fire()[16] 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.

Available since RTSJ 1.0.1 became unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.7.1 Constructors

---

[16] Section 8.3.3.4.2

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.

15.2.2.7.2 Methods

---

get

Signature
public static javax.realtime.MITViolationException
get()

Description
Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.8 MemoryInUseException

Inheritance
java.lang.Object
java.lang.Throwable
java.lang.Exception
java.lang.RuntimeException
javax.realtime.StaticRuntimeException
javax.realtime.MemoryInUseException

Description

There has been attempt to allocate a range of physical or virtual memory that is already in use.

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.8.1 Constructors

MemoryInUseException

Signature

public
MemoryInUseException()

Description

A constructor for MemoryInUseException, but application code should use get()[17] instead.

MemoryInUseException(String)

Signature

public
MemoryInUseException(String description)

[17] Section 15.2.2.8.2

Description

A descriptive constructor for MemoryInUseException.

Deprecated since RTSJ 2.0; application code should use get()[18] instead.

Parameters
description Description of the error.

15.2.2.8.2 Methods

---

get

Signature

public static javax.realtime.MemoryInUseException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.9 MemoryScopeException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.MemoryScopeException

Description

[18] Section 15.2.2.8.2

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.

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.9.1 Constructors

MemoryScopeException

Signature

public
MemoryScopeException()

Description

A constructor for MemoryScopeException, but application code should use get()[19] instead.

15.2.2.9.2 Methods

---

get

Signature

public static javax.realtime.MemoryScopeException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

[19] Section 15.2.2.9.2

Available since RTSJ 2.0

15.2.2.10 MemoryTypeConflictException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.MemoryTypeConflictException

Description

This exception is thrown when the PhysicalMemoryManager[20] 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.

Available since RTSJ 1.0.1 Changed to an unchecked exception.

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.10.1 Constructors

MemoryTypeConflictException

Signature

public
MemoryTypeConflictException()

Description

A constructor for MemoryTypeConflictException, but application code should use get()[21] instead.

[20] Section A.2.3.20
[21] Section 15.2.2.10.2

MemoryTypeConflictException(String)

Signature

public
MemoryTypeConflictException(String description)

Description

A descriptive constructor for MemoryTypeConflictException.

Deprecated since RTSJ 2.0; application code should use get()[22] instead.

Parameters

description A description of the exception.

15.2.2.10.2 Methods

---

get

Signature

public static javax.realtime.MemoryTypeConflictException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.11 OffsetOutOfBoundsException

Inheritance

[22] Section 15.2.2.10.2

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.OffsetOutOfBoundsException

Description

when the constructor of an ImmortalPhysicalMemory[23], LTPhysicalMemory[24], VTPhysicalMemory[25], RawMemoryAccess[26], or RawMemoryFloatAccess[27] is given an invalid address.

Available since RTSJ 1.0.1 became unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.11.1 Constructors

OffsetOutOfBoundsException

Signature

public
OffsetOutOfBoundsException()

Description

A constructor for OffsetOutOfBoundsException, application code should use get()[28] instead.

15.2.2.11.2 Methods

[23] Section A.2.3.10
[24] Section A.2.3.12
[25] Section A.2.3.37
[26] Section A.2.3.25
[27] Section A.2.3.26
[28] Section 15.2.2.11.2

get

Signature

public static javax.realtime.OffsetOutOfBoundsException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.12 POSIXException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.POSIXException

Description

A base class for all POSIX exceptions.

Available since RTSJ 2.0

15.2.2.13 POSIXInvalidSignalException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.POSIXException
          javax.realtime.POSIXInvalidSignalException

Description

An invalid POSIX signal number has been specified.

Available since RTSJ 2.0

15.2.2.13.1 Methods

---

get

Signature

public static javax.realtime.POSIXInvalidSignalException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

15.2.2.14 POSIXInvalidTargetException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.POSIXException
          javax.realtime.POSIXInvalidTargetException

Description

The target of the signal does not exist.

Available since RTSJ 2.0

15.2.2.14.1 Methods

---

get

Signature

public static javax.realtime.POSIXInvalidTargetException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

15.2.2.15 POSIXSignalPermissionException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.POSIXException
          javax.realtime.POSIXSignalPermissionException

Description

The process does not have permission to send the given signal to the given target.

Available since RTSJ 2.0

15.2.2.15.1 Methods

---

get

Signature

public static javax.realtime.POSIXSignalPermissionException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

15.2.2.16 ProcessorAffinityException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.ProcessorAffinityException

Description

Exception used to report processor affinity-related errors.

Available since RTSJ 2.0

15.2.2.16.1 Methods

---

get

Signature
public static javax.realtime.ProcessorAffinityException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

15.2.2.17 RangeOutOfBoundsException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException
        javax.realtime.RangeOutOfBoundsException
Description

Available since RTSJ 2.0

15.2.2.17.1 Methods

get

Signature
public static javax.realtime.RangeOutOfBoundsException
get()

Description
Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

15.2.2.18 RegistrationException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException

javax.realtime.RegistrationException

Description

An exception to throw when trying to register an ActiveEvent[29] with an ActiveEventDispatcher[30] to which it is already registered.

Available since RTSJ 2.0

15.2.2.18.1 Methods

---

get

Signature

public static javax.realtime.RegistrationException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

15.2.2.19 ScopedCycleException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.ScopedCycleException

Description

Thrown when a schedulable attempts to enter an instance of ScopedMemory[31] where that operation would cause a violation of the single parent rule.

[29] Section 8.3.1.1
[30] Section 8.3.3.1
[31] Section A.2.3.32

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.19.1 Constructors

ScopedCycleException

Signature

public
ScopedCycleException()

Description

A constructor for ScopedCycleException, but application code should use get()[32] instead.

ScopedCycleException(String)

Signature

public
ScopedCycleException(String description)

Description

A descriptive constructor for ScopedCycleException.

Deprecated since RTSJ 2.0; application code should use get()[33] instead.

Parameters

description Description of the error.

15.2.2.19.2 Methods

[32]Section 15.2.2.19.2
[33]Section 15.2.2.19.2

get

Signature

public static javax.realtime.ScopedCycleException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.20 SizeOutOfBoundsException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.SizeOutOfBoundsException

Description

To throw when the constructor of an ImmortalPhysicalMemory[34], LTPhysicalMemory[35], or VTPhysicalMemory[36] is given an invalid size or when a memory access generated by a raw memory accessor instance (See javax.realtime.device.RawMemory[37].) would cause access to an invalid address.

Available since RTSJ 1.0.1 became unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

[34]Section A.2.3.10
[35]Section A.2.3.12
[36]Section A.2.3.37
[37]Section 12.3.1.16

15.2.2.20.1 Constructors

SizeOutOfBoundsException

Signature

public
SizeOutOfBoundsException()

Description

A constructor for SizeOutOfBoundsException, but application code should use get()[38] instead.

SizeOutOfBoundsException(String)

Signature

public
SizeOutOfBoundsException(String description)

Description

A descriptive constructor for SizeOutOfBoundsException.

Deprecated since RTSJ 2.0; application code should use get()[39] instead.

Parameters

description The description of the exception.

15.2.2.20.2 Methods

[38] Section 15.2.2.20.2
[39] Section 15.2.2.20.2

get

Signature

public static javax.realtime.SizeOutOfBoundsException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.21 StaticCheckedException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.StaticCheckedException

Interfaces

javax.realtime.StaticThrowable

Description

A base class for all checked exceptions defined in the specification and do not extend a conventional Java exception.

Available since RTSJ 2.0

15.2.2.21.1 Constructors

StaticCheckedException

Signature

protected
StaticCheckedException()

Description

15.2.2.21.2 Methods

---

initMessage(String)

Signature
public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters
message is the text to save.

getMessage

Signature
public java.lang.String
getMessage()

Description

get the message describing the problem from SO local memory.

Returns
the message given to the constructor or null when no message was set.

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

Initializes the cause to the given Throwable is SO local memory.

Parameters
causingThrowable the reason why this Throwable gets Thrown.
Throws
IllegalArgumentException when the cause is this Throwable itself.

Returns
the reference to this Throwable.

getCause

Signature

public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns
The cause or null.

fillInStackTrace

Signature

public java.lang.Throwable
fillInStackTrace()

Description

Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns

a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature

public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description

This method allows 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 replace be used.

Throws

NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[40]), 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
array representing the stack trace, never null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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

[40]Section 11.3.3.3

Print 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 writer)

Description

Print 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.

15.2.2.22 StaticRuntimeException

Inheritance
java.lang.Object
java.lang.Throwable
java.lang.Exception
java.lang.RuntimeException
javax.realtime.StaticRuntimeException
Interfaces
javax.realtime.StaticThrowable
Description

A base class for all unchecked exceptions defined in the specification and do not extend a conventional Java exception.

Available since RTSJ 2.0

15.2.2.22.1 Constructors

StaticRuntimeException

Signature

protected
StaticRuntimeException()

Description

15.2.2.22.2 Methods

initMessage(String)

Signature

public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters

message is the text to save.

getMessage

Signature

public java.lang.String
getMessage()

Description

get the message describing the problem from SO local memory.

Returns
the message given to the constructor or null when no message was set.

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

Initializes the cause to the given Throwable is SO local memory.

Parameters
causingThrowable the reason why this Throwable gets Thrown.
Throws
IllegalArgumentException when the cause is this Throwable itself.

Returns
the reference to this Throwable.

getCause

Signature
public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns
The cause or null.

fillInStackTrace

Signature
public java.lang.Throwable
fillInStackTrace()

Description

Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns
a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description

This method allows 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 replace be used.
Throws
NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[41]), 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

array representing the stack trace, never null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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.

[41] Section 11.3.3.3

printStackTrace(PrintStream)

Signature

public void
printStackTrace(PrintStream stream)

Description

Print 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 writer)

Description

Print 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.

15.2.2.23 UnsupportedPhysicalMemoryException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException

javax.realtime.UnsupportedPhysicalMemoryException

Description

Thrown when the underlying hardware does not support the type of physical memory requested.

See Section PhysicalMemoryFactory

Available since RTSJ 1.0.1 became unchecked

Available since RTSJ 2.0 extends StaticRuntimeException

15.2.2.23.1 Constructors

UnsupportedPhysicalMemoryException

Signature

public
UnsupportedPhysicalMemoryException()

Description

A constructor for UnsupportedPhysicalMemoryException, but application code should use get()[42] instead.

15.2.2.23.2 Methods

get

Signature

public static javax.realtime.UnsupportedPhysicalMemoryException
get()

Description

[42] Section 15.2.2.23.2

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

Available since RTSJ 2.0

15.2.2.24 UnsupportedRawMemoryRegionException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.StaticRuntimeException
          javax.realtime.UnsupportedRawMemoryRegionException

Description

Indicates an invalid raw memory region.

Available since RTSJ 2.0

15.2.2.24.1 Methods

---

get

Signature

public static javax.realtime.UnsupportedRawMemoryRegionException
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns
the single instance of this throwable.

15.2.3 Classes

15.2.3.1 AlignmentError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      javax.realtime.StaticError
        javax.realtime.AlignmentError

Description

The exception thrown on an 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.

Available since RTSJ 2.0 extends StaticError

15.2.3.1.1 Methods

---

get

Signature

public static javax.realtime.AlignmentError
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.3.2 IllegalAssignmentError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      javax.realtime.StaticError
        javax.realtime.IllegalAssignmentError

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 be an instance of ScopedMemory[43]) to a field of an object in immortal memory.

Available since RTSJ 2.0 extends StaticError

15.2.3.2.1 Constructors

IllegalAssignmentError

Signature

public
IllegalAssignmentError()

Description

A constructor for IllegalAssignmentError, but the application should use get()[44] instead.

15.2.3.2.2 Methods

---

[43]Section A.2.3.32
[44]Section 15.2.3.2.2

get

Signature

public static javax.realtime.IllegalAssignmentError
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.3.3 MemoryAccessError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      javax.realtime.StaticError
        javax.realtime.MemoryAccessError

Description

This error is thrown on an attempt to refer to an object in an inaccessible MemoryArea[45]. For example this will be when logic in a NoHeapRealtimeThread[46] attempts to refer to an object in the traditional Java heap.

Available since RTSJ 2.0 extends StaticError

15.2.3.3.1 Constructors

[45] Section 11.3.3.3
[46] Section A.2.3.15

MemoryAccessError

Signature

public
MemoryAccessError()

Description

A constructor for MemoryAccessError, but application code should use get()[47] instead.

15.2.3.3.2 Methods

---

get

Signature

public static javax.realtime.MemoryAccessError
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.3.4 ResourceLimitError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      javax.realtime.StaticError

[47] Section 15.2.3.3.2

javax.realtime.ResourceLimitError

Description

When an attempt is made to exceed a system resource limit, such as the maximum number of locks.

Available since RTSJ 2.0 extends StaticError

15.2.3.4.1 Constructors

ResourceLimitError

Signature

public
ResourceLimitError()

Description

A constructor for ResourceLimitError, but application code should use get()[48] instead.

ResourceLimitError(String)

Signature

public
ResourceLimitError(String description)

Description

A descriptive constructor for ResourceLimitError.

Deprecated since RTSJ 2.0; application code should use get()[49] instead.

Parameters

description The description of the exception.

[48] Section 15.2.3.4.2
[49] Section 15.2.3.4.2

15.2.3.4.2 Methods

get

Signature

public static javax.realtime.ResourceLimitError
get()

Description

Obtain the singleton of this static throwable. It is prepared for immediate throwing.

Returns

the single instance of this throwable.

Available since RTSJ 2.0

15.2.3.5 StaticError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      javax.realtime.StaticError

Interfaces

javax.realtime.StaticThrowable

Description

A base class for all errors defined in the specification and do not extend a conventional Java error.

Available since RTSJ 2.0

15.2.3.5.1 Constructors

StaticError

Signature
protected
StaticError()

Description

15.2.3.5.2 Methods

---

initMessage(String)

Signature
public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters
message is the text to save.

getMessage

Signature
public java.lang.String
getMessage()

Description

get the message describing the problem from SO local memory.

Returns
the message given to the constructor or null when no message was set.

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

Initializes the cause to the given Throwable is SO local memory.

Parameters

causingThrowable the reason why this Throwable gets Thrown.

Throws

IllegalArgumentException when the cause is this Throwable itself.

Returns

the reference to this Throwable.

getCause

Signature

public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns
The cause or null.

fillInStackTrace

Signature
public java.lang.Throwable
fillInStackTrace()

Description
Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns
a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description
This method allows 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 replace be used.
Throws
NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature
public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[50]), 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

array representing the stack trace, never null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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

[50]Section 11.3.3.3

Print 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 writer)

Description

Print 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.

15.2.3.6 StaticOutOfMemoryError

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Error
      java.lang.VirtualMachineError
        java.lang.OutOfMemoryError
          javax.realtime.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[51]. It is up to the

[51] Section 11.3.3.1

implementation as to whether HeapMemory throws this exception or its parent.

Available since RTSJ 2.0

15.2.3.6.1 Methods

---

get

Signature

public static javax.realtime.StaticOutOfMemoryError
get()

Description

Get the preallocated version of this Throwable. Allocation is done in memory that acts like ImmortalMemory[52]. The message and cause are cleared and the stack trace is filled out.

Returns

the preallocated exception

initMessage(String)

Signature

public java.lang.Throwable
initMessage(String message)

Description

Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters

message is the text to save.

[52]Section 11.3.3.2

getMessage

Signature
public java.lang.String
getMessage()

Description
get the message describing the problem from SO local memory.

Returns
the message given to the constructor or null when no message was set.

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
Initializes the cause to the given Throwable is SO local memory.

Parameters
causingThrowable the reason why this Throwable gets Thrown.
Throws
IllegalArgumentException when the cause is this Throwable itself.
Returns
the reference to this Throwable.

getCause

Signature

public java.lang.Throwable
getCause()

Description

getCause returns the cause of this exception or null when no cause was set. The cause is another exception that was caught before this exception was created.

Returns

The cause or null.

fillInStackTrace

Signature

public java.lang.Throwable
fillInStackTrace()

Description

Calls into the virtual machine to capture the current stack trace in SO local memory.

Returns

a reference to this Throwable.

setStackTrace(StackTraceElement)

Signature

public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)
throws NullPointerException

Description

This method allows 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 replace be used.

Throws

NullPointerException when new_stackTrace or any element of new_stackTrace is null.

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get the stack trace created by fillInStackTrace for this Throwable 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[53]), 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

array representing the stack trace, never null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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

[53] Section 11.3.3.3

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

Print 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

Print 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.

15.2.3.7 StaticThrowableStorage

Inheritance

java.lang.Object

java.lang.Throwable
javax.realtime.StaticThrowableStorage

Interfaces

javax.realtime.StaticThrowable

Description

Provide 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[54]. 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 on of StaticCheckedException[55], StaticRuntimeException[56], or StaticError[57] instead.

Available since RTSJ 2.0

15.2.3.7.1 Methods

getCurrent

Signature

public static javax.realtime.StaticThrowableStorage
getCurrent()

Description

A means of obtaining the storage object for the current task.

Returns

the storage object for the current task.

fillInStackTrace

Signature

[54]Section 15.2.1.1
[55]Section 15.2.2.21
[56]Section 15.2.2.22
[57]Section 15.2.3.5

public java.lang.Throwable
fillInStackTrace()

Description

Capture the current thread's stack trace and save 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

getMessage

Signature
public java.lang.String
getMessage()

Description

Get 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 java.lang.Throwable
initMessage(String message)

Description

Save 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 message to save.

getCause

Signature

public java.lang.Throwable
getCause()

Description

Get the cause from thread local storage that was saved by the last preallocated exception thrown. The actual exception that of the 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 message

initCause(Throwable)

Signature

public java.lang.Throwable
initCause(Throwable causingThrowable)

Description

Save 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

causingThrowable

Returns

this

getStackTrace

Signature

public java.lang.StackTraceElement[]
getStackTrace()

Description

Get 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()

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().

setStackTrace(StackTraceElement)

Signature
public void
setStackTrace(java.lang.StackTraceElement[] new_stackTrace)

Description

This method allows 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 replace be used.
Throws
NullPointerException when new_stackTrace or any element of new_stackTrace is null.

printStackTrace

Signature

public void
printStackTrace()

Description

Print 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

Print 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 writer)

Description

Print 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.

15.2.3.8 ThrowBoundaryError

Inheritance
java.lang.Object
java.lang.Throwable
java.lang.Error
javax.realtime.StaticError
javax.realtime.ThrowBoundaryError

Description

The error thrown by MemoryArea.enter(Runnable logic)[58] when a Throwable allocated from memory that is not usable in the surrounding scope tries to propagate out of the scope of the enter.

Available since RTSJ 2.0 extends StaticError

15.2.3.8.1 Constructors

ThrowBoundaryError

Signature
public
ThrowBoundaryError()

Description

A constructor for ThrowBoundaryError, but application code should use get()[59] instead.

[58] Section 11.3.3.3.2
[59] Section 15.2.3.8.2

15.2.3.8.2 Methods

get

Signature
public static javax.realtime.ThrowBoundaryError
get()

Description
Get the preallocated instance of this exception.

Returns
the preallocated instance of this exception.

initMessage(String)

Signature
public java.lang.Throwable
initMessage(String message)

Description
Set the message in SO local storage. This is the only method not defined in java.lang.Throwable.

Parameters
message is the text to save.

15.3 Rationale

The need for additional exceptions given the new semantics added by the other sections of this specification is obvious. That the specification attaches new, nonconventional, exception semantics to AsynchronouslyInterruptedException is, perhaps, not so obvious. However, after careful thought, and given our self-imposed directive that only well-defined code blocks would be subject to having their control asynchronously transferred, the chosen mechanism is logical.

Open Issues

Editorial Issues

- The \classref tag should suppress multiple footnotes on the same {page,section,whatever}.
- We should consider numbered pagaraphs.
- Make sure all other constructors are defined in terms of the complete constructor. (Mostly done –jjh)
- Make the code environment use a monospaced font.
- Method reference do not generate footnotes
- We have a general issue of whether we signify when Illegal Assignment Exceptions can occur

List of Semantic Issues

List of Review Requests

Appendix A

Deprecated APIs

Since modules are new in 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 are deprecated and appear only here. Other deprecated methods, constructors, and fields are also here. Only full implementation of the RTSJ should implement them.

A.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.

A.2 javax.realtime

A.2.1 Interfaces

A.2.1.1 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[1], not directly from application code.

Deprecated as of RTSJ 2.0

A.2.1.1.1 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.

[1] Section A.2.3.20

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[2] 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.

Available since RTSJ 1.0.1

onInsertion(long, long, AsyncEventHandler)

Signature

public void
onInsertion(long base,
long size,
AsyncEventHandler aeh)

Description

Register the specified AsyncEventHandler[3] to run when any memory of this type, and in the range is added to the system. When the size or the base is less than 0, unregister all "onInsertion" references to the handler.

[2]Section 8.3.3.4
[3]Section 8.3.3.5

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.

Deprecated as of RTSJ 1.0.1 Replace with onInsertion(long, long, AsyncEvent)

onRemoval(long, long, AsyncEvent)

Signature

```
public void
onRemoval(long base,
          long size,
          AsyncEvent ae)
```

Description

Register 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.

Available since RTSJ 1.0.1

onRemoval(long, long, AsyncEventHandler)

Signature

public void
onRemoval(long base,
long size,
AsyncEventHandler aeh)

Description

Register the specified AEH to run when any memory in the range is removed from the system. When size or base is less than 0, unregister 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 known to this filter, 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.

Deprecated as of RTSJ 1.0.1

unregisterInsertionEvent(long, long, AsyncEvent)

Signature

public boolean
unregisterInsertionEvent(long base,
long size,
AsyncEvent ae)

Description

Unregister 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.

Available since RTSJ 1.0.1

unregisterRemovalEvent(long, long, AsyncEvent)

Signature

```
public boolean
unregisterRemovalEvent(long base,
                       long size,
                       AsyncEvent ae)
```

Description

Unregister 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.

Available since RTSJ 1.0.1

vFind(long, long)

Signature

```
public long
vFind(long base,
      long size)
```

Description

Search 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.

A.2.1.2 *Schedulable*

The following elements of Schedulable are deprecated. The required elements are documented in Section 6.3.1.3 above.

A.2.1.2.1 Methods

---

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public void
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             javax.realtime.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[4] 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[5].)

release A reference to the ReleaseParameters[6] 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[7].)

memoryParameters A reference to the MemoryParameters[8] which will be associated with this. When null, the default value is governed by scheduler (a new object

[4]Section 6.3.3.14
[5]Section 6.3.3.8
[6]Section 6.3.3.10
[7]Section 6.3.3.8
[8]Section 11.3.3.4

is created when the default value is not null). (See PriorityScheduler[9].)

group A reference to the ProcessingGroupParameters[10] which will be associated with this. When null, the default value is governed by scheduler (a new object is created). (See PriorityScheduler[11].)

Throws

IllegalArgumentException Thrown 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.

SecurityException 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[12] object for this schedulable.

Returns

A reference to the current ProcessingGroupParameters[13] object.

Deprecated since RTSJ 2.0

setProcessingGroupParameters(ProcessingGroupParameters)

[9] Section 6.3.3.8
[10] Section A.2.3.23
[11] Section 6.3.3.8
[12] Section A.2.3.23
[13] Section A.2.3.23

Signature

public void
setProcessingGroupParameters(ProcessingGroupParameters group)

Description

Sets the ProcessingGroupParameters[14] 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[15] 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[16].)

Throws

IllegalArgumentException Thrown 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 ProcessingGroup[17]

setProcessingGroupParametersIfFeasible(ProcessingGroupParameters)

Signature

public boolean
setProcessingGroupParametersIfFeasible(ProcessingGroupParameters group)

Description

[14]Section A.2.3.23
[15]Section A.2.3.23
[16]Section 6.3.3.8
[17]Section 6.3.3.9

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 proposed processing group parameters. 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[18].)

Throws

IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError when this cannot hold a reference to the proposed 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 anlaysis is inadequate

addIfFeasible

Signature

public boolean
addIfFeasible()

Description

[18]Section 6.3.3.8

This method first performs a feasibility analysis with this added to the system. When the resulting system is feasible, inform the scheduler and cooperating facilities that this instance of Schedulable[19] should be considered in feasibility analysis until further notified. When the analysis showed 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, do 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.

Available since RTSJ 1.0.1 Promoted to the Schedulable interface

Deprecated as of RTSJ 2.0, because the framework for feasibility anlaysis is inadequate.

addToFeasibility

Signature

public boolean
addToFeasibility()

Description

Inform the scheduler and cooperating facilities that this instance of Schedulable[20] should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, do nothing.

Returns

True, when the resulting system is feasible. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

removeFromFeasibility

Signature

[19] Section 6.3.1.3
[20] Section 6.3.1.3

```
public boolean
removeFromFeasibility()
```

Description

Inform the scheduler and cooperating facilities that this instance of Schedulable[21] 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 anlaysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(javax.realtime.ReleaseParameters<?> release,
              MemoryParameters memory)
throws IllegalArgumentException,
       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

[21] Section 6.3.1.3

release The proposed release parameters. 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[22].)

memory The proposed memory parameters. 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[23].)

Throws

IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError when this cannot hold references to the proposed 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.

Available since RTSJ 1.0.1 Promoted to the Schedulable interface.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(javax.realtime.ReleaseParameters<?> release,
              MemoryParameters memory,
              ProcessingGroupParameters group)
throws IllegalArgumentException,
       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

[22]Section 6.3.3.8
[23]Section 6.3.3.8

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 proposed release parameters. 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[24].)

memory The proposed memory parameters. 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[25].)

group The proposed processing group parameters. 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[26].)

Throws

IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError when this cannot hold references to the proposed 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.

Available since RTSJ 1.0.1 Promoted to the Schedulable interface.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

[24]Section 6.3.3.8
[25]Section 6.3.3.8
[26]Section 6.3.3.8

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

public boolean
setIfFeasible(javax.realtime.ReleaseParameters<?> release,
ProcessingGroupParameters group)
throws IllegalArgumentException,
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 proposed release parameters. 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[27].)

group The proposed processing group parameters. 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[28].)

Throws

IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

[27]Section 6.3.3.8
[28]Section 6.3.3.8

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.

Available since RTSJ 1.0.1 Promoted to the Schedulable interface.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              javax.realtime.ReleaseParameters<?> release,
              MemoryParameters memory)
throws IllegalArgumentException,
       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 proposed scheduling parameters. 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[29].)

[29] Section 6.3.3.8

release The proposed release parameters. 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[30].)

memory The proposed memory parameters. 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[31].)

Throws

IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError when this cannot hold references to the proposed 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.

Available since RTSJ 1.0.1

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              javax.realtime.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.

[30] Section 6.3.3.8
[31] Section 6.3.3.8

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 proposed scheduling parameters. 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[32].)

release The proposed release parameters. 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[33].)

memory The proposed memory parameters. 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[34].)

group The proposed processing group parameters. 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[35].)

Throws

IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError when this cannot hold references to the proposed 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.

Available since RTSJ 1.0.1

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

[32]Section 6.3.3.8
[33]Section 6.3.3.8
[34]Section 6.3.3.8
[35]Section 6.3.3.8

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 proposed memory parameters. 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[36].)

Throws

IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError when this cannot hold a reference to the proposed 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 anlaysis is inadequate

[36]Section 6.3.3.8

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

public boolean
setReleaseParametersIfFeasible(javax.realtime.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 proposed release parameters. 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[37].)

Throws

IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError when this cannot hold a reference to the proposed 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 anlaysis is inadequate.

[37] Section 6.3.3.8

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 proposed scheduling parameters. 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[38].)

Throws

IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError when this cannot hold a reference to the proposed 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 anlaysis is inadequate

[38]Section 6.3.3.8

A.2.2 Exceptions

A.2.2.1 *ArrivalTimeQueueOverflowException*

The following elements of ArrivalTimeQueueOverflowException are deprecated. The required elements are documented in Section 15.2.2.1 above.

A.2.2.1.1 Constructors

ArrivalTimeQueueOverflowException(String)

Signature

public
ArrivalTimeQueueOverflowException(String description)

Description

A descriptive constructor for ArrivalTimeQueueOverflowException.

Deprecated since RTSJ 2.0; application code should use get()[39] instead.

Parameters

description A description of the exception.

A.2.2.2 *AsynchronouslyInterruptedException*

The following elements of AsynchronouslyInterruptedException are deprecated. The required elements are documented in Section 8.3.2.1 above.

A.2.2.2.1 Methods

---

[39] Section 15.2.2.1.2

happened(boolean)

Signature

public boolean
happened(boolean propagate)

Description

Used with an instance of this exception to see if the current exception is this exception. When an AsynchronouslyInterruptedException is caught, the catch clause may invoke the happened() method on the AsynchronouslyInterruptedException in which it is interested to see if it matches the pending AsynchronouslyInterruptedException. When so, the pending AsynchronouslyInterruptedException is cleared for the schedulable and happened returns true. Otherwise, the behavior of happened depends on its propagation parameter. When propagation parameter is true, the AsynchronouslyInterruptedException will continue to propagate outward; i.e., it will be re-thrown by a mechanism that bypassed the normal requirement that the checked exception be identified in the method's signature. When propagation parameter is false, happened will return false and the AsynchronouslyInterruptedException remains pending.

Parameters

propagate Control the behavior when this is not the current exception:

- When true and this exception is the current one, set the state of this to non pending and return true.
- When true and this exception is not the current one, propagate the exception; i.e., rethrow it.
- When false and this exception is the current one, the state of this is set to nonpending (i.e., it will stop propagating) and return true.
- When false and this exception is not the current one, return false.

Throws

IllegalThreadStateException when called from a Java thread.

Returns

true, when this is the current exception, and false, when this is not the current exception.

Deprecated as of RTSJ 1.0.1. This method seriously violates standard Java exception semantics, and while it is a convenience it is not required. The happened method can be replaced with the clear method and application logic.

propagate

Signature

public static void
propagate()

Description

Cause the pending exception to continue up the stack. The current AIE remains pending and control is transferred immediately to the next suitable catch or finally clause under the normal rules for AIE propagation.

When there is no current AIE, the method does nothing and simply returns.

This method is normally used in a catch clause that is handling an AIE, but that is not required. The method may be invoked at any time (from a schedulable).

Throws

IllegalThreadStateException when called from a Java thread.

Deprecated as of RTSJ 1.0.1. This method seriously violates standard Java exception semantics, and while it is a convenience it is not required. It should be replaced with throw of an instance of AsynchronouslyInterruptedException.

A.2.2.3 DuplicateFilterException

Inheritance

java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      javax.realtime.DuplicateFilterException

Description

PhysicalMemoryManager[40] 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

[40] Section A.2.3.20

A.2.2.3.1 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.

A.2.2.4 *MemoryScopeException*

The following elements of MemoryScopeException are deprecated. The required elements are documented in Section 15.2.2.9 above.

A.2.2.4.1 Constructors

MemoryScopeException(String)

Signature
public
MemoryScopeException(String description)

Description
A descriptive constructor for MemoryScopeException.

Deprecated since RTSJ 2.0; application code should use get()[41] instead.

Parameters
description A description of the exception.

A.2.2.5 *OffsetOutOfBoundsException*

The following elements of OffsetOutOfBoundsException are deprecated. The required elements are documented in Section 15.2.2.11 above.

A.2.2.5.1 Constructors

OffsetOutOfBoundsException(String)

Signature
public
OffsetOutOfBoundsException(String description)

Description
A descriptive constructor for OffsetOutOfBoundsException.

Deprecated since RTSJ 2.0; pplication code should use get()[42] instead.

Parameters

[41] Section 15.2.2.9.2
[42] Section 15.2.2.11.2

description A description of the exception.

A.2.2.6 UnknownHappeningException

Inheritance
java.lang.Object
  java.lang.Throwable
    java.lang.Exception
      java.lang.RuntimeException
        javax.realtime.UnknownHappeningException

Description

This exception is used to indicate a situation where an instance of AsyncEvent[43] attempts to bind to a happening that does not exist.

Deprecated since RTSJ 2.0

A.2.2.6.1 Constructors

UnknownHappeningException

Signature

public
UnknownHappeningException()

Description

A constructor for UnknownHappeningException.

UnknownHappeningException(String)

Signature

public
UnknownHappeningException(String description)

[43]Section 8.3.3.4

Description

A descriptive constructor for UnknownHappeningException.

Parameters
description Description of the error.

A.2.2.7 *UnsupportedPhysicalMemoryException*

The following elements of UnsupportedPhysicalMemoryException are deprecated. The required elements are documented in Section 15.2.2.23 above.

A.2.2.7.1 Constructors

UnsupportedPhysicalMemoryException(String)

Signature

public
UnsupportedPhysicalMemoryException(String description)

Description

A descriptive constructor for UnsupportedPhysicalMemoryException.

Deprecated since RTSJ 2.0; application code should use get()[44] instead.

Parameters
description The description of the exception.

A.2.3 Classes

A.2.3.1 *AbsoluteTime*

The following elements of AbsoluteTime are deprecated. The required elements are documented in Section 9.3.1.1 above.

[44] Section 15.2.2.23.2

A.2.3.1.1 Constructors

AbsoluteTime(long, int, Clock)

Signature

public
AbsoluteTime(long millis,
int nanos,
Clock clock)
throws IllegalArgumentException

Description

Superceeded by and equivalent to AbsoluteTime(long, int, Chronograph)[45]

Available 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

IllegalArgumentException when there is an overflow in the millisecond component when normalizing.

AbsoluteTime(AbsoluteTime, Clock)

Signature

public
AbsoluteTime(AbsoluteTime time,
Clock clock)

[45]Section 9.3.1.1.1

throws IllegalArgumentException

Description

Equivalent to AbsoluteTime(long, int, Chronograph)[46] with the arguments time. getMilliseconds(), time.getNanoseconds(), clock().

Available since RTSJ 1.0.1

Deprecated since version 2.0

Parameters

time is the AbsoluteTime object which is the source for the copy.

clock is the clock providing the association for the newly constructed object.

Throws

IllegalArgumentException when the time parameter is null.

AbsoluteTime(Date, Clock)

Signature

public
AbsoluteTime(Date date,
Clock clock)
throws IllegalArgumentException

Description

Superceeded by and equivalent to AbsoluteTime(Date, Chronograph)[47]

Available 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

IllegalArgumentException when the date parameter is null.

[46] Section 9.3.1.1.1
[47] Section 9.3.1.1.1

AbsoluteTime(Clock)

Signature
public
AbsoluteTime(Clock clock)

Description
Superceeded by and equivalent to AbsoluteTime(Chronograph)[48]

Available since RTSJ 1.0.1

Deprecated since version 2.0

Parameters
clock The clock providing the association for the newly constructed object.

A.2.3.1.2 Methods

---

absolute(Clock)

Signature
public javax.realtime.AbsoluteTime
absolute(Clock clock)

Description
Superceeded by and equivalent to absolute(Chronograph)[49].

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

[48]Section 9.3.1.1.1
[49]Section 9.3.1.1.2

absolute(Clock, AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
absolute(Clock clock,
AbsoluteTime dest)

Description

Superceeded by and equivalent to absolute(Chronograph, AbsoluteTime)[50].

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. Otherwise, a new object is allocated for the result.

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)[51].

Parameters

clock The instance of Clock[52] 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

[50] Section 9.3.1.1.2
[51] Section 9.3.1.1.2
[52] Section 10.3.2.1

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)[53].

Parameters

clock The instance of Clock[54] 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 there and returned. Otherwise, a new object is allocated for the result.

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

A.2.3.2 *AperiodicParameters*

The following elements of AperiodicParameters are deprecated. The required elements are documented in Section 6.3.3.2 above.

[53]Section 9.3.1.1.2
[54]Section 10.3.2.1

A.2.3.2.1 Fields

arrivalTimeQueueOverflowExcept

public static final 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[55]. 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[56] is bound then the arrival time is ignored.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0

arrivalTimeQueueOverflowIgnore

public static final 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.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0

[55]Section 15.2.2.1
[56]Section 8.3.3.5

arrivalTimeQueueOverflowReplace

public static final 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.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0

arrivalTimeQueueOverflowSave

public static final 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" 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.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0

A.2.3.2.2 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.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0 replaced by ReleaseParameters.getInitialQueueLength()[57].

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
IllegalArgumentException when initial is less than zero.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated since RTSJ 2.0 replaced by ReleaseParameters.setInitialQueueLength(int initial)[58].

[57]Section 6.3.3.10.2
[58]Section 6.3.3.10.2

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.

Available since RTSJ 1.0.1 Moved from SporadicParameters

Deprecated since RTSJ 2.0 and replaced by ReleaseParameters.getEventQueueOverflowPolicy[59]

setArrivalTimeQueueOverflowBehavior(String)

Signature

public void
setArrivalTimeQueueOverflowBehavior(String behavior)

Description

Sets the behavior of the arrival time queue in the case where the insertion of a new element would make the queue size greater than the initial size given in this.

Values of behavior are compared using reference equality (==) not value equality (equals()).

Parameters

behavior A string representing the behavior.

Throws

IllegalArgumentException when behavior is not one of the final queue overflow behavior values defined in this class.

Available since RTSJ 1.0.1 Moved here from SporadicParameters.

Deprecated Since RTSJ 2.0

[59] Section 6.3.3.10.2

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. 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

IllegalArgumentException 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[60], need not return false.)

Deprecated as of RTSJ 2.0

A.2.3.3 *AsyncEvent*

The following elements of AsyncEvent are deprecated. The required elements are documented in Section 8.3.3.4 above.

[60] Section 6.3.3.15

A.2.3.3.1 Methods

handledBy(AsyncEventHandler)

Signature

public boolean
handledBy(AsyncEventHandler handler)

Description

Replaced by AsyncBaseEvent.handledBy(AsyncBaseEventHandler)[61]

Parameters

handler to query its association with this.

Returns

true when and only whem handler is associated with this event.

Deprecated since RTSJ 2.0

addHandler(AsyncEventHandler)

Signature

public void
addHandler(AsyncEventHandler handler)

Description

Replaced by AsyncBaseEvent.addHandler(AsyncBaseEventHandler)[62]

Parameters

handler to add to this.

Deprecated since RTSJ 2.0

setHandler(AsyncEventHandler)

Signature

[61] Section 8.3.3.2.1
[62] Section 8.3.3.2.1

public void
setHandler(AsyncEventHandler handler)

Description

Replaced by AsyncBaseEvent.setHandler(AsyncBaseEventHandler)[63]

Parameters
handler to be the sole handler for this.
Deprecated since RTSJ 2.0

removeHandler(AsyncEventHandler)

Signature
public void
removeHandler(AsyncEventHandler handler)

Description

Replaced by AsyncBaseEvent.removeHandler(AsyncBaseEventHandler)[64]

Parameters
handler to be removed.
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.

[63]Section 8.3.3.2.1
[64]Section 8.3.3.2.1

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.

IllegalArgumentException 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.

IllegalArgumentException when happening is null.

Deprecated since RTSJ 2.0

A.2.3.4 *AsyncEventHandler*

The following elements of AsyncEventHandler are deprecated. The required elements are documented in Section 8.3.3.5 above.

A.2.3.4.1 Constructors

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, boolean, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
                  javax.realtime.ReleaseParameters<?> release,
                  MemoryParameters memory,
                  MemoryArea area,
                  SchedulingGroup group,
                  boolean nonheap,
                  Runnable logic)
```

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[65] with arguments (scheduling, release, memory.clone(!nonheap), group, null, logic).

Deprecated in version 2.0.

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
AsyncEventHandler(SchedulingParameters scheduling,
```

[65] Section 8.3.3.5.1

javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory,
MemoryArea area,
ProcessingGroupParameters group,
Runnable logic)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[66] with arguments (scheduling, release, memory, area, group, null, logic).

Deprecated in version 2.0.

AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean)

Signature

public
AsyncEventHandler(SchedulingParameters scheduling,
javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory,
MemoryArea area,
ProcessingGroupParameters group,
boolean nonheap)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[67] with arguments (scheduling, release, memory, area, group.getProcessingGroup(), null, null).

Deprecated in version 2.0.

[66] Section 8.3.3.5.1
[67] Section 8.3.3.5.1

AsyncEventHandler(boolean, Runnable)

Signature

public
AsyncEventHandler(boolean nonheap,
Runnable logic)

Description

Calling this constructor is equivalent to calling AsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, SchedulingGroup, ConfigurationParameters, Runnable)[68] with arguments (null, null, new MemoryParameters(!nonheap), null, null, null, 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, SchedulingGroup, ConfigurationParameters, Runnable)[69] with arguments (null, null, new MemoryParameters(!nonheap), null, null, null, null).

Deprecated in version 2.0.

A.2.3.4.2 Methods

[68] Section 8.3.3.5.1
[69] Section 8.3.3.5.1

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.

The effect of a call to getAndIncrementPendingFireCount on the arrival-time queue and the scheduling of this AEH depends on the semantics of the scheduler controlling this AEH.

Throws

MITViolationException Thrown 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 Thrown 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,
javax.realtime.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 scheduler A reference to the scheduler that will manage the execution of this schedulable. Null is not a permissible value.

scheduling scheduling A reference to the SchedulingParameters[70] 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[71].)

release release A reference to the ReleaseParameters[72] 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[73].)

memoryParameters memoryParameters A reference to the MemoryParameters[74] 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[75].)

group group A reference to the ProcessingGroupParameters[76] which will be associated with this. When null, the default value is governed by scheduler (a new object is created). (See PriorityScheduler[77].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 IllegalAssignmentError when this object cannot hold references to all the parameter objects or the parameters cannot hold references to this.

SecurityException SecurityException when the caller is not permitted to set the scheduler for this schedulable.

Deprecated since RTSJ 2.0

[70] Section 6.3.3.14
[71] Section 6.3.3.8
[72] Section 6.3.3.10
[73] Section 6.3.3.8
[74] Section 11.3.3.4
[75] Section 6.3.3.8
[76] Section A.2.3.23
[77] Section 6.3.3.8

getProcessingGroupParameters

Signature

public javax.realtime.ProcessingGroupParameters
getProcessingGroupParameters()

Description

Gets a reference to the ProcessingGroupParameters[78] object for this schedulable.

Returns

A reference to the current ProcessingGroupParameters[79] object.

Deprecated since RTSJ 2.0

setProcessingGroupParameters(ProcessingGroupParameters)

Signature

public void
setProcessingGroupParameters(ProcessingGroupParameters group)

Description

Sets the ProcessingGroupParameters[80] 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 group A ProcessingGroupParameters[81] 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[82].)

Throws

[78] Section A.2.3.23
[79] Section A.2.3.23
[80] Section A.2.3.23
[81] Section A.2.3.23
[82] Section 6.3.3.8

IllegalArgumentException IllegalArgumentException Thrown 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 IllegalAssignmentError when this object cannot hold a reference to group or group cannot hold a reference to this.

IllegalThreadStateException 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

Inform the scheduler and cooperating facilities that this instance of Schedulable[83] should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, do 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, inform the scheduler and cooperating facilities that this instance of Schedulable[84] should be considered in feasibility

[83] Section 6.3.1.3
[84] Section 6.3.1.3

analysis until further notified. When the analysis showed 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, do 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

Inform the scheduler and cooperating facilities that this instance of Schedulable[85] 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(javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory)

Description

[85] Section 6.3.1.3

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 release The proposed release parameters. 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[86].)

memory memory The proposed memory parameters. 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[87].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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)

[86] Section 6.3.3.8
[87] Section 6.3.3.8

Signature

public boolean
setIfFeasible(SchedulingParameters scheduling,
javax.realtime.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 scheduling The proposed scheduling parameters. 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[88].)

release release The proposed release parameters. 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[89].)

memory memory The proposed memory parameters. 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[90].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a

[88]Section 6.3.3.8
[89]Section 6.3.3.8
[90]Section 6.3.3.8

reference to this.

IllegalThreadStateException 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(javax.realtime.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 release The proposed release parameters. 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[91].)

[91] Section 6.3.3.8

memory memory The proposed memory parameters. 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[92].)

group group The proposed processing group parameters. 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[93].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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,
              javax.realtime.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

[92]Section 6.3.3.8
[93]Section 6.3.3.8

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 scheduling The proposed scheduling parameters. 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[94].)

release release The proposed release parameters. 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[95].)

memory memory The proposed memory parameters. 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[96].)

group group The proposed processing group parameters. 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[97].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException IllegalThreadStateException when the schedulable's scheduler prohibits this parameter change at this time due to the state of the schedulable.

Returns

[94]Section 6.3.3.8
[95]Section 6.3.3.8
[96]Section 6.3.3.8
[97]Section 6.3.3.8

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 anlaysis is inadequate

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

public boolean
setReleaseParametersIfFeasible(javax.realtime.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 release The proposed release parameters. 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[98].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException IllegalThreadStateException when the schedulable's scheduler prohibits the changing of the release parameter at this time due to the state of the schedulable.

[98] Section 6.3.3.8

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 anlaysis is inadequate

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 group The proposed processing group parameters. 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[99].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

[99] Section 6.3.3.8

IllegalThreadStateException 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 anlaysis is inadequate

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

public boolean
setIfFeasible(javax.realtime.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 release The proposed release parameters. 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[100].)

group group The proposed processing group parameters. 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[101].)

[100] Section 6.3.3.8
[101] Section 6.3.3.8

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setMemoryParametersIfFeasible(MemoryParameters)

Signature

public final 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 memory The proposed memory parameters. 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[102].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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

[102]Section 6.3.3.8

scheduling scheduling The proposed scheduling parameters. 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[103].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

A.2.3.5 *BoundAsyncEventHandler*

The following elements of BoundAsyncEventHandler are deprecated. The required elements are documented in Section 8.3.3.10 above.

A.2.3.5.1 Constructors

BoundAsyncEventHandler(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, boolean, Runnable)

Signature

[103]Section 6.3.3.8

```
public
BoundAsyncEventHandler(SchedulingParameters scheduling,
                       javax.realtime.ReleaseParameters<?> release,
                       MemoryParameters memory,
                       MemoryArea area,
                       ProcessingGroupParameters group,
                       boolean nonheap,
                       Runnable logic)
```

Description

Create an instance of BoundAsyncEventHandler with the specified parameters. The newly-created handler inherits the affinity of its creator.

Deprecated since RTSJ 2.0

Parameters

scheduling A SchedulingParameters[104] object which will be associated with the constructed instance. When null, and the creator is a Java thread, a SchedulingParameters object is created which has the default SchedulingParameters for the scheduler associated with the current thread. When null, and the creator is a schedulable object, the SchedulingParameters are inherited from the current schedulable (a new SchedulingParameters object is cloned).

release A ReleaseParameters[105] object which will be associated with the constructed instance. When null, this will have default ReleaseParameters for the BAEH's scheduler.

memory A MemoryParameters[106] object which will be associated with the constructed instance. When null, this will have no MemoryParameters.

area The MemoryArea[107] for this. When null, the memory area will be that of the current thread/schedulable.

group A ProcessingGroupParameters[108] 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()[109]. When null, the default handleAsyncEvent() method invokes nothing.

[104]Section 6.3.3.14
[105]Section 6.3.3.10
[106]Section 11.3.3.4
[107]Section 11.3.3.3
[108]Section A.2.3.23
[109]Section 8.3.3.5.2

nonheap when true, the code executed by this handler may not reference or store objects in HeapMemory[110]; otherwise, that code may do so. When true and the current handler tries to reference or store objects in HeapMemory or enter the HeapMemory a IllegalArgumentException is thrown.

Throws

IllegalArgumentException when nonheap is true and logic, any parameter object, or this is in heap memory. Also when noheap 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.

A.2.3.6 *Clock*

The following elements of Clock are deprecated. The required elements are documented in Section 10.3.2.1 above.

A.2.3.6.1 Methods

---

setResolution(RelativeTime)

Signature

public abstract void
setResolution(RelativeTime resolution)

Description

Set the resolution of this. For some hardware clocks setting resolution is impossible and when this method is called on those clocks, then an UnsupportedOperationException is thrown.

Parameters

resolution The new resolution of this, when the requested value is supported by this clock. When resolution is smaller than the minimum resolution supported by this clock then it throws IllegalArgumentException. When the requested

[110]Section 11.3.3.1

resolution is not available and it is larger than the minimum resolution, then the clock will be set to the closest resolution that the clock supports, via truncation. The value of the resolution parameter is not altered. The clock association of the resolution parameter is ignored.

Throws

IllegalArgumentException when resolution is null, or when the requested resolution is smaller than the minimum resolution supported by this clock.

UnsupportedOperationException when the clock does not support setting its resolution.

Deprecated since RTSJ 2.0

getResolution

Signature

public final javax.realtime.RelativeTime
getResolution()

Description

Gets the resolution of the clock, the nominal interval between ticks.

Returns

A newly allocated RelativeTime[111] object representing the resolution of this. The returned object is associated with this clock.

Deprecated since RTSJ 2.0

See Section getDrivePrecision

See Section getQueryPrecision

A.2.3.7 *GarbageCollector*

The following elements of GarbageCollector are deprecated. The required elements are documented in Section 14.2.2.1 above.

[111] Section 9.3.1.3

A.2.3.7.1 Constructors

GarbageCollector

Signature

public
GarbageCollector()

Description

Create an instance of this.

Deprecated as of RTSJ 1.0.1 This class and any subclasses should be singletons.

A.2.3.8 *HighResolutionTime*

The following elements of HighResolutionTime are deprecated. The required elements are documented in Section 9.3.1.2 above.

A.2.3.8.1 Methods

absolute(Clock, AbsoluteTime)

Signature

public abstract javax.realtime.AbsoluteTime
absolute(Clock clock,
AbsoluteTime dest)

Description

Equivalent to and superseded by absolute(Chronograph, AbsoluteTime)[112]. When dest is not null, the result is placed there and returned. Otherwise, a new object

[112]Section 9.3.1.2.1

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[113] 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. Otherwise, a new object is allocated for the result.

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)[114].

Parameters

clock is the instance of Clock[115] 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

[113]Section 10.3.2.1
[114]Section 9.3.1.2.1
[115]Section 10.3.2.1

public abstract javax.realtime.RelativeTime
relative(Clock clock,
RelativeTime dest)

Description

Equivalent to and superseded by relative(Chronograph, RelativeTime)[116]

Parameters

clock The instance of Clock[117] 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 there and returned. Otherwise, a new object is allocated for the result.

Returns

The RelativeTime[118] 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)[119]

Parameters

clock The instance of Clock[120] 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

[116]Section 9.3.1.2.1
[117]Section 10.3.2.1
[118]Section 9.3.1.3
[119]Section 9.3.1.2.1
[120]Section 10.3.2.1

A.2.3.9 *IllegalAssignmentError*

The following elements of IllegalAssignmentError are deprecated. The required elements are documented in Section 15.2.3.2 above.

A.2.3.9.1 Constructors

IllegalAssignmentError(String)

Signature

public
IllegalAssignmentError(String description)

Description

A descriptive constructor for IllegalAssignmentError.

Deprecated since RTSJ 2.0; application code should use get()[121] instead.

Parameters

description Description of the error.

A.2.3.10 ImmortalPhysicalMemory

Inheritance

java.lang.Object
javax.realtime.MemoryArea
javax.realtime.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

[121] Section 15.2.3.2.2

ImmortalMemory[122] 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.

Deprecated since RTSJ 2.0

A.2.3.10.1 Constructors

ImmortalPhysicalMemory(Object, long, long, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       long size,
                       Runnable logic)
```

Description

Create 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.

[122] Section 11.3.3.2

logic The run() method of this object will be called whenever MemoryArea.enter()[123] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[124] has been registered with the PhysicalMemoryManager[125].

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.

OutOfMemoryError 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, SizeEstimator, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       SizeEstimator size,
                       Runnable logic)
```

Description

[123]Section 11.3.3.3.2
[124]Section A.2.1.1
[125]Section A.2.3.20

Create 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()[126] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[127] has been registered with the PhysicalMemoryManager[128].

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.

OutOfMemoryError 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.

[126] Section 11.3.3.3.2
[127] Section A.2.1.1
[128] Section A.2.3.20

ImmortalPhysicalMemory(Object, long, Runnable)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long size,
                       Runnable logic)
```

Description

Create 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()[129] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[130] has been registered with the PhysicalMemoryManager[131].

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.

OutOfMemoryError when there is insufficient memory for the ImmortalPhysicalMemory object or for the backing memory.

[129] Section 11.3.3.3.2
[130] Section A.2.1.1
[131] Section A.2.3.20

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

Create 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()[132] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[133] has been registered with the PhysicalMemoryManager[134].

IllegalArgumentException when size is null, or size.getEstimate() is negative.

MemoryTypeConflictException when type specifies incompatible memory attributes.

[132]Section 11.3.3.3.2
[133]Section A.2.1.1
[134]Section A.2.3.20

OutOfMemoryError 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, long)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       long size)
```

Description

Create 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

SecurityException 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[135] has been registered with the PhysicalMemoryManager[136].

MemoryTypeConflictException when the specified base does not point to memory that matches the requested type, or when type specifies incompatible memory attributes.

[135] Section A.2.1.1
[136] Section A.2.3.20

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.

OutOfMemoryError when there is insufficient memory for the ImmortalPhysicalMemory object or for the backing memory.

ImmortalPhysicalMemory(Object, long, SizeEstimator)

Signature

```
public
ImmortalPhysicalMemory(Object type,
                       long base,
                       SizeEstimator size)
```

Description

Create 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

SecurityException 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[137] has been registered with the PhysicalMemoryManager[138].

[137]Section A.2.1.1
[138]Section A.2.3.20

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.

OutOfMemoryError when there is insufficient memory for the ImmortalPhysicalMemory object or for the backing memory.

ImmortalPhysicalMemory(Object, long)

Signature

public
ImmortalPhysicalMemory(Object type,
long size)

Description

Create 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

SecurityException 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[139] has been registered with the PhysicalMemoryManager[140].

MemoryTypeConflictException when type specifies incompatible memory attributes.

[139] Section A.2.1.1
[140] Section A.2.3.20

IllegalArgumentException when size is less than zero.

OutOfMemoryError when there is insufficient memory for the ImmortalPhysicalMemory object or for the backing memory.

SizeOutOfBoundsException when the size extends into an invalid range of memory.

ImmortalPhysicalMemory(Object, SizeEstimator)

Signature

public
ImmortalPhysicalMemory(Object type,
SizeEstimator size)

Description

Create 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

SecurityException 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[141] has been registered with the PhysicalMemoryManager[142].

MemoryTypeConflictException when type specifies incompatible memory attributes.

IllegalArgumentException when size is null, or size.getEstimate() is negative.

OutOfMemoryError when there is insufficient memory for the ImmortalPhysicalMemory object or for the backing memory.

[141] Section A.2.1.1
[142] Section A.2.3.20

A.2.3.11 LTMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.ScopedMemory
      javax.realtime.LTMemory

Description

Equivalent to and superseded by javax.realtime.memory.LTMemory[143].

Deprecated since RTSJ 2.0; moved to package javax.realtime.memory.

A.2.3.11.1 Constructors

LTMemory(long, long, Runnable)

Signature

```
public
LTMemory(long initial,
         long maximum,
         Runnable logic)
```

Description

Create 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)[144].

Throws

[143] Section 11.4.3.1
[144] Section A.2.3.11.1

IllegalArgumentException when initial is greater than maximum, or when initial or maximum is less than zero.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

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)[145] with the argument list (initial.getEstimate(), maximum.getEstimate(), logic).

Parameters

initial An instance of SizeEstimator[146] 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[147] 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)[148].

Throws

IllegalArgumentException when initial is null, maximum is null, initial.getEstimate() is greater than maximum.getEstimate(), or when initial.getEstimate() is less than zero.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

[145] Section A.2.3.11.1
[146] Section 11.3.3.5
[147] Section 11.3.3.5
[148] Section A.2.3.11.1

LTMemory(long, long)

Signature

public
LTMemory(long initial,
long maximum)

Description

Equivalent to LTMemory(long, long, Runnable)[149] 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.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

LTMemory(SizeEstimator, SizeEstimator)

Signature

public
LTMemory(SizeEstimator initial,
SizeEstimator maximum)

Description

Equivalent to LTMemory(long, long, Runnable)[150] with the argument list (initial.getEstimate(), maximum.getEstimate(), null).

Parameters

initial An instance of SizeEstimator[151] used to give an estimate of the initial size. This memory must be committed before the completion of the constructor.

[149] Section A.2.3.11.1
[150] Section A.2.3.11.1
[151] Section 11.3.3.5

maximum An instance of SizeEstimator[152] 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.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

LTMemory(long, Runnable)

Signature

public
LTMemory(long size,
Runnable logic)

Description

Equivalent to LTMemory(long, long, Runnable)[153] with the argument list (size, size, logic).

Available 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)[154].

Throws

IllegalArgumentException when size is less than zero.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

[152] Section 11.3.3.5
[153] Section A.2.3.11.1
[154] Section A.2.3.11.1

LTMemory(SizeEstimator, Runnable)

Signature

public
LTMemory(SizeEstimator size,
Runnable logic)

Description

Equivalent to LTMemory(long, long, Runnable)[155] with the argument list (size.getEstimate(), size.getEstimate(), logic).

Available since RTSJ 1.0.1

Parameters

size An instance of SizeEstimator[156] 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 initial)[157].

Throws

IllegalArgumentException when size is null, or size.getEstimate() is less than zero.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

LTMemory(long)

Signature

public
LTMemory(long size)

Description

[155]Section A.2.3.11.1
[156]Section 11.3.3.5
[157]Section A.2.3.11.1

Equivalent to LTMemory(long, long, Runnable)[158] with the argument list (size, size, null).

Available 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.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

LTMemory(SizeEstimator)

Signature

public
LTMemory(SizeEstimator size)

Description

Equivalent to LTMemory(long, long, Runnable)[159] with the argument list (size.getEstimate(), size.getEstimate(), null).

Available since RTSJ 1.0.1

Parameters

size An instance of SizeEstimator[160] 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.

OutOfMemoryError when there is insufficient memory for the LTMemory object or for the backing memory.

A.2.3.11.2 Methods

[158] Section A.2.3.11.1
[159] Section A.2.3.11.1
[160] Section 11.3.3.5

toString

Signature

public java.lang.String
toString()

Description

Create a string representation of this object. The string is of the form

(LTMemory) Scoped memory # num

where num uniquely identifies the LTMemory area.

Returns

A string representing the value of this.

A.2.3.12 LTPhysicalMemory

Inheritance

java.lang.Object
javax.realtime.MemoryArea
javax.realtime.ScopedMemory
javax.realtime.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[161] memory areas, and the same performance restrictions as LTMemory[162].

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

[161] Section A.2.3.32
[162] Section A.2.3.11

A.2.3.12.1 Constructors

LTPhysicalMemory(Object, long, long, Runnable)

Signature

public
LTPhysicalMemory(Object type,
long base,
long size,
Runnable logic)

Description

Create 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()[163] 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.

SecurityException 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.

[163] Section 11.3.3.3.2

UnsupportedPhysicalMemoryException when the underlying hardware does not support the given type, or when no matching PhysicalMemoryTypeFilter[164] has been registered with the PhysicalMemoryManager[165].

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)[166] 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.

[164]Section A.2.1.1
[165]Section A.2.3.20
[166]Section A.2.3.12.1

logic The run() method of this object will be called whenever MemoryArea.enter()[167] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[168] has been registered with the PhysicalMemoryManager[169].

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)[170] with the the argument list (type, base, size, null).

See Section PhysicalMemoryManager

[167] Section 11.3.3.3.2
[168] Section A.2.1.1
[169] Section A.2.3.20
[170] Section A.2.3.12.1

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

SecurityException 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[171] has been registered with the PhysicalMemoryManager[172].

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)[173] with the argument list (type, base, size.getEstimate(), null).

[171] Section A.2.1.1
[172] Section A.2.3.20
[173] Section A.2.3.12.1

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

SecurityException 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[174] has been registered with the PhysicalMemoryManager[175].

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

[174]Section A.2.1.1
[175]Section A.2.3.20

Equivalent to LTPhysicalMemory(Object, long, long, Runnable)[176] with the argument list (type, 0, size, 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).

size The size of the area in bytes.

logic The run() method of this object will be called whenever MemoryArea.enter()[177] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[178] has been registered with the PhysicalMemoryManager[179].

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

[176] Section A.2.3.12.1
[177] Section 11.3.3.3.2
[178] Section A.2.1.1
[179] Section A.2.3.20

```
public
LTPhysicalMemory(Object type,
                 SizeEstimator size,
                 Runnable logic)
```

Description

Equivalent to LTPhysicalMemory(Object, long, long, Runnable)[180] with the argument list (type, 0, 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).

size A size estimator for this area.

logic The run() method of this object will be called whenever MemoryArea.enter()[181] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[182] has been registered with the PhysicalMemoryManager[183].

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 would violate the assignment rules.

[180] Section A.2.3.12.1
[181] Section 11.3.3.3.2
[182] Section A.2.1.1
[183] Section A.2.3.20

LTPhysicalMemory(Object, long)

Signature

public
LTPhysicalMemory(Object type,
long size)

Description

Equivalent to LTPhysicalMemory(Object, long, long, Runnable)[184] with the argument list (type, 0, 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).

size The size of the area in bytes.

Throws

SecurityException 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[185] has been registered with the PhysicalMemoryManager[186].

MemoryTypeConflictException when type specifies incompatible memory attributes.

LTPhysicalMemory(Object, SizeEstimator)

Signature

[184]Section A.2.3.12.1
[185]Section A.2.1.1
[186]Section A.2.3.20

```
public
LTPhysicalMemory(Object type,
                 SizeEstimator size)
```

Description

Equivalent to LTPhysicalMemory(Object, long, long, Runnable)[187] with the argument list (type, 0, 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).

size A size estimator for this area.

Throws

SecurityException 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[188] has been registered with the PhysicalMemoryManager[189].

MemoryTypeConflictException when type specifies incompatible memory attributes.

IllegalArgumentException when size is null, or size.getEstimate() is negative.

A.2.3.12.2 Methods

---

toString

Signature

[187] Section A.2.3.12.1
[188] Section A.2.1.1
[189] Section A.2.3.20

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.

A.2.3.13 *MemoryAccessError*

The following elements of MemoryAccessError are deprecated. The required elements are documented in Section 15.2.3.3 above.

A.2.3.13.1 Constructors

MemoryAccessError(String)

Signature

public
MemoryAccessError(String description)

Description

A descriptive constructor for MemoryAccessError.

Deprecated since RTSJ 2.0; application code should use get()[190] instead.

Parameters

description Description of the error.

[190] Section 15.2.3.3.2

A.2.3.14 *MemoryParameters*

The following elements of MemoryParameters are deprecated. The required elements are documented in Section 11.3.3.4 above.

A.2.3.14.1 Fields

A.2.3.14.2 Methods

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.

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[191]. 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

IllegalArgumentException when any value other than positive, zero, or NO_MAX is passed as the value of allocationRate.

Returns

[191] Section 11.3.3.4.1

True when the request was fulfilled.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis 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.

Parameters

maximum Units are in bytes. When zero, no allocation allowed in immortal. To specify no limit, use NO_MAX.

Throws

IllegalArgumentException 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 anlaysis 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.

Parameters

maximum Units are in bytes. When zero, no allocation allowed in the initial memory area. To specify no limit, use NO_MAX.

Throws

IllegalArgumentException 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 anlaysis is inadequate

A.2.3.15 NoHeapRealtimeThread

Inheritance

java.lang.Object
  java.lang.Thread
    javax.realtime.RealtimeThread
      javax.realtime.NoHeapRealtimeThread

Description

A NoHeapRealtimeThread is a specialized form of RealtimeThread[192]. 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[193] or ImmortalMemory[194].

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

[192]Section 5.3.2.2
[193]Section A.2.3.32
[194]Section 11.3.3.2

A.2.3.15.1 Constructors

NoHeapRealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
NoHeapRealtimeThread(SchedulingParameters scheduling,
                     javax.realtime.ReleaseParameters release,
                     MemoryParameters memory,
                     MemoryArea area,
                     ProcessingGroupParameters group,
                     Runnable logic)
```

Description

Create 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 it defaults to the a copy of the creator's release parameters 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 memory parameters, 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 NoHeapRealtimeThread.

NoHeapRealtimeThread(SchedulingParameters, ReleaseParameters, MemoryArea)

Signature

```
public
NoHeapRealtimeThread(SchedulingParameters scheduling,
                     javax.realtime.ReleaseParameters release,
                     MemoryArea area)
```

Description

Create a realtime thread which may not use the heap with the given SchedulingParameters[195], ReleaseParameters[196] and MemoryArea[197], and default values for all other parameters. This constructor is equivalent to NoHeapRealtimeThread(scheduling, release, null, area, null, null, null).

NoHeapRealtimeThread(SchedulingParameters, MemoryArea)

[195]Section 6.3.3.14
[196]Section 6.3.3.10
[197]Section 11.3.3.3

Signature

public
NoHeapRealtimeThread(SchedulingParameters scheduling,
MemoryArea area)

Description

Create a realtime thread with the given SchedulingParameters[198] and MemoryArea[199] and default values for all other parameters.

This constructor is equivalent to NoHeapRealtimeThread(scheduling, null, null, area, null, null, null).

A.2.3.15.2 Methods

---

start

Signature

public void
start()

Description

Set up the realtime thread's environment and start it. The set up might include delaying it until the assigned start time and initializing the thread's scope stack. (See ScopedMemory[200].)

Throws

IllegalStateException when the configured Scheduler and SchedulingParameters for this RealtimeThread are not compatible.

Available since RTSJ 2.0 adds new exception

startPeriodic(PhasingPolicy)

Signature

[198] Section 6.3.3.14
[199] Section 11.3.3.3
[200] Section A.2.3.32

public void
startPeriodic(PhasingPolicy phasingPolicy)
throws LateStartException

Description

Start the thread with the specified phasing policy.

Available since RTSJ 2.0

A.2.3.16 *OneShotTimer*

The following elements of OneShotTimer are deprecated. The required elements are documented in Section 10.3.2.2 above.

A.2.3.16.1 Constructors

OneShotTimer(HighResolutionTime, Clock, AsyncEventHandler)

Signature

public
OneShotTimer(javax.realtime.HighResolutionTime<?> time,
Clock clock,
AsyncEventHandler handler)
throws IllegalArgumentException,
UnsupportedOperationException,
IllegalAssignmentError

Description

Create an instance of OneShotTimer[201], based on the given clock, that will execute its fire method according to the given time. The Clock[202] association of the parameter time is ignored.

[201] Section 10.3.2.2
[202] Section 10.3.2.1

Deprecated 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().

clock The clock on which to base this timer, overriding the clock associated with the parameter time. When null, the system Realtime clock is used. The clock associated with the parameter time is always ignored.

handler The AsyncEventHandler[203] that will be released when fire is invoked. When null, no handler is associated with this 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

IllegalArgumentException when time is a RelativeTime instance less than zero.

UnsupportedOperationException when the Chronograph[204] associated with time is not a Clock[205].

IllegalAssignmentError when this OneShotTimer cannot hold references to time, handler, or clock.

A.2.3.17 POSIXSignalHandler

Inheritance

java.lang.Object
  javax.realtime.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

[203] Section 8.3.3.5
[204] Section 10.3.1.2
[205] Section 10.3.2.1

A.2.3.17.1 Fields

SIGHUP

public static final SIGHUP

Description

Hangup (POSIX).

SIGINT

public static final SIGINT

Description

interrupt (ANSI)

SIGQUIT

public static final SIGQUIT

Description

quit (POSIX)

SIGILL

public static final SIGILL

Description

illegal instruction (ANSI)

SIGTRAP

public static final SIGTRAP

Description

trace trap (POSIX), optional signal.

SIGABRT

public static final SIGABRT

Description

Abort (ANSI).

SIGBUS

public static final SIGBUS

Description

BUS error (4.2 BSD), optional signal.

SIGFPE

public static final SIGFPE

Description

floating point exception

SIGKILL

public static final SIGKILL

Description

Kill, unblockable (POSIX).

SIGUSR1

public static final SIGUSR1

Description

User-defined signal 1 (POSIX).

SIGSEGV

public static final SIGSEGV

Description

Segmentation violation (ANSI).

SIGUSR2

public static final SIGUSR2

Description

User-defined signal 2 (POSIX).

SIGPIPE

public static final SIGPIPE

Description

Broken pipe (POSIX).

SIGALRM

public static final SIGALRM

Description

Alarm clock (POSIX).

SIGTERM

public static final SIGTERM

Description

Termination (ANSI).

SIGCHLD

public static final SIGCHLD

Description

Child status has changed (POSIX).

SIGCONT

public static final SIGCONT

Description

Continue (POSIX), optional signal.

SIGSTOP

public static final SIGSTOP

Description

Stop, unblockable (POSIX), optional signal.

SIGTSTP

public static final SIGTSTP

Description

Keyboard stop (POSIX), optional signal.

SIGTTIN

public static final SIGTTIN

Description

Background read from tty (POSIX), optional signal.

SIGTTOU

public static final SIGTTOU

Description

Background write to tty (POSIX), optional signal.

SIGURG

public static final SIGURG

Description

Urgent condition on socket (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGXCPU

public static final SIGXCPU

Description

CPU limit exceeded (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGXFSZ

public static final SIGXFSZ

Description

File size limit exceeded (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGVTALRM

public static final SIGVTALRM

Description

Virtual alarm clock (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGPROF

public static final SIGPROF

Description

Profiling alarm clock (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGWINCH

public static final SIGWINCH

Description

Window size change (4.3 BSD, Sun).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGIO

public static final SIGIO

Description

I/O now possible (4.2 BSD).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGPWR

public static final SIGPWR

Description

Power failure restart (System V).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGSYS

public static final SIGSYS

Description

Bad system call, optional signal.

SIGIOT

public static final SIGIOT

Description

IOT instruction (4.2 BSD), optional signal.

SIGPOLL

public static final SIGPOLL

Description

Pollable event occurred (System V).

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGCLD

public static final SIGCLD

Description

Same as SIGCHLD (System V), optional signal.

SIGEMT

public static final SIGEMT

Description

EMT instruction, optional signal.

SIGLOST

public static final SIGLOST

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGCANCEL

public static final SIGCANCEL

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGFREEZE

public static final SIGFREEZE

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGLWP

public static final SIGLWP

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGTHAW

public static final SIGTHAW

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

SIGWAITING

public static final SIGWAITING

Description

Deprecated as of RTSJ 1.0.1 not part of POSIX 9945-1-1996 standard

A.2.3.17.2 Methods

addHandler(int, AsyncEventHandler)

Signature

public static void
addHandler(int signal,
AsyncEventHandler handler)

Description

addHandler 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 iff 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

removeHandler 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 iff 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

setHandler 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 iff signal is not defined by any of the constants in this class.

A.2.3.18 *PeriodicParameters*

The following elements of PeriodicParameters are deprecated. The required elements are documented in Section 6.3.3.6 above.

A.2.3.18.1 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 (by being passed through the schedulable's constructor or set with a method such as RealtimeThread.setReleaseParameters(ReleaseParameters)[206]) 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

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. 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 anlaysis is inadequate

A.2.3.19 *PeriodicTimer*

The following elements of PeriodicTimer are deprecated. The required elements are documented in Section 10.3.2.3 above.

A.2.3.19.1 Constructors

---

[206] Section 5.3.1

PeriodicTimer(HighResolutionTime, RelativeTime, Clock, AsyncEventHandler)

Signature

```
public
PeriodicTimer(javax.realtime.HighResolutionTime<?> start,
              RelativeTime interval,
              Clock clock,
              AsyncEventHandler handler)
throws IllegalArgumentException,
       UnsupportedOperationException,
       IllegalAssignmentError
```

Description

Create a timer that executes its fire method periodically.

Deprecated 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 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[207].

clock The clock to be used to time the start and interval. When null, the system Realtime clock is used. The Clock[208] association of the parameters start and interval is always ignored.

handler The AsyncEventHandler[209] that will be released when fire is invoked. When null, no handler is associated with this 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

IllegalArgumentException when start or interval is a RelativeTime instance with a value less than zero; or the clocks associated with start and interval are not

[207] Section 10.3.2.2
[208] Section 10.3.2.1
[209] Section 8.3.3.5

the identical.

IllegalAssignmentError when this PeriodicTimer cannot hold references to handler, clock and interval.

UnsupportedOperationException when the Chronograph[210] associated with time is not a Clock[211].

A.2.3.20 PhysicalMemoryManager

Inheritance

java.lang.Object
  javax.realtime.PhysicalMemoryManager

Description

The PhysicalMemoryManager is not ordinarily used by applications, except that the implementation may require the application to use the registerFilter[212] 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[213], LTPhysicalMemory[214], and ImmortalPhysicalMemory[215]) 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 holes in the memory space. Some of these holes may be filled with removable memory.

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.

[210] Section 10.3.1.2
[211] Section 10.3.2.1
[212] Section A.2.3.20.2
[213] Section A.2.3.37
[214] Section A.2.3.12
[215] Section A.2.3.10

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 if the 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 (on systems that support virtual memory). and locks the virtual memory to the memory chunk.

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 or other interested parties may provide PhysicalMemoryTypeFilter[216] classes that allow additional characteristics of memory devices to be specified.

Deprecated as of RTSJ 2.0

A.2.3.20.1 Fields

ALIGNED

public static final 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.

[216] Section A.2.1.1

See Section javax.realtime.device.RawMemory

BYTESWAP

public static final BYTESWAP

Description

When automatic byte swapping is supported by the implementation specify BYTESWAP when byte swapping should be used. Byte-swapping memory reorders 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 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 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.

Available since RTSJ 1.0.1

SHARED

public static final 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.

A.2.3.20.2 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

Register the specified AsyncEvent[217] to fire when any memory in the range is added to the system. When the specified range of physical memory contains

[217] Section 8.3.3.4

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.

Available since RTSJ 1.0.1

onInsertion(long, long, AsyncEventHandler)

Signature

```
public static void
onInsertion(long base,
            long size,
            AsyncEventHandler aeh)
```

Description

Register the specified AsyncEventHandler[218] 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, unregister 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.

[218] Section 8.3.3.5

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

Register 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

Register 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, unregister 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

Register 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.

SecurityException when this operation is not permitted.

removeFilter(Object)

Signature

public static final void
removeFilter(Object name)

Description

Remove the identified filter from the set of registered filters. When the filter is not registered, silently do 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.

SecurityException when this operation is not permitted.

unregisterInsertionEvent(long, long, AsyncEvent)

Signature

public static boolean
unregisterInsertionEvent(long base,
long size,
AsyncEvent ae)

Description

Unregister 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.

Available since RTSJ 1.0.1

unregisterRemovalEvent(long, long, AsyncEvent)

Signature

```
public static boolean
unregisterRemovalEvent(long base,
                       long size,
                       AsyncEvent ae)
```

Description

Unregister 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.

Available since RTSJ 1.0.1

A.2.3.21 *PriorityCeilingEmulation*

The following elements of PriorityCeilingEmulation are deprecated. The required elements are documented in Section 7.3.1.2 above.

A.2.3.21.1 Methods

---

getDefaultCeiling

Signature
public int
getDefaultCeiling()

Description

Gets the priority ceiling for this PriorityCeilingEmulation object.

Returns
The priority ceiling.

Deprecated as of RTSJ 1.0.1. The method name is misleading. Replaced with getCeiling()

A.2.3.22 *PriorityScheduler*

The following elements of PriorityScheduler are deprecated. The required elements are documented in Section 6.3.3.8 above.

A.2.3.22.1 Fields

MAX_PRIORITY

public static final MAX_PRIORITY

Description

The maximum priority value used by the implementation.

Deprecated as of RTSJ 1.0.1 Use the getMaxPriority[219] method instead.

MIN_PRIORITY

public static final MIN_PRIORITY

Description

The minimum priority value used by the implementation.

Deprecated as of RTSJ 1.0.1 Use the getMinPriority[220] method instead.

A.2.3.22.2 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 a Java thread then the maximum priority of its thread group is returned. Otherwise an exception is thrown.

[219] Section 6.3.3.8.3
[220] Section 6.3.3.8.3

Parameters
thread An instance of Thread. When null, the maximum priority of this scheduler is returned.
Throws
IllegalArgumentException 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 a Java thread then 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
IllegalArgumentException 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 a Java thread then 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

IllegalArgumentException 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

Return 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[221] and SporadicParameters[222].

When any schedulable within the feasibility set has release parameters of the exact type AperiodicParameters[223] (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[224], or passes proposed release parameters of type AperiodicParameters[225], 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[226], is when the method will change those release parameters to not be AperiodicParameters[227].

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 anlaysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters)

Signature

public boolean

[221] Section 6.3.3.6
[222] Section 6.3.3.15
[223] Section 6.3.3.2
[224] Section 6.3.3.2
[225] Section 6.3.3.2
[226] Section 6.3.3.2
[227] Section 6.3.3.2

setIfFeasible(javax.realtime.Schedulable<?> schedulable,
javax.realtime.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[228].)

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[229].)

Throws

IllegalArgumentException 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()[230] or RealtimeThread.waitForNextPeriodInterruptible()[231].

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.

[228]Section 6.3.3.8
[229]Section 6.3.3.8
[230]Section **??**
[231]Section **??**

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

public boolean
setIfFeasible(javax.realtime.Schedulable<?> schedulable,
javax.realtime.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[232].)

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[233].)

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[234].)

Throws

IllegalArgumentException when Schedulable is null, or Schedulable is not associated with this scheduler, or the proposed parameters are not compatible with this scheduler.

[232]Section 6.3.3.8
[233]Section 6.3.3.8
[234]Section 6.3.3.8

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()[235] or RealtimeThread.waitForNextPeriodInterruptible()[236].

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 anlaysis is inadequate

setIfFeasible(Schedulable, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(javax.realtime.Schedulable<?> schedulable,
              SchedulingParameters scheduling,
              javax.realtime.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.

[235] Section **??**
[236] Section **??**

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[237].)

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[238].)

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[239].)

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[240].)

Throws

IllegalArgumentException 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()[241] or RealtimeThread.waitForNextPeriodInterruptible()[242].

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 anlaysis is inadequate

addToFeasibility(Schedulable)

Signature

protected boolean

[237] Section 6.3.3.8
[238] Section 6.3.3.8
[239] Section 6.3.3.8
[240] Section 6.3.3.8
[241] Section **??**
[242] Section **??**

addToFeasibility(javax.realtime.Schedulable<?> schedulable)

Description

Inform this scheduler and cooperating facilities that the resource demands of the given instance of Schedulable[243] will be considered in the feasibility analysis of the associated Scheduler[244] 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, do nothing.

Parameters

schedulable A reference to the given instance of Schedulable[245]

Throws

IllegalArgumentException 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. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

removeFromFeasibility(Schedulable)

Signature

protected boolean
removeFromFeasibility(javax.realtime.Schedulable<?> schedulable)

Description

Inform this scheduler and cooperating facilities that the resource demands of the given instance of Schedulable[246] should no longer be considered in the feasibility analysis of the associated Scheduler[247]. Whether the resulting system is feasible or not, the removal is completed.

Parameters

schedulable A reference to the given instance of Schedulable[248]

Throws

[243] Section 6.3.1.3
[244] Section 6.3.3.12
[245] Section 6.3.1.3
[246] Section 6.3.1.3
[247] Section 6.3.3.12
[248] Section 6.3.1.3

IllegalArgumentException 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 anlaysis is inadequate

fireSchedulable(Schedulable)

Signature

public void
fireSchedulable(javax.realtime.Schedulable<?> schedulable)

Description

Trigger the execution of a schedulable (like an AsyncEventHandler[249]).

Parameters

schedulable schedulable The schedulable to make active. When null, nothing happens.

Throws

UnsupportedOperationException Thrown in all cases by the PriorityScheduler

Deprecated RTSJ 2.0

A.2.3.23 ProcessingGroupParameters

Inheritance

java.lang.Object
javax.realtime.ProcessingGroupParameters

Interfaces

Cloneable
Serializable

Description

[249]Section 8.3.3.5

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. 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. The default affinity set is given by Affinity.getGroupDefaultAffinity().

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 objects 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 (budget) parameter, (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 (budget) 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[250] values for cost, deadline, period and start time. Since those times are expressed as a HighResolutionTime[251], 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

[250]Section 9.3.1.2
[251]Section 9.3.1.2

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[252] 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 that 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 A.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.

[252] Section 9.3.1.2

Deprecated as of RTSJ 2.0; replaced by ProcessingGroup[253].

A.2.3.23.1 Constructors

ProcessingGroupParameters(HighResolutionTime, RelativeTime, RelativeTime, RelativeTime, AsyncEventHandler, AsyncEventHandler)

Signature

```
public
ProcessingGroupParameters(javax.realtime.HighResolutionTime<?> start,
                          RelativeTime period,
                          RelativeTime cost,
                          RelativeTime deadline,
                          AsyncEventHandler overrunHandler,
                          AsyncEventHandler missHandler)
throws IllegalArgumentException,
       IllegalAssignmentError
```

Description

Create 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

[253]Section 6.3.3.9

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.

A.2.3.23.2 Methods

---

clone

Signature

public java.lang.Object
clone()
throws CloneNotSupportedException

Description

Create 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.)

Throws
CloneNotSupportedException never

Returns
the clone of this

Available 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[254] that is cost overrun handler of this.

getDeadline

Signature
public javax.realtime.RelativeTime
getDeadline()

[254]Section 8.3.3.5

Description

Gets the value of deadline.

Returns

A reference to an instance of RelativeTime[255] 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[256]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[257] that represents the value of period.

getStart

Signature

public javax.realtime.HighResolutionTime<?>
getStart()

[255]Section 9.3.1.3
[256]Section 8.3.3.5
[257]Section 9.3.1.3

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[258] 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

[258] Section 9.3.1.2

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(javax.realtime.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.

A.2.3.24 RationalTime

Inheritance
java.lang.Object
javax.realtime.HighResolutionTime
javax.realtime.RelativeTime
javax.realtime.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

A.2.3.24.1 Constructors

RationalTime(int, long, int)

Signature

```
public
RationalTime(int frequency,
             long millis,
             int nanos)
```

Description

Construct 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

Construct an instance of RationalTime from the given RelativeTime[259].

Parameters

frequency The frequency value.

interval The given instance of RelativeTime[260].

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

Construct an instance of RationalTime. Equivalent to new RationalTime(1000, 0, frequency)&#151essentially a cycles-per-second value.

Throws

IllegalArgumentException when frequency is less than or equal to zero.

[259]Section 9.3.1.3
[260]Section 9.3.1.3

A.2.3.24.2 Methods

absolute(Clock, AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
absolute(Clock clock,
AbsoluteTime destination)

Description

Convert 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.

addInterarrivalTo(AbsoluteTime)

Signature

public void
addInterarrivalTo(AbsoluteTime destination)

Description

Add the time of this to an AbsoluteTime[261] It is almost the same dest.add(this, dest) except that it accounts for (i.e. divides by) the frequency.

Parameters

destination A reference to the destination instance.

getFrequency

Signature

public int
getFrequency()

Description

Gets the value of frequency.

[261] Section 9.3.1.1

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[262].

getInterarrivalTime(RelativeTime)

Signature

public javax.realtime.RelativeTime
getInterarrivalTime(RelativeTime dest)

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[263].

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.

[262]Section 9.3.1.3
[263]Section 9.3.1.3

Parameters
millis The new value for the millisecond field.
nanos The new value for the nanosecond field.
Returns
this

setFrequency(int)

Signature
public javax.realtime.RationalTime
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.

Returns
this

toString

Signature
public java.lang.String
toString()

Description

Create 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
String object converted from the time given by this.

A.2.3.25 RawMemoryAccess

Inheritance

java.lang.Object
  javax.realtime.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[264] static byte variable in class RealtimeSystem[265]. 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[266] 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[267]. 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[268]. 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.

[264] Section 14.2.2.3.1
[265] Section 14.2.2.3
[266] Section A.2.1.1
[267] Section 15.2.2.11
[268] Section 15.2.2.20

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

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.

Table A.2: 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.

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 getxxx or putxxx method, 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[269] to create the appropriate javax.realtime.device.RawMemory[270] object.

A.2.3.25.1 Constructors

RawMemoryAccess(Object, long, long)

Signature
public

[269]Section 12.3.2.6
[270]Section 12.3.1.16

RawMemoryAccess(Object type,
long base,
long size)

Description

Construct an instance of RawMemoryAccess with the given parameters, and set the object to the mapped state. When the platform supports virtual memory, map 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[271] and PhysicalMemoryTypeFilter.getVMFlags[272].

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

SecurityException 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[273] has been registered with the PhysicalMemoryManager[274].

MemoryTypeConflictException when the specified base does not point to memory that matches the request type, or when type specifies incompatible memory attributes.

[271] Section A.2.1.1.1
[272] Section A.2.1.1.1
[273] Section A.2.1.1
[274] Section A.2.3.20

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

Construct an instance of RawMemoryAccess with the given parameters, and set the object to the mapped state. When the platform supports virtual memory, map 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[275] and PhysicalMemoryTypeFilter.getVMFlags[276].

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

SecurityException 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[277]

[275] Section A.2.1.1.1
[276] Section A.2.1.1.1
[277] Section A.2.1.1

has been registered with the PhysicalMemoryManager[278].

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.

SecurityException when the application doesn't have permissions to access physical memory or the given range of memory.

A.2.3.25.2 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[279] somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

[278] Section A.2.3.20
[279] Section 15.2.2.20

SecurityException 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[280] somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

[280] Section 15.2.2.20

SizeOutOfBoundsException when the object is not mapped, or when the 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 bytes 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.

SecurityException 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[281] 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.

[281] Section 15.2.2.20

SecurityException 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 loaded.

Throws

OffsetOutOfBoundsException when the offset is negative or greater than the size of the raw memory area. The role of the SizeOutOfBoundsException[282] 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 integers fall 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 ints 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.

SecurityException 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 double falls in an invalid address range.

SecurityException when this access is not permitted by the security manager.

[282] Section 15.2.2.20

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 long 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[283] 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

[283] Section 15.2.2.20

for the possibility that the memory area could be unmapped or remapped. The longs 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.

SecurityException 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). Same as the base address when virtual memory is not supported.

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[284] 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.

SecurityException 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

[284] Section 15.2.2.20

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[285] 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 shorts 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.

SecurityException 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.

[285] Section 15.2.2.20

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[286] and PhysicalMemoryTypeFilter.getVMFlags[287].

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[288] and PhysicalMemoryTypeFilter.getVMFlags[289].

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.

[286] Section A.2.1.1.1
[287] Section A.2.1.1.1
[288] Section A.2.1.1.1
[289] Section A.2.1.1.1

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[290] and PhysicalMemoryTypeFilter.getVMFlags[291].

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[292]. 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.

[290] Section A.2.1.1.1
[291] Section A.2.1.1.1
[292] Section 15.2.2.20

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[293] 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.

SecurityException when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

[293] Section 15.2.2.20

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[294] 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 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.

[294] Section 15.2.2.20

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.

SecurityException 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[295] 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.

SecurityException when this access is not permitted by the security manager.

[295] Section 15.2.2.20

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[296] somewhat overlaps this exception since it is when the offset is within the object but outside the mapped area.

[296] Section 15.2.2.20

SizeOutOfBoundsException when the object is not mapped, or when an int 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.

SecurityException 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[297] somewhat

[297] Section 15.2.2.20

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.

SecurityException 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[298] 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 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.

SecurityException 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

[298] Section 15.2.2.20

OffsetOutOfBoundsException when the offset is negative or greater than the size of the raw memory area. The role of the SizeOutOfBoundsException[299] 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.

SecurityException 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.

[299] Section 15.2.2.20

Throws

OffsetOutOfBoundsException when the offset is negative or greater than the size of the raw memory area. The role of the SizeOutOfBoundsException[300] 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 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.

SecurityException when this access is not permitted by the security manager.

See Section RawMemoryAccess.map(long,long)

unmap

Signature

public void
unmap()

Description

Unmap 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[301].

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.

[300] Section 15.2.2.20
[301] Section 15.2.2.20

A.2.3.26 RawMemoryFloatAccess

Inheritance

java.lang.Object
  javax.realtime.RawMemoryAccess
    javax.realtime.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[302] *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[303] 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.

[302] Section A.2.3.25
[303] Section A.2.1.1

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 a optional system properties that identify a platform's level of support for atomic raw put and get. (See RawMemoryAccess[304].) The properties represent a four-dimensional sparse array with boolean values 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[305]. 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[306]. 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[307].

A.2.3.26.1 Constructors

RawMemoryFloatAccess(Object, long, long)

Signature

```
public
RawMemoryFloatAccess(Object type,
                     long base,
                     long size)
```

Description

[304]Section A.2.3.25
[305]Section 15.2.2.11
[306]Section 15.2.2.20
[307]Section 12.3.1.16

Construct an instance of RawMemoryFloatAccess with the given parameters, and set the object to the mapped state. When the platform supports virtual memory, map 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[308] and PhysicalMemoryTypeFilter.getVMFlags[309].

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

SecurityException 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[310] has been registered with the PhysicalMemoryManager[311].

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

RawMemoryFloatAccess(Object, long)

[308] Section A.2.1.1.1
[309] Section A.2.1.1.1
[310] Section A.2.1.1
[311] Section A.2.3.20

Signature

public
RawMemoryFloatAccess(Object type,
long size)

Description

Construct an instance of RawMemoryFloatAccess with the given parameters, and set the object to the mapped state. When the platform supports virtual memory, map 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[312] and PhysicalMemoryTypeFilter.getVMFlags[313].

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

SecurityException 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[314] has been registered with the PhysicalMemoryManager[315].

MemoryTypeConflictException when the specified base does not point to memory that matches the request type, or when type specifies incompatible memory attributes.

[312]Section A.2.1.1.1
[313]Section A.2.1.1.1
[314]Section A.2.1.1
[315]Section A.2.3.20

OutOfMemoryError when the requested type of memory exists, but there is not enough of it free to satisfy the request.

A.2.3.26.2 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 long.

Throws

OffsetOutOfBoundsException when the offset is invalid.

SizeOutOfBoundsException when the object is not mapped, or when the double falls in an invalid address range.

SecurityException 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 assign 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)[316]).

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.

SecurityException when this access is not permitted by the security manager.

[316] Section A.2.3.25.2

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)[317]).

SizeOutOfBoundsException when the object is not mapped, or when the float falls in an invalid address range.

SecurityException 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,

[317] Section A.2.3.25.2

int number)

Description

Gets number floats 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 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 loaded.

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)[318]).

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 floats 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.

SecurityException when this access is not permitted by the security manager.

[318] Section A.2.3.25.2

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)[319]).

SizeOutOfBoundsException when the object is not mapped, or when the double falls in an invalid address range.

SecurityException 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)

[319]Section A.2.3.25.2

Description

Sets number doubles starting at the given offset in the memory area associated with this object from the double 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)[320]).

SizeOutOfBoundsException when the object is not mapped, or when the 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 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.

SecurityException when this access is not permitted by the security manager.

setFloat(long, float)

Signature

```
public void
setFloat(long offset,
         float value)
```

[320] Section A.2.3.25.2

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 integer.

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)[321]).

SizeOutOfBoundsException when the object is not mapped, or when the float falls in an invalid address range.

SecurityException 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

[321] Section A.2.3.25.2

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)[322]).

SizeOutOfBoundsException when the object is not mapped, or when the 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.

SecurityException when this access is not permitted by the security manager.

A.2.3.27 *RealtimeSystem*

The following elements of RealtimeSystem are deprecated. The required elements are documented in Section 14.2.2.3 above.

A.2.3.27.1 Fields

[322] Section A.2.3.25.2

A.2.3.28 *RealtimeThread*

The following elements of RealtimeThread are deprecated. The required elements are documented in Section 5.3.2.2 above.

A.2.3.28.1 Constructors

RealtimeThread(SchedulingParameters, ReleaseParameters, MemoryParameters, MemoryArea, ProcessingGroupParameters, Runnable)

Signature

```
public
RealtimeThread(SchedulingParameters scheduling,
               javax.realtime.ReleaseParameters<?> release,
               MemoryParameters memory,
               MemoryArea area,
               ProcessingGroupParameters group,
               Runnable logic)
```

Description

Create 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

A.2.3.28.2 Methods

---

sleep(Clock, HighResolutionTime)

Signature

```
public static void
sleep(Clock clock,
      javax.realtime.HighResolutionTime<?> time)
throws InterruptedException,
       ClassCastException,
       UnsupportedOperationException,
       IllegalArgumentException
```

Description

A sleep method that is controlled by a generalized clock. Since the time is expressed as a HighResolutionTime[323], 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[324] 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.

It is permissible to call sleep when control is in an AsyncEventHandler[325]. The method cause 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[326] used as the base. When clock is null the realtime clock (see Clock.getRealtimeClock[327]) 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()[328] or AsynchronouslyInterruptedExcep
fire()[329] during the time between calling this method and returning from it.

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

[323]Section 9.3.1.2
[324]Section 10.3.2.1
[325]Section 8.3.3.5
[326]Section 10.3.2.1
[327]Section 10.3.2.1.2
[328]Section 5.3.2.2.2
[329]Section 8.3.2.1.2

UnsupportedOperationException when the sleep operation is not supported by clock.

IllegalArgumentException 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[330] type of PeriodicParameters[331] 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[332].)

Throws

IllegalThreadStateException when this does not have a reference to a ReleaseParameters[333] type of PeriodicParameters[334].

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.

Available since RTSJ 1.0.1 Changed from an instance method to a static method.

[330] Section 6.3.3.10
[331] Section 6.3.3.6
[332] Section 6.3.3.8
[333] Section 6.3.3.10
[334] Section 6.3.3.6

Deprecated RTSJ 2.0 Replaced by waitForNextRelease()[335]

waitForNextPeriodInterruptible

Signature

public static boolean
waitForNextPeriodInterruptible()
throws InterruptedException,
ClassCastException,
IllegalThreadStateException

Description

The waitForNextPeriodInterruptible() method is a duplicate of waitForNextPeriod()[336] except that waitForNextPeriodInterruptible is able to throw InterruptedException.

Used by threads that have a reference to a ReleaseParameters[337] type of PeriodicParameters[338] 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[339])

Throws

InterruptedException when the thread is interrupted by interrupt()[340] or AsynchronouslyInterruptedException.fire()[341] 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[342] type of PeriodicParameters[343].

[335]Section 5.3.2.2.2
[336]Section **??**
[337]Section 6.3.3.10
[338]Section 6.3.3.6
[339]Section 6.3.3.8
[340]Section 5.3.2.2.2
[341]Section 8.3.2.1.2
[342]Section 6.3.3.10
[343]Section 6.3.3.6

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.

Available since RTSJ 1.0.1

Deprecated RTSJ 2.0 Replaced by waitForNextRelease[344]

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, inform the scheduler and cooperating facilities that this instance of Schedulable[345] should be considered in feasibility analysis until further notified. When the analysis showed 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, do 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 anlaysis is inadequate

addToFeasibility

Signature

public boolean
addToFeasibility()

Description

[344]Section 5.3.2.2.2
[345]Section 6.3.1.3

Inform the scheduler and cooperating facilities that this instance of Schedulable[346] should be considered in feasibility analysis until further notified.

When the object is already included in the feasibility set, do nothing.

Returns

True, when the resulting system is feasible. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

deschedulePeriodic

Signature

public void
deschedulePeriodic()

Description

When the ReleaseParameters[347] object associated with this RealtimeThread is an instance of PeriodicParameters[348], perform any *deschedulePeriodic* actions specified by this thread's scheduler. When the type of the associated instance of ReleaseParameters[349] is not PeriodicParameters[350] nothing happens.

Deprecated since RTSJ 2.0

getProcessingGroupParameters

Signature

public javax.realtime.ProcessingGroupParameters
getProcessingGroupParameters()

Description

Gets a reference to the ProcessingGroupParameters[351] object for this schedulable.

Returns

A reference to the current ProcessingGroupParameters[352] object.

[346] Section 6.3.1.3
[347] Section 6.3.3.10
[348] Section 6.3.3.6
[349] Section 6.3.3.10
[350] Section 6.3.3.6
[351] Section A.2.3.23
[352] Section A.2.3.23

Deprecated since RTSJ 2.0

removeFromFeasibility

Signature

public boolean
removeFromFeasibility()

Description

Inform the scheduler and cooperating facilities that this instance of Schedulable[353] 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 anlaysis is inadequate

schedulePeriodic

Signature

public void
schedulePeriodic()

Description

Begin unblocking RealtimeThread.waitForNextPeriod()[354] for a periodic thread. When deadline miss detection is disabled, enable it. Typically used when a periodic schedulable is in a deadline miss condition. The details of the interaction of this method with deschedulePeriodic[355] and waitForNextPeriod()[356] are dictated by this thread's scheduler.

When this RealtimeThread does not have a type of PeriodicParameters[357] as its ReleaseParameters[358] nothing happens.

[353] Section 6.3.1.3
[354] Section **??**
[355] Section **??**
[356] Section **??**
[357] Section 6.3.3.6
[358] Section 6.3.3.10

Deprecated since RTSJ 2.0

setIfFeasible(ReleaseParameters, MemoryParameters)

Signature

public boolean
setIfFeasible(javax.realtime.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 release The proposed release parameters. 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[359].)

memory memory The proposed memory parameters. 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[360].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

[359]Section 6.3.3.8
[360]Section 6.3.3.8

IllegalThreadStateException 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 anlaysis is inadequate

setIfFeasible(ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

public boolean
setIfFeasible(javax.realtime.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 release The proposed release parameters. 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[361].)

memory memory The proposed memory parameters. 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[362].)

[361] Section 6.3.3.8
[362] Section 6.3.3.8

group group The proposed processing group parameters. 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[363].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setIfFeasible(ReleaseParameters, ProcessingGroupParameters)

Signature

```
public boolean
setIfFeasible(javax.realtime.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.

[363]Section 6.3.3.8

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 release The proposed release parameters. 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[364].)

group group The proposed processing group parameters. 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[365].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters)

Signature

```
public boolean
setIfFeasible(SchedulingParameters scheduling,
              javax.realtime.ReleaseParameters<?> release,
              MemoryParameters memory)
```

[364]Section 6.3.3.8
[365]Section 6.3.3.8

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 scheduling The proposed scheduling parameters. 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[366].)

release release The proposed release parameters. 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[367].)

memory memory The proposed memory parameters. 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[368].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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.

[366]Section 6.3.3.8
[367]Section 6.3.3.8
[368]Section 6.3.3.8

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis is inadequate

setIfFeasible(SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

public boolean
setIfFeasible(SchedulingParameters scheduling,
javax.realtime.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 scheduling The proposed scheduling parameters. 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[369].)

release release The proposed release parameters. 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[370].)

memory memory The proposed memory parameters. 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[371].)

[369]Section 6.3.3.8
[370]Section 6.3.3.8
[371]Section 6.3.3.8

group group The proposed processing group parameters. 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[372].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 proposed parameter objects are located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold references to the proposed parameter objects, or the parameter objects cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis 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.

[372]Section 6.3.3.8

Parameters

memory memory The proposed memory parameters. 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[373].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setProcessingGroupParameters(ProcessingGroupParameters)

Signature

public void
setProcessingGroupParameters(ProcessingGroupParameters group)

Description

Sets the ProcessingGroupParameters[374] 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

[373]Section 6.3.3.8
[374]Section A.2.3.23

group group A ProcessingGroupParameters[375] 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[376].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 IllegalAssignmentError when this object cannot hold a reference to group or group cannot hold a reference to this.

IllegalThreadStateException 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

[375] Section A.2.3.23
[376] Section 6.3.3.8

group group The proposed processing group parameters. 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[377].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setReleaseParametersIfFeasible(ReleaseParameters)

Signature

public boolean
setReleaseParametersIfFeasible(javax.realtime.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.

[377] Section 6.3.3.8

Parameters

release release The proposed release parameters. 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[378].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

setScheduler(Scheduler, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public void
setScheduler(Scheduler scheduler,
             SchedulingParameters scheduling,
             javax.realtime.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.

[378] Section 6.3.3.8

Parameters

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

scheduling scheduling A reference to the SchedulingParameters[379] 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[380].)

release release A reference to the ReleaseParameters[381] 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[382].)

memoryParameters memoryParameters A reference to the MemoryParameters[383] 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[384].)

group group A reference to the ProcessingGroupParameters[385] which will be associated with this. When null, the default value is governed by scheduler (a new object is created). (See PriorityScheduler[386].)

Throws

IllegalArgumentException IllegalArgumentException Thrown 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 IllegalAssignmentError when this object cannot hold references to all the parameter objects or the parameters cannot hold references to this.

IllegalThreadStateException IllegalThreadStateException when scheduler prohibits the changing of the scheduler or a parameter at this time due to the state of the schedulable.

SecurityException SecurityException when the caller is not permitted to set the scheduler for this schedulable.

Deprecated since RTSJ 2.0

[379] Section 6.3.3.14
[380] Section 6.3.3.8
[381] Section 6.3.3.10
[382] Section 6.3.3.8
[383] Section 11.3.3.4
[384] Section 6.3.3.8
[385] Section A.2.3.23
[386] Section 6.3.3.8

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 scheduling The proposed scheduling parameters. 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[387].)

Throws

IllegalArgumentException IllegalArgumentException Thrown when the parameter value is not compatible with the schedulable's scheduler. Also when this schedulable may not use the heap and the proposed parameter object is located in heap memory.

IllegalAssignmentError IllegalAssignmentError when this cannot hold a reference to the proposed parameter object, or the parameter object cannot hold a reference to this.

IllegalThreadStateException 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 anlaysis is inadequate

[387] Section 6.3.3.8

A.2.3.29 *RelativeTime*

The following elements of RelativeTime are deprecated. The required elements are documented in Section 9.3.1.3 above.

A.2.3.29.1 Constructors

RelativeTime(long, int, Clock)

Signature

```
public
RelativeTime(long millis,
             int nanos,
             Clock clock)
throws IllegalArgumentException
```

Description

Construct a RelativeTime object representing an interval based on the parameter millis plus the parameter nanos. The construction is subject to millis and nanos parameters normalization. When there is an overflow in the millisecond component when normalizing then an IllegalArgumentException 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.

Available 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

IllegalArgumentException when there is an overflow in the millisecond component when normalizing.

RelativeTime(RelativeTime, Clock)

Signature

public
RelativeTime(RelativeTime time,
Clock clock)
throws IllegalArgumentException

Description

Make 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 realtime clock.

Available 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

IllegalArgumentException 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.

Available since RTSJ 1.0.1

Deprecated since version 2.0

Parameters
clock The clock providing the association for the newly constructed object.

A.2.3.29.2 Methods

---

absolute(Clock)

Signature

public javax.realtime.AbsoluteTime
absolute(Clock clock)
throws ArithmeticException

Description

Convert the time of this to an absolute time, using the given instance of Clock[388] to determine the current time. The calculation is the current time indicated by the given instance of Clock[389] 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[390] 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

[388] Section 10.3.2.1
[389] Section 10.3.2.1
[390] Section 10.3.2.1

absolute(Clock, AbsoluteTime)

Signature

public javax.realtime.AbsoluteTime
absolute(Clock clock,
AbsoluteTime dest)
throws ArithmeticException

Description

Convert the time of this to an absolute time, using the given instance of Clock[391] 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[392] 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. Otherwise, a new object is allocated for the result.

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

[391]Section 10.3.2.1
[392]Section 10.3.2.1

Return 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

Return 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. Otherwise, a new object is allocated for the result.

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

addInterarrivalTo(AbsoluteTime)

Signature

public void
addInterarrivalTo(AbsoluteTime timeAndDestination)

Description

Add the interval of this to the given instance of AbsoluteTime[393].

Parameters

timeAndDestination A reference to the given instance of AbsoluteTime[394] and the result.

Deprecated as of RTSJ 1.0.1

getInterarrivalTime

Signature

public javax.realtime.RelativeTime
getInterarrivalTime()

Description

Gets the interval defined by this. For an instance of RationalTime[395] it is the interval divided by the frequency.

Returns

A reference to a new instance of RelativeTime[396] with the same interval as this.

Deprecated as of RTSJ 1.0.1

getInterarrivalTime(RelativeTime)

Signature

public javax.realtime.RelativeTime
getInterarrivalTime(RelativeTime destination)

[393] Section 9.3.1.1
[394] Section 9.3.1.1
[395] Section A.2.3.24
[396] Section 9.3.1.3

Description

Gets the interval defined by this. For an instance of RationalTime[397] it is the interval divided by the frequency.

Parameters

destination A reference to the new object holding the result.

Returns

A reference to an object holding the result.

Deprecated as of RTSJ 1.0.1

A.2.3.30 *ReleaseParameters*

The following elements of ReleaseParameters are deprecated. The required elements are documented in Section 6.3.3.10 above.

A.2.3.30.1 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

[397] Section A.2.3.24

cost The proposed cost. Equivalent to RelativeTime(0,0) when null. (A new instance of RelativeTime[398] 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

IllegalArgumentException 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. False, when the resulting system is not feasible and no changes are made.

Deprecated as of RTSJ 2.0

A.2.3.31 *Scheduler*

The following elements of Scheduler are deprecated. The required elements are documented in Section 6.3.3.12 above.

A.2.3.31.1 Methods

---

addToFeasibility(Schedulable)

Signature

protected abstract boolean
addToFeasibility(javax.realtime.Schedulable<?> schedulable)

Description

Inform this scheduler and cooperating facilities that the resource demands of the given instance of Schedulable[399] will be considered in the feasibility analysis of the associated Scheduler[400] until further notice. Whether the resulting system is

[398] Section 9.3.1.3
[399] Section 6.3.1.3
[400] Section 6.3.3.12

feasible or not, the addition is completed. When the object is already included in the feasibility set, do nothing.

Parameters
schedulable A reference to the given instance of Schedulable[401]
Throws
IllegalArgumentException 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. False, when not.

Deprecated as of RTSJ 2.0 The framework for feasibility anlaysis 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 anlaysis is inadequate

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters)

Signature
public abstract boolean
setIfFeasible(javax.realtime.Schedulable<?> schedulable,
javax.realtime.ReleaseParameters<?> release,
MemoryParameters memory)

[401] Section 6.3.1.3

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[402].)

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[403].)

Throws

IllegalArgumentException 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()[404] or RealtimeThread.waitForNextPeriodInterruptible()[405].

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 anlaysis is inadequate

[402]Section 6.3.3.8
[403]Section 6.3.3.8
[404]Section **??**
[405]Section **??**

setIfFeasible(Schedulable, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

public abstract boolean
setIfFeasible(javax.realtime.Schedulable<?> schedulable,
javax.realtime.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[406].)

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[407].)

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[408].)

Throws

IllegalArgumentException 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.

[406] Section 6.3.3.8
[407] Section 6.3.3.8
[408] Section 6.3.3.8

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()[409] or RealtimeThread.waitForNextPeriodInterruptible()[410].

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 anlaysis is inadequate

setIfFeasible(Schedulable, SchedulingParameters, ReleaseParameters, MemoryParameters, ProcessingGroupParameters)

Signature

```
public abstract boolean
setIfFeasible(javax.realtime.Schedulable<?> schedulable,
              SchedulingParameters scheduling,
              javax.realtime.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[411].)

[409] Section **??**
[410] Section **??**
[411] Section 6.3.3.8

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[412].)

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[413].)

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[414].)

Throws

IllegalArgumentException 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()[415] or RealtimeThread.waitForNextPeriodInterruptible()[416].

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 anlaysis is inadequate

removeFromFeasibility(Schedulable)

Signature

protected abstract boolean
removeFromFeasibility(javax.realtime.Schedulable<?> schedulable)

Description

[412]Section 6.3.3.8
[413]Section 6.3.3.8
[414]Section 6.3.3.8
[415]Section **??**
[416]Section **??**

Inform this scheduler and cooperating facilities that the resource demands of the given instance of Schedulable[417] should no longer be considered in the feasibility analysis of the associated Scheduler[418]. Whether the resulting system is feasible or not, the removal is completed.

Parameters

schedulable A reference to the given instance of Schedulable[419]

Throws

IllegalArgumentException 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 anlaysis is inadequate

fireSchedulable(Schedulable)

Signature

public abstract void
fireSchedulable(javax.realtime.Schedulable<?> schedulable)

Description

Trigger the execution of a schedulable (like an AsyncEventHandler[420]).

Parameters

schedulable The schedulable to make active. When null, nothing happens.

Throws

UnsupportedOperationException when the scheduler cannot release schedulable for execution.

Deprecated RTSJ 2.0

[417] Section 6.3.1.3
[418] Section 6.3.3.12
[419] Section 6.3.1.3
[420] Section 8.3.3.5

A.2.3.32 ScopedMemory

Inheritance
java.lang.Object
javax.realtime.MemoryArea
javax.realtime.ScopedMemory

Description

Equivalent to and superseded by javax.realtime.memory.ScopedMemory[421].

Deprecated in RTSJ 2.0; moved to package javax.realtime.memory

A.2.3.32.1 Constructors

ScopedMemory(long, Runnable)

Signature

public
ScopedMemory(long size,
Runnable logic)

Description

Create a new ScopedMemory area with the given parameters.

Deprecated since RTSJ 2.0 no longer visible

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.

[421] Section 11.4.3.6

OutOfMemoryError when there is insufficient memory for the ScopedMemory object or for the backing memory.

ScopedMemory(SizeEstimator, Runnable)

Signature

public
ScopedMemory(SizeEstimator size,
Runnable logic)

Description

Equivalent to ScopedMemory(long, Runnable)[422] with the argument list (size.getEstimate(), logic).

Deprecated since RTSJ 2.0

Parameters

size The size of the new ScopedMemory area estimated by an instance of SizeEstimator[423].

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.

OutOfMemoryError when there is insufficient memory for the ScopedMemory object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

ScopedMemory(long)

Signature

public
ScopedMemory(long size)

[422]Section A.2.3.32.1
[423]Section 11.3.3.5

Description

Equivalent to ScopedMemory(long, Runnable)[424] with the argument list (size, null).

Deprecated since RTSJ 2.0 no longer visible.

Parameters

size of the new ScopedMemory area in bytes.

Throws

IllegalArgumentException when size is less than zero.

OutOfMemoryError when there is insufficient memory for the ScopedMemory object or for the backing memory.

ScopedMemory(SizeEstimator)

Signature

public
ScopedMemory(SizeEstimator size)

Description

Equivalent to ScopedMemory(long, Runnable)[425] with the argument list (size. getEstimate(), null).

Deprecated since RTSJ 2.0.

Parameters

size The size of the new ScopedMemory area estimated by an instance of SizeEstimator[426].

Throws

IllegalArgumentException when size is null, or size.getEstimate() is negative.

OutOfMemoryError when there is insufficient memory for the ScopedMemory object or for the backing memory.

A.2.3.32.2 Methods

[424] Section A.2.3.32.1
[425] Section A.2.3.32.1
[426] Section 11.3.3.5

enter

Signature

public void
enter()

Description

Associate 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[427]) 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 IllegalAssignmentError[428], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[429] 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 IllegalArgumentException when the caller is a schedulable and a null value for logic was supplied when the memory area was constructed.

MemoryAccessError 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

[427] Section A.2.3.32.2
[428] Section 15.2.3.2
[429] Section 15.2.3.8

enter(Runnable logic)

Description

Associate 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[430]) or the enter method exits.

Parameters

logic logic The Runnable object whose run() method should be invoked.

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 IllegalAssignmentError[431], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[432] 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 IllegalArgumentException when the caller is a schedulable and logic is null.

executeInArea(Runnable)

Signature

public void
executeInArea(Runnable logic)

Description

Execute 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.

[430]Section A.2.3.32.2
[431]Section 15.2.3.2
[432]Section 15.2.3.8

Parameters
logic The runnable object whose run() method should be executed.
Throws
IllegalThreadStateException when the caller is a Java thread.
InaccessibleAreaException when the memory area is not in the schedulable's scope stack.
IllegalArgumentException when the caller is a schedulable and logic is null.

getPortal

Signature
public java.lang.Object
getPortal()

Description

Return 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 is a Java thread.

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, 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

Wait until the reference count of this ScopedMemory goes down to zero. Return immediately when the memory is unreferenced.

Throws

InterruptedException When this schedulable is interrupted by RealtimeThread.interrupt()[433] or AsynchronouslyInterruptedException.fire()[434] while waiting for the reference count to go to zero.

IllegalThreadStateException when the caller is a Java thread.

join(HighResolutionTime)

Signature

public void
join(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException

Description

Wait at most until the time designated by the time parameter for the reference count of this ScopedMemory to drop to zero. Return immediately when the memory area is unreferenced.

Since the time is expressed as a HighResolutionTime[435], this method is an accurate timer with nanosecond granularity. The actual resolution of the timer

[433] Section 5.3.2.2.2
[434] Section 8.3.2.1.2
[435] Section 9.3.1.2

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

InterruptedException When this schedulable is interrupted by RealtimeThread.interrupt()[436] or AsynchronouslyInterruptedException.fire()[437] while waiting for the reference count to go to zero.

IllegalThreadStateException when the caller is a Java thread.

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.

[436] Section 5.3.2.2.2
[437] Section 8.3.2.1.2

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()[438] or AsynchronouslyInterruptedException.fire()[439] 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 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[440], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[441] 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(javax.realtime.HighResolutionTime<?> time)
throws InterruptedException

[438] Section 5.3.2.2.2
[439] Section 8.3.2.1.2
[440] Section 15.2.3.2
[441] Section 15.2.3.8

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[442], 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[443].

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 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[444], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[445] is allocated in the current allocation context and contains information about the exception it replaces.

InterruptedException When this schedulable is interrupted by RealtimeThread.interrupt()[446] or AsynchronouslyInterruptedException.fire()[447] while waiting for the reference count to go to zero.

[442]Section 9.3.1.2
[443]Section A.2.3.32.2
[444]Section 15.2.3.2
[445]Section 15.2.3.8
[446]Section 5.3.2.2.2
[447]Section 8.3.2.1.2

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.

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()[448] or AsynchronouslyInterruptedException.fire()[449] 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 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[450], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[451] 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,
             javax.realtime.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[452], 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.

[448] Section 5.3.2.2.2
[449] Section 8.3.2.1.2
[450] Section 15.2.3.2
[451] Section 15.2.3.8
[452] Section 9.3.1.2

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)[453].

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()[454] or AsynchronouslyInterruptedException.fire()[455] 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 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[456], so the JVM cannot be permitted to deliver the exception. The ThrowBoundaryError[457] 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.

[453]Section A.2.3.32.2
[454]Section 5.3.2.2.2
[455]Section 8.3.2.1.2
[456]Section 15.2.3.2
[457]Section 15.2.3.8

newArray(Class, int)

Signature

public java.lang.Object
newArray(java.lang.Class<?> type,
int number)

Description

Allocate an array of the given type in this memory area. This method may be concurrently used by multiple threads.

Parameters

type 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 number The number of elements in the new array.

Throws

IllegalArgumentException IllegalArgumentException when number is less than zero, type is null, or type is java.lang.Void.TYPE.

OutOfMemoryError OutOfMemoryError when space in the memory area is exhausted.

IllegalThreadStateException when the caller is a Java thread.

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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

type type The class of which to create a new instance.

Throws

IllegalAccessException IllegalAccessException The class or initializer is inaccessible.

IllegalArgumentException IllegalArgumentException when type is null.

ExceptionInInitializerError ExceptionInInitializerError when an unexpected exception has occurred in a static initializer.

OutOfMemoryError OutOfMemoryError when space in the memory area is exhausted.

InstantiationException 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 is a Java thread.

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

Allocate an object in this memory area. This method may be concurrently used by multiple threads.

Parameters

c Tc The constructor for the new instance.

args args An array of arguments to pass to the constructor.

Throws

IllegalAccessException IllegalAccessException when the class or initializer is inaccessible under Java access control.

InstantiationException InstantiationException when the specified class object could not be instantiated. Possible causes are it is an interface, it is abstract, it is an array.

OutOfMemoryError OutOfMemoryError when space in the memory area is exhausted.

IllegalArgumentException IllegalArgumentException 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.

IllegalThreadStateException when the caller is a Java thread.

InvocationTargetException 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 is a Java Thread.

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

A.2.3.33 *SporadicParameters*

The following elements of SporadicParameters are deprecated. The required elements are documented in Section 6.3.3.15 above.

A.2.3.33.1 Fields

---

mitViolationExcept

public static final 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[458] which has this as its instance of ReleaseParameters[459] occurs at a time less then the minimum interarrival time defined here then the fire() method shall throw MITViolationException[460]. 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[461] is bound then the arrival time is ignored.

[458] Section 6.3.1.3
[459] Section 6.3.3.10
[460] Section 15.2.2.7
[461] Section 8.3.3.5

Deprecated since RTSJ 2.0

mitViolationIgnore

public static final 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[462] which has this as its instance of ReleaseParameters[463] 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 mitViolationSave

Description

Represents the "SAVE" policy for dealing with minimum interarrival time violations. Under this policy the arrival time for any instance of Schedulable[464] which has this as its instance of ReleaseParameters[465] 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 mitViolationReplace

Description

[462]Section 6.3.1.3
[463]Section 6.3.3.10
[464]Section 6.3.1.3
[465]Section 6.3.3.10

Represents the "REPLACE" policy for dealing with minimum interarrival time violations. Under this policy when an arrival time for any instance of Schedulable[466] which has this as its instance of ReleaseParameters[467] 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

A.2.3.33.2 Methods

---

setMitViolationBehavior(String)

Signature

public void
setMitViolationBehavior(String behavior)

Description

Sets the behavior of the arrival time queue in 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

IllegalArgumentException 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[468].

[466] Section 6.3.1.3
[467] Section 6.3.3.10
[468] Section 6.3.3.15.3

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[469].

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 cost The proposed cost. 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

IllegalArgumentException IllegalArgumentException 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.

[469]Section 6.3.3.15.3

IllegalAssignmentError 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 anlaysis 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

IllegalArgumentException 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 anlaysis is inadequate

A.2.3.34 *ThrowBoundaryError*

The following elements of ThrowBoundaryError are deprecated. The required elements are documented in Section 15.2.3.8 above.

A.2.3.34.1 Constructors

ThrowBoundaryError(String)

Signature

public
ThrowBoundaryError(String description)

Description

A descriptive constructor for ThrowBoundaryError.

Deprecated since RTSJ 2.0; application code should use get()[470] instead.

Parameters

description Description of the error.

A.2.3.35 *Timer*

The following elements of Timer are deprecated. The required elements are documented in Section 10.3.2.6 above.

A.2.3.35.1 Methods

---

[470] Section 15.2.3.8.2

destroy

Signature

public void
destroy()
throws IllegalStateException

Description

Stop this from counting or comparing when *active*, remove from it all the associated handlers if any, and release as many of its resources as possible back to the system. Every method invoked on a Timer that has been *destroyed* will throw IllegalStateException.

Throws

IllegalStateException when this Timer has been *destroyed*.

Deprecated since RTSJ 2.0

bindTo(String)

Signature

public void
bindTo(String happening)
throws UnsupportedOperationException

Description

Should not be called.

Parameters

happening to which to bind

Throws

UnsupportedOperationException when bindTo is called on a Timer.

Available since RTSJ 1.0.1

Deprecated RTSJ 2.0

A.2.3.36 VTMemory

Inheritance

java.lang.Object
  javax.realtime.MemoryArea
    javax.realtime.ScopedMemory
      javax.realtime.VTMemory

Description

VTMemory is similar to LTMemory[471] 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

A.2.3.36.1 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 this memory area to which the size may grow.

[471] Section A.2.3.11

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)[472].

Throws

IllegalArgumentException when initial is greater than maximum, or when initial or maximum is less than zero.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

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)[473] with the argument list (initial.getEstimate(), maximum.getEstimate(), logic).

Parameters

initial The size in bytes of the memory to initially allocate for this area.

maximum The maximum size in bytes this memory area to which the size may grow estimated by an instance of SizeEstimator[474].

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)[475].

Throws

IllegalArgumentException when initial is null, maximum is null, initial.getEstimate() is greater than maximum.getEstimate(), or when initial.getEstimate() is less than zero.

[472]Section A.2.3.36.1
[473]Section A.2.3.36.1
[474]Section 11.3.3.5
[475]Section A.2.3.36.1

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

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)[476] 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 this memory area to which the size may grow.

Throws

IllegalArgumentException when initial is greater than maximum or when initial or maximum is less than zero.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

VTMemory(SizeEstimator, SizeEstimator)

Signature

public
VTMemory(SizeEstimator initial,
SizeEstimator maximum)

Description

[476] Section A.2.3.36.1

Equivalent to VTMemory(long, long, Runnable)[477] with the argument list (initial.getEstimate(), maximum.getEstimate(), null).

Parameters

initial The size in bytes of the memory to initially allocate for this area.

maximum The maximum size in bytes this memory area to which the size may grow estimated by an instance of SizeEstimator[478].

Throws

IllegalArgumentException when initial is null, maximum is null, initial.getEstimate() is greater than maximum.getEstimate(), or when initial.getEstimate() is less than zero.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

VTMemory(long, Runnable)

Signature

```
public
VTMemory(long size,
         Runnable logic)
```

Description

Equivalent to VTMemory(long, long, Runnable)[479] with the argument list (size, size, logic).

Available 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)[480].

Throws

IllegalArgumentException when size is less than zero.

[477] Section A.2.3.36.1
[478] Section 11.3.3.5
[479] Section A.2.3.36.1
[480] Section A.2.3.36.1

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

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)[481] with the argument list (size.getEstimate(), size.getEstimate(), logic).

Available since RTSJ 1.0.1

Parameters

size An instance of SizeEstimator[482] 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 initial)[483].

Throws

IllegalArgumentException when size is null, or size.getEstimate() is less than zero.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

IllegalAssignmentError when storing logic in this would violate the assignment rules.

VTMemory(long)

Signature

[481] Section A.2.3.36.1
[482] Section 11.3.3.5
[483] Section A.2.3.36.1

public
VTMemory(long size)

Description

Equivalent to VTMemory(long, long, Runnable)[484] with the argument list (size, size, null).

Available 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.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

VTMemory(SizeEstimator)

Signature

public
VTMemory(SizeEstimator size)

Description

Equivalent to VTMemory(long, long, Runnable)[485] with the argument list (size.getEstimate(), size.getEstimate(), null).

Available since RTSJ 1.0.1

Parameters

size An instance of SizeEstimator[486] 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.

OutOfMemoryError when there is insufficient memory for the VTMemory object or for the backing memory.

[484] Section A.2.3.36.1
[485] Section A.2.3.36.1
[486] Section 11.3.3.5

A.2.3.36.2 Methods

toString

Signature

public java.lang.String
toString()

Description

Create a string representing this object. The string is of the form (VTMemory) Scoped memory # num
where num uniquely identifies the VTMemory area.

Returns

A string representing the value of this.

A.2.3.37 VTPhysicalMemory

Inheritance

java.lang.Object
javax.realtime.MemoryArea
javax.realtime.ScopedMemory
javax.realtime.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[487] 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.

[487] Section A.2.3.32

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

A.2.3.37.1 Constructors

VTPhysicalMemory(Object, long, long, Runnable)

Signature

```
public
VTPhysicalMemory(Object type,
                 long base,
                 long size,
                 Runnable logic)
```

Description

Create 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()[488] 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.

SecurityException 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[489] has been registered with the PhysicalMemoryManager[490].

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,
```

[488] Section 11.3.3.3.2
[489] Section A.2.1.1
[490] Section A.2.3.20

SizeEstimator size,
Runnable logic)

Description

Equivalent to VTPhysicalMemory(Object, long, long, Runnable)[491] 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()[492] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[493] has been registered with the PhysicalMemoryManager[494].

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.

[491] Section A.2.3.37.1
[492] Section 11.3.3.3.2
[493] Section A.2.1.1
[494] Section A.2.3.20

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)[495] 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

SecurityException 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[496] has been registered with the PhysicalMemoryManager[497].

[495] Section A.2.3.37.1
[496] Section A.2.1.1
[497] Section A.2.3.20

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)[498] 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

SecurityException 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[499]

[498] Section A.2.3.37.1
[499] Section A.2.1.1

has been registered with the PhysicalMemoryManager[500].

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)[501] with the argument list (type, 0, size, 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).

size The size of the area in bytes.

logic The run() method of this object will be called whenever MemoryArea.enter()[502] is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException when the application does not have permissions to access physical memory or the given range of memory.

[500] Section A.2.3.20
[501] Section A.2.3.37.1
[502] Section 11.3.3.3.2

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[503] has been registered with the PhysicalMemoryManager[504].

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)[505] with the argument list (type, 0, 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).

size A size estimator for this area.

logic The run() method of this object will be called whenever MemoryArea.enter()[506]

[503] Section A.2.1.1
[504] Section A.2.3.20
[505] Section A.2.3.37.1
[506] Section 11.3.3.3.2

is called. When logic is null, logic must be supplied when the memory area is entered.

Throws

SecurityException 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[507] has been registered with the PhysicalMemoryManager[508].

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)[509] with the argument list (type, 0, 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

[507] Section A.2.1.1
[508] Section A.2.3.20
[509] Section A.2.3.37.1

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

SecurityException 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[510] has been registered with the PhysicalMemoryManager[511].

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)[512] with the argument list (type, 0, 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).

[510] Section A.2.1.1
[511] Section A.2.3.20
[512] Section A.2.3.37.1

size A size estimator for this area.

Throws

SecurityException 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[513] has been registered with the PhysicalMemoryManager[514].

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.

A.2.3.37.2 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.

A.2.3.38 WaitFreeDequeue

Inheritance

[513]Section A.2.1.1
[514]Section A.2.3.20

java.lang.Object
  javax.realtime.WaitFreeDequeue

Description

A WaitFreeDequeue encapsulates a WaitFreeWriteQueue and a WaitFreeReadQueue. Each method on a WaitFreeDequeue corresponds to an equivalent operation on the underlying WaitFreeWriteQueue or WaitFreeReadQueue.

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.

WaitFreeDequeue is one of the classes allowing NoHeapRealtimeThreads and regular Java threads to synchronize on an object without the risk of a NoHeapRealtimeThread incurring Garbage Collector latency due to priority inversion avoidance management.

Deprecated as of RTSJ 1.0.1

A.2.3.38.1 Constructors

WaitFreeDequeue(Runnable, Runnable, int, MemoryArea)

Signature

```
public
WaitFreeDequeue(Runnable writer,
                Runnable reader,
                int maximum,
                MemoryArea memory)
```

Description

Constructs a queue, in memory, with an underlying WaitFreeWriteQueue[515] and WaitFreeReadQueue[516], each of size maximum.

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 queue; moreover, there is no check that they actually access the queue at all.

Note that the wait free queues' internal queues are allocated in memory, but the memory area of the wait free dequeue 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 Then maximum number of elements in the both the WaitFreeReadQueue[517] and the WaitFreeWriteQueue[518].

memory The MemoryArea[519] in which internal elements are allocated.

Throws

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.

IllegalArgumentException 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 object. The maximum argument must be greater than zero.

InaccessibleAreaException when memory is a scoped memory that is not on the caller's scope stack.

A.2.3.38.2 Methods

[515] Section 7.3.1.5
[516] Section 7.3.1.4
[517] Section 7.3.1.4
[518] Section 7.3.1.5
[519] Section 11.3.3.3

nonBlockingRead

Signature

public java.lang.Object
nonBlockingRead()

Description

An unsynchronized call of the read() method of the underlying WaitFreeReadQueue[520].

Returns

A java.lang.Object object read from this. When there are no elements in this then null is returned.

blockingWrite(Object)

Signature

public void
blockingWrite(Object object)
throws InterruptedException

Description

A synchronized call of the write() method of the underlying WaitFreeReadQueue[521]. This call blocks on queue full and waits until there is space in this.

Parameters

object The java.lang.Object to place in this.

Throws

MemoryScopeException when a memory access error or illegal assignment error would occur while storing object in the queue.

InterruptedException when the thread is interrupted by interrupt() or AsynchronouslyInterruptedExc fire()[522] during the time between calling this method and returning from it.

Available since RTSJ 1.0.1 Return type changed from boolean to void because this method *always* returned true, and added InterruptedException.

[520]Section 7.3.1.4
[521]Section 7.3.1.4
[522]Section 8.3.2.1.2

nonBlockingWrite(Object)

Signature

public boolean
nonBlockingWrite(Object object)

Description

An unsynchronized call of the write() method of the underlying WaitFreeWriteQueue[523]. This call does not block on queue full.

Parameters

object The Object to attempt to place in this.

Throws

MemoryScopeException when a memory access error or illegal assignment error would occur while storing object in the queue.

Returns

true when object was inserted (i.e., the queue was not full), false otherwise.

blockingRead

Signature

public java.lang.Object
blockingRead()
throws InterruptedException

Description

A synchronized call of the read() method of the underlying WaitFreeWriteQueue[524]. This call blocks on queue empty and will wait until there is an element in the queue to return.

Throws

InterruptedException when the thread is interrupted by interrupt() or AsynchronouslyInterruptedExceptio fire()[525] during the time between calling this method and returning from it.

Returns

The java.lang.Object read.

Available since RTSJ 1.0.1 Added throws InterruptedException.

[523]Section 7.3.1.5
[524]Section 7.3.1.5
[525]Section 8.3.2.1.2

force(Object)

Signature

public boolean
force(Object object)

Description

When this's underlying WaitFreeWriteQueue[526] is full, then overwrite with object the most recently inserted element. Otherwise this call is equivalent to nonBlockingWrite().

Parameters

object The object to be written.

Throws

MemoryScopeException when a memory access error or illegal assignment error would occur while storing object in the queue.

Returns

true when an element was overwritten; false when there as an empty element into which the write occurred.

A.3 Rationale

These are interface and classes that have been shown to be less the ideal. They have been replaced by elements that better fulfill the requirements. Compatibility can be provided by implemenations that use existing facilities so there is not reason to continue requiring their inclusion new implementations.

[526] Section 7.3.1.5

Appendix B

Bibliography

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