SPARCompiler Ada Runtime System Guide

SunSoft
A Sun Microsystems, Inc. Business
2550 Garcia Avenue
Mountain View, CA 94043
U.S.A.

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"Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that."

Lewis Carroll

Runtime System Overview 1

1.1 Introduction

This section is an overview of the implementations of the two SPARCompiler Ada Runtime Systems. Hereafter, SPARCompiler Ada is called SC Ada. There are two implementations of the Ada runtime in this product, the VADS threaded runtime and the Solaris multithreaded (MT) runtime. These runtime systems deliver significantly different functionality. In fact, they are so different that each runtime system requires its own version of the Ada `standard` library as well as its own version of the SunSoft-supplied libraries and configuration directories.

Before compiling your application, you must choose the runtime system you are going to use. If you decide to switch runtime systems after you have built your application, you will be required to recompile your application using the other set of SunSoft-supplied libraries.

The two versions of the SunSoft-supplied libraries are in the directories `self` and `self_thr` in *ada_location* (*ada_location* indicates the directory where SC Ada was installed from the distribution media). Your application must be built with SunSoft-supplied Ada libraries exclusively from one of these two directories.

In the following sections we present the structure of the SC Ada runtime system, an overview of runtime system components, the differences between the two runtime systems delivered with this product, and some miscellaneous information.

1.2 The SC Ada Runtime Structure

The SC Ada runtime system has been designed to be fast and portable. Portability has been achieved by using a layered model for constructing the runtime system, with a microkernel as the innermost layer.

Figure 1-1 shows the different layers of the runtime system.

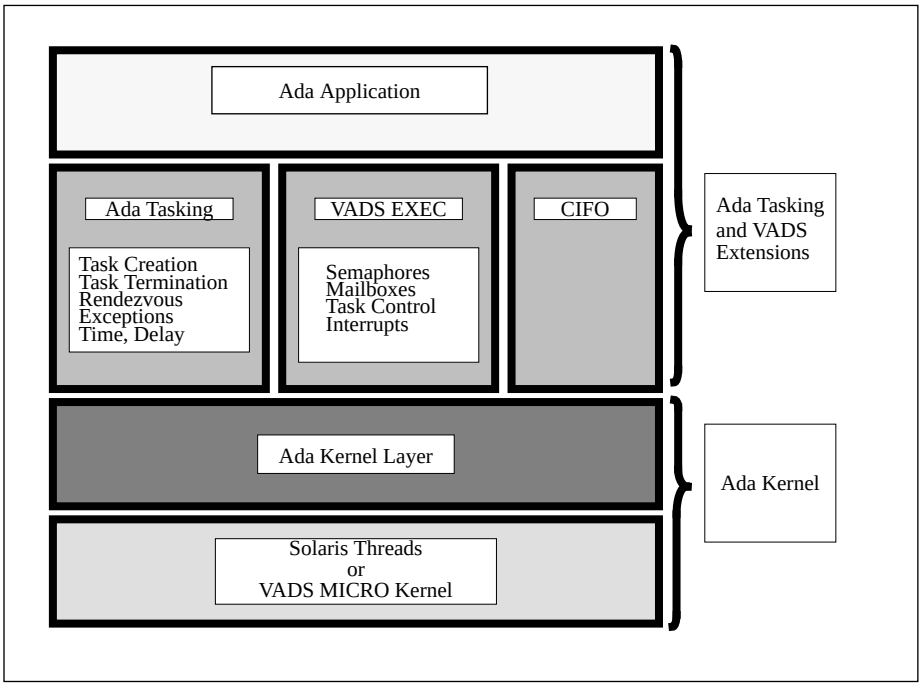


Figure 1-1 Threaded AdaRuntime Layers

1.2.1 The Ada Kernel

This layered model has enabled us to use different microkernels underneath the SC Ada runtime, yet still provide an identical set of services to the Ada application. We have implemented our own microkernel, called VADS MICRO. We support VADS MICRO in embedded systems as well as on workstation hosts. We have also ported the runtime on top of other kernels, in particular the Solaris Multithread architecture, which we abbreviate to Solaris MT.

The two runtime systems that are part of SC Ada are different because of these two different underlying microkernels, VADS MICRO and Solaris threads. Later in this chapter there is a section called VADS threaded vs. Solaris MT runtime. That section discusses some of the differences between the VADS MICRO microkernel and the Solaris threads microkernel.

On top of the microkernel is the Ada kernel layer, which maps the microkernel features into the interface required by the Ada tasking and VADS Extensions layer. When the runtime system is ported onto a new microkernel, the main job of porting is writing a new Ada kernel layer for the new microkernel. Together the microkernel and the Ada kernel layer are known as the Ada Kernel.

Multitasking runtime system performance is measured in task switch times, semaphore lock times, etc. The layered design of the runtime has enabled us to move much of the Ada tasking and semaphore semantics to a level higher than the kernel, closer to the application. As a result, many of the common operations are handled without going into the Ada kernel at all and the total throughput of the system is enhanced.

The Ada kernel is discussed in the section Ada Kernel. We recommend that you do not call Ada kernel services directly. These services are described mainly for completeness. There is one exception; there are some object attributes such as tasking attributes that the application can set to cause different behavior. The Ada Kernel interface provides routines to initialize these attributes. These routines are supported on all SC Ada implementations, even though the underlying representation of the attributes may vary from microkernel to microkernel.

References

"Ada Kernel" on page 2-1

1.2.2 Ada Tasking and VADS Extensions

This layer of the SC Ada runtime system is common to all implementations of SC Ada although some of the extensions shown are part of add-on products. Each box in the Ada Tasking and VADS Extensions layer represents a set of services that are directly available to the application program. These services are implemented using the interface provided by the Ada Kernel Layer. The boxes are separated to indicate that these services are mostly independent.

The Ada Tasking services are different from the rest of the services in this layer because the Ada Tasking services are called implicitly by the code generated by the SC Ada compiler. In other words, although your Ada tasking application calls the functions in Ada Tasking, the calls are not visible in your source code. You can see the calls if you disassemble certain parts of your program in the debugger. An overview of this interface is given in the Tasking section of the "Runtime Systems Topics" chapter. We strongly discourage you from putting calls to any of the routines in Ada Tasking into your source code.

The VADS EXEC functions are documented in the "Ada Runtime Services" chapter. The packages in the file `v_vads_exec.a` in the `vads_exec` library provide the user's interface to the following VADS EXEC services:

- Signal Handling
- Mailboxes
- Memory Management
- Semaphores
- Tasking Extensions
- Stack Operations

CIFO is a functional area that is not part of the base SC Ada product but will be available as an add-on product.

References

Section 1.2.2, "Ada Tasking and VADS Extensions," on page 1-3"

1.3 How the VADS Threaded Runtime Works

The VADS threaded runtime implements Ada tasking inside a single UNIX process. The VADS MICRO kernel supports a very lightweight thread, meaning that the state of a thread is very small and switching between threads is quite fast.

An Ada program using the VADS threaded runtime executes as a UNIX process. When the process begins, it's first instruction is in `V_START_PROGRAM` which finishes by calling the VADS Kernel entry point `TS_INITIALIZE`. This

kernel entry point (among other functions) creates the task to correspond to the main program and the idle task. After initialization, the user program is resumed in `V_START_PROGRAM_CONTINUE`.

As the application executes it can create more tasks and these tasks can interact. If time slicing is enabled, task execution is preempted by `SIGALRM` signals and VADS MICRO executes tasks of equal priority in a round-robin fashion. All this tasking is taking place inside of one UNIX process and the OS is not aware it is going on.

References:

`V_START_PROGRAM`, *SPARCompiler Ada Programmer's Guide*

1.4 Debugging and the Runtime System

The SC Ada debugger is aware of the tasking supported in the runtime system, regardless of the microkernel being used. The debugger's `lt` command displays all the tasks in the program with appropriate status. For the Solaris MT runtime, lt shows the task-to-thread mapping.

In addition to listing the tasks, the debugger allows you to select each of the tasks and move up and down on the call stack of that task to examine it's current execution state, including the values of variables and registers.

References

`lt` command, *SPARCompiler Ada Reference Guide*
`la` command, *SPARCompiler Ada Reference Guide*
`task` command, *SPARCompiler Ada Reference Guide*

1.5 VADS Threaded vs. Solaris MT Runtime

The two Ada runtime systems supplied with this product are called the VADS threaded and the Solaris MT runtime systems. The VADS threaded runtime system is based on the VADS MICRO microkernel. The Solaris MT runtime is based on Solaris threads as a kernel.

You choose which runtime system you want for your application when you make your application Ada libraries with `a.mklib`. The Solaris MT runtime is indicated by *ada_location*`/self_thr/standard`. This runtime has the Solaris

threads as its microkernel. The VADS threaded runtime is in *ada_location*`/self/standard` and it is based on the VADS MICRO microkernel.

A complete description of the functions provided by the Solaris MT runtime system is provided in the manual titled Multithreaded Ada.

References

`a.info`, *SPARCompiler Ada Reference Guide*
`a.mklib`, *SPARCompiler Ada Reference Guide*
Getting Started,*SPARCompiler Ada User's Guide*
LINK Directive Names, *SPARCompiler Ada Reference Guide*
Multithreaded Ada, *Multithreading Your Ada Applications*

1.5.1 Concurrency

One primary difference between the Solaris MT and VADS threaded runtime systems is concurrency. Concurrency (or concurrency level) measures the number of Ada tasks in your program that the operating system will run at the same time. For the VADS threaded runtime, there is no operating system concurrency, so the concurrency level is one -- when one task is doing something, all other tasks are stopped. As a consequence, when an Ada task blocks performing an operating system function (e.g., reading a file, opening a socket), the entire Ada program is blocked.

By contrast, the Solaris MT runtime lets you configure the concurrency of your program. For example, if your application has three tasks that do I/O and four tasks that do only computations, you may want a concurrency level of seven. Or you may want a concurrency of four, three to cover the tasks doing I/O and one more to make sure that some computation is getting done even if all three I/O tasks are blocked.

1.5.2 Multithreaded Ada

If your host computer has symmetric multiprocessors, the operating system concurrency level translates to true concurrency: multiple Ada tasks can be executing at the same time. The Solaris MT Ada runtime has been designed so that your application can exploit symmetric multiprocessors. If your application contains functions that run in parallel, then you should use the Solaris MT runtime system and gain the performance benefits of parallel

processing. For a large class of applications containing parallelism, the performance improvements that can be realized by taking advantage of multiple processors can be truly breathtaking!

The VADS threaded runtime system does not exploit multiple processors.

1.5.3 When to Use the VADS Threaded Runtime

If an Ada application does not contain tasking, it will not benefit from the concurrency of the Solaris MT runtime. Simple programs that read, process, and write information, as well as applications containing no inherent parallelism fall into this category.

It is best to use the VADS threaded runtime if your program contains no parallelism. The VADS threaded runtime has been optimized to provide the minimum overhead for an Ada program that doesn't require concurrency. The Solaris MT runtime can also be configured to provide no concurrency. If you are planning to add concurrency to you application at a later time, you may want to start with Solaris threads, just to maintain a consistent development and debugging environment throughout the application's lifecycle.

1.5.4 Parallel Programming is Tricky

Parallel programming in the context of concurrency is difficult. An Ada program that works with the VADS threaded runtime may not work in the Solaris MT runtime with a concurrency level greater than one. Here is one pitfall to avoid:

Task priority cannot be used to serialize execution

In the VADS threaded runtime, raising the priority of a task is a way to guarantee a certain pattern of execution, for example to make sure that a certain operation is not interrupted by lower priority tasks. This does not work with true concurrency, since multiple tasks can execute at the same time. For the same reasons, disabling preemption is another technique that cannot be used to serialize execution. Synchronization methods such as rendezvous, semaphores, mailboxes, or some other method should be used to implement critical sections.

1.6 Runtime System Interfaces

Figure 1-2 is a copy of Figure 1-1 with the interface file names shown

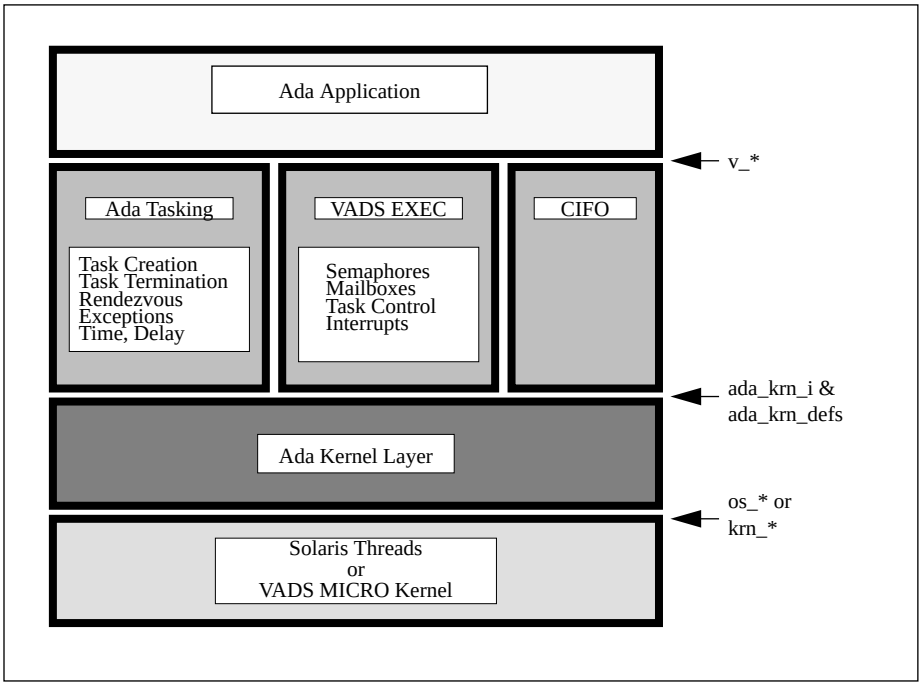


Figure 1-2 Runtime Interfaces

Table 1-1 lists the files in the SC Ada release that correspond to the interfaces shown in Figure 1-2.

Table 1-1 Runtime Interfaces

Common to VADS Threaded and Solaris MT Runtimes				

Ada Tasking
`/self/standard`
`/self_thr/standard`
	VADS EXEC
	`/self/vads_exec`
	`/selt_thr/vads_exec`
		Ada Kernel
		`/self/standard`
		`/self_thr/standard`
			Solaris Threads
			`/selt_thr/standard`
				VADS MICRO
				`/self/standard`

`v_i_alloc.a`	`v_intr_b.a`	`ada_krn_defs.a`	`os_alloc.a`	`krn_call_i.a`
`v_i_bits.a`	`v_mbox_b.a`	`ada_krn_i.a`	`os_signal.a`	`krn_cpu_defs.a`
`v_i_callout.a`	`v_mem_b.a`		os_synch.a	krn_defs.a
`v_i_csema.a`	`v_semaph_b.a`		`os_thread.a`	`krn_entries.a`
`v_i_except.a`	`v_stack_b.a`		`os_time.a`	
v_i_intr.a	`v_vads_exec.a`			
`v_i_libop.a`	`v_xtask_b.a`			
`v_i_mbox.a`				
`v_i_mem.a`				
`v_i_mutex.a`				
`v_i_pass.a`				
`v_i_raise.a`				
`v_i_sema.a`				
`v_i_sig.a`				
`v_i_taskop.a`				
`v_i_tasks.a`				
`v_i_time.a`				
`v_i_timeop.a`				
`v_i_types.a`				

References

Section 2.1, “Ada Kernel,” on page 2-1
contents of the standard library, *SPARCompiler Ada Reference Guide*
Multithreaded Ada, *Multithreading Your Ada Applications*
Appendix A, “A Summary of RTS Changes
Chapter 4 , “Ada Runtime Services"

1.6.1 `ada_krn_defs.a` *and* `ada_krn_i.a`

We recommends that you do not directly call the interface presented in `ada_krn_i.a` and `ada_krn_defs.a`. This internal interface is documented to provide an understanding of how the Ada Kernel works.

The exception to this is the object attribute initialization routines in `ada_krn_def.a`. In Section 2.1.1, “Ada Kernel Implementation,” on page 2-3, there is a list of mechanisms available to the application programmer to control the attributes of the Ada kernel objects. The attribute initialization routines from ada_krn_defs.a are provided for exactly this purpose.

In earlier releases, the interface to the low level kernel services was scattered across multiple `v_i_*` files. In this version, the interface is consolidated in one package, `ADA_KRN_I`. Most of the services are needed to support the Ada tasking semantics. The remaining services are needed to support VADS EXEC. The VADS EXEC services are optional and not supported by all versions of the microkernel.

The services are subdivided into the following groups.

Program
Kernel scheduling
Task management
Task masters synchronization
Task synchronization
Interrupt
Time
Allocation
Mutex
ISR mutex
Semaphore
Count semaphore

Mailbox
Callout
Task storage

All type definitions used by the Ada tasking layer that are microkernel specific are defined in package ADA_KRN_DEFS. package ADA_KRN_DEFS also contains numerous functions for allocating and initializing object attribute records.

ada_krn_defs.a contains type definitions for the following objects:

mutex
condition variable
semaphore
counting semaphore
mailbox

References

package ADA_KRN_DEFS, Section A.4.14, “ADA_KRN_DEFS: Ada Kernel Type Definitions,” on page A-24
package ADA_KRN_I, Section A.4.13, “ADA_KRN_I: Interface To the Ada Kernel Services,” on page A-19

1

"We are all framed of flaps and patches and of so shapeless and diverse a texture that every piece and every moment playeth his part."

Montaigne

Runtime System Topics 2

This chapter discusses the following runtime system topics:

- Ada Kernel
- Passive Tasks
- When a Program Exits or Deadlocks
- SC Ada Archive Interface Packages
- Tasking
- Fast Rendezvous Optimization

2.1 Ada Kernel

The Ada Kernel is a runtime nucleus with concurrency and synchronization services. It was designed to satisfy all the runtime requirements of Ada tasking and the VADS Extensions (VADS EXEC and CIFO).

The Ada Kernel defines and provides operations for the following concurrency and synchronization objects:

- Ada program
- Ada task
- Ada task master
- Ada "new" allocation

- kernel scheduling
- callout
- task storage
- interrupts
- time
- mutex
- condition variable
- binary semaphore
- counting semaphore
- mailbox

For each object there are type definitions and a collection of services. Most objects have a set of user definable attributes that are used to initialize it. Type and attribute definitions for each object are in `package ADA_KRN_DEFS`. `package ADA_KRN_I` contains the interface to all the object services. Both packages are located in the standard directory.

The mutex and condition variable object types have been added to complement semaphores. The definition of these object types is extracted from the POSIX 1003.4a standard, “IEEE Threads Extension for Portable Operating Systems”. See the latest draft of that standard for more details about POSIX threads.

Mutex

Mutex is a synchronization object used to allow multiple threads to serialize their access to shared data. The name derives from the capability it provides, MUTual EXclusion.

The thread that has locked a mutex becomes its owner and remains the owner until the same thread unlocks the `mutex`. Other threads that attempt to lock the `mutex` during this period suspend execution until the original thread unlocks it. The act of suspending the execution of a thread awaiting a mutex does not prevent other threads from making progress in their computations.

We have also added an `ABORT_SAFE` option to mutexes. A task that has locked an `ABORT_SAFE` mutex is inhibited from being completed by an Ada abort until it unlocks the mutex.

Condition Variable

A condition variable is a synchronization object that allows a thread to suspend execution until some condition is true. Typically, a thread holding a mutex determines that it cannot proceed by examining the shared data guarded by the mutex. The thread then waits on a condition variable associated with some state of the shared data. Waiting on the condition variable atomically releases the mutex. If another thread modifies the shared data to make the condition true, that thread signals threads waiting on the condition variable. This wakes up the waiting thread which must reacquire the mutex and resume its execution.

An ABORT_SAFE option has been added to condition variables. A task locking an ABORT_SAFE mutex is inhibited from being completed by an Ada abort until it unlocks the mutex. However, if a task is aborted while waiting at a condition variable (after an implicit mutex unlock), then it is allowed to complete.

2.1.1 Ada Kernel Implementation

The Ada Kernel has been designed to be portable so that it can be layered upon numerous microkernels. Each Ada Kernel implementation does whatever it takes to map the objects, attributes, and services defined in ADA_KRN_DEFS and ADA_KRN_I onto the underlying microkernel objects and services. By layering Ada tasks upon microkernels, Ada tasks can co-exist with and call thread based services written in other languages, such as, threaded windows written in C.

The same ADA_KRN_DEFS and ADA_KRN_I interface is provided across all the Ada Kernel implementations. However, each implementation has a different representation for the object and attribute type definitions. Microkernel specific capabilities are made available to the application program via the object attributes. Object attributes can be used in the following places in an application program:

1. The address of a mutex attributes record is the second argument of a PASSIVE pragma. The passive task's critical region is protected by locking and unlocking the mutex initialized using the mutex attributes. The mutex attributes specifies the locking mechanism (test-and-set or disable interrupts) and the queuing order when the task blocks waiting for the mutex (fifo, priority or priority inheritance). In the CIFO add-on product,

VADS MICRO also supports priority ceiling mutexes using the priority ceiling protocol emulation algorithm documented in the POSIX 1003.4a standard.

2. A semaphore attributes access value is passed to the VADS EXEC service, `V_SEMAPHORES.CREATE_SEMAPHORE` which returns a binary semaphore ID.

3. A counting semaphore attributes access value is passed to the VADS EXEC service, `V_SEMAPHORES.CREATE_SEMAPHORE` which returns a counting semaphore ID.

4. A mailbox attributes access value is passed to the VADS EXEC service, `V_MAILBOXES.CREATE_MAILBOX`.

5. The address of a task attributes record is the first or second argument of a `TASK_ATTRIBUTES` pragma.

`ADA_KRN_DEFS` provides a set of subprograms for initializing the object attributes. For example, the following subprograms are provided to initialize mutex attributes:

```
fifo_mutex_attr_init()
prio_mutex_attr_init()
prio_inherit_mutex_attr_init()
prio_ceiling_mutex_attr_init()
intr_attr_init()
```

These subprograms are applicable to all implementations of the Ada Kernel. If an implementation doesn't support a particular attribute capability, it raises the `PROGRAM_ERROR` exception. Since these subprograms insulate the application software from the underlying attribute type representation, they should be used instead of explicitly initializing each field of an attribute record.

Even though the Ada Kernel primarily exists to satisfy the requirements of Ada tasking and the VADS Extensions, some of its services are of interest to the application programmer. VADS EXEC has services for binary semaphores, counting semaphores and mailboxes. These services are layered upon the corresponding services in the Ada Kernel. The application may elect to bypass the additional overhead incurred by the VADS EXEC layer and call the Ada Kernel services directly. Additionally, the Ada Kernel has objects currently not supported in the VADS EXEC: mutexes and condition variables. The Ada Kernel services for these objects may be directly called from user code

Caution – Since the program, master, and task services have complex semantics and implicit dependencies, we advise against calling these services directly.

We have presented an overview of the Ada Kernel. Now we would like to focus our attention on each of the objects in the Ada Kernel. We will address the following topics for each object:

- Types
- Constants
- Attributes
- Services
- Support Subprograms

The interface to the services is provided in `ada_krn_i.a`. `ada_krn_defs.a` contains the rest. Both files are in the `standard` directory.

2.1.1.1 Ada Program

There is a single Ada program object per executable entity. The Ada program object is automatically created and initialized during program startup.

Types

`PROGRAM_ID`
Type of the Ada program's object. The type definition for `PROGRAM_ID` is in the SYSTEM package.

`KRN_PROGRAM_ID`
Type of the underlying program / process. There are services for mapping between the Ada `PROGRAM_ID` and `KRN_PROGRAM_ID`.

Attributes

None.

Services

Since the Ada program services shouldn't be called directly, we only list them here. Consult `ada_krn_i.a` in standard for more details.

Program services
- `PROGRAM_INIT`
- `PROGRAM_EXIT`
- `PROGRAM_DIAGNOSTIC`
- `PANIC_EXIT`
- `PROGRAM_IS_ACTIVE`
- `PROGRAM_SELF`

Program services (VADS EXEC augmentation)
- `PROGRAM_GET`
- `PROGRAM_START`
- `PROGRAM_TERMINATE`
- `PROGRAM_GET_KEY`
- `PROGRAM_GET_ADA_ID`
- `PROGRAM_GET_KRN_ID`

2.1.1.2 Ada Task

An Ada task object exists for each thread of execution. Most operations on Ada task objects are done implicitly via the tasking semantics of the Ada language.

Types

`TASK_ID`
Type of the Ada task's object. The type definition for `TASK_ID` is in the `SYSTEM` package.

`KRN_TASK_ID`
Type of the underlying thread. There are services for mapping between the Ada `TASK_ID` and `KRN_TASK_ID`.

Attributes

`TASK_ATTR_T`
The address of a `TASK_ATTR_T` record is the first or second argument of the `TASK_ATTRIBUTES` pragma and is passed to the underlying microkernel at task create. The definition of the `TASK_ATTR_T` record is microkernel specific. However, all variations of the `TASK_ATTR_T` record contain at least the `prio`, `mutex_attr_address` and `cond_attr_address` fields.`prio` specifies the priority of the task. If the task also had a `pragma PRIORITY(PRIO`, then, the `prio` specified in the `TASK_ATTR_T` record takes precedence.

The `mutex_attr_address` field contains the address of the attributes to be used to initialize the mutex object implicitly created for the task. This mutex is used to protect the task's data structure. For example, the task's mutex is locked when another task attempts to rendezvous with it. If `mutex_attr_address` is set to `NO_ADDR`, the `mutex_attr_address` value specified by the `V_USR_CONF.CONFIGURATION_TABLE` parameter, `DEFAULT_TASK_ATTRIBUTES` is used. Otherwise, `mutex_attr_address` must be set to the address of an `ADA_KRN_DEFS.MUTEX_ATTR_T` record. The `MUTEX_ATTR_T` record should be initialized using one of the mutex attribute init subprograms.

References

“Mutex Support Subprograms” on page 2-24.

The cond_attr_address field contains the address of the attributes to be used to initialize the condition variable object implicitly created for the task. When the task blocks, it waits on this condition variable. If cond_attr_address is set to NO_ADDR, the cond_attr_address value specified by the V_USR_CONF.CONFIGURATION_TABLE parameter, DEFAULT_TASK_ATTRIBUTES is used. Otherwise, cond_attr_address must be set to the address of a ADA_KRN_DEFS.COND_ATTR_T record. The COND_ATTR_T record should be initialized using one of the condition variable attribute init routines.

References

"Condition Variable" on page 2-27.

The TASK_ATTR_T record can be initialized using one of the overloaded TASK_ATTR_INIT subprograms. See "Ada Task Support Subprograms" on page 2-9

SPORADIC_ATTR_T

In the CIFO add-on product using VADS MICRO, an Ada task is made sporadic by updating the sporadic_attr_address field in the TASK_ATTR_T record with the address of a SPORADIC_ATTR_T record. The easiest way to initialize both the TASK_ATTR_T and SPORADIC_ATTR_T records is to use one of the overloaded SPORADIC_TASK_ATTR_INIT subprograms. See the CIFO documentation for more details about the attributes and characteristics of a sporadic task.

Services

There are two services for mapping between the Ada TASK_ID and the KRN_TASK_ID:

```
function task_get_Ada_id(krn_tsk: krn_task_id) return task_id;
-- Returns NO_TASK_ID if the kernel task isn't also an Ada task

function task_get_krn_id(tsk: task_id) return krn_task_id;
```

Since the remaining Ada task services shouldn't be called directly, we only list them here. Consult ada_krn_i.a in standard for more details.

Task management services
- TASK_SELF
- TASK_SET_PRIORITY
- TASK_GET_PRIORITY
- TASK_CREATE
- TASK_ACTIVATE
- TASK_STOP
- TASK_DESTROY
- TASK_STOP_SELF
- TASK_DESTROY_SELF

Task management services (VADS EXEC augmentation)
- TASK_DISABLE_PREEMPTION
- TASK_ENABLE_PREEMPTION
- TASK_SUSPEND
- TASK_RESUME
- TASK_GET_TIME_SLICE
- TASK_SET_TIME_SLICE
- TASK_GET_SUPERVISOR_STATE
- TASK_ENTER_SUPERVISOR_STATE
- TASK_LEAVE_SUPERVISOR_STATE

Task synchronization services
- TASK_LOCK
- TASK_UNLOCK
- TASK_WAIT
- TASK_WAIT_LOCKED_MASTERS
- TASK_TIMED_WAIT
- TASK_SIGNAL
- TASK_WAIT_UNLOCK
- TASK_SIGNAL_UNLOCK
- TASK_SIGNAL_WAIT_UNLOCK

Sporadic task services (CIFO augmentation)
- TASK_IS_SPORADIC
- TASK_SET_FORCE_HIGH_PRIORITY

Ada Task Support Subprograms

The TASK_ATTR_T record can be initialized using one of the overloaded TASK_ATTR_INIT subprograms.

```
 procedure task_attr_init(
      task_attr   : a_task_attr_t;
      prio        : priority := priority'first;
      -- ...  OS Threads specific fields
      mutex_attr  : a_mutex_attr_t := null;
      cond_attr   : a_cond_attr_t := null );

function task_attr_init(
      task_attr   : a_task_attr_t;
      prio        : priority := priority'first;
      -- ...  OS Threads specific fields
      mutex_attr  : a_mutex_attr_t := null;
      cond_attr   : a_cond_attr_t := null );
 ) return address;

function task_attr_init(
      -- does an implicit "task_attr: a_task_attr_t :=
      --                          new task_attr_t;”
      prio        : priority := priority'first;
      -- ...  OS Threads specific fields
      mutex_attr  : a_mutex_attr_t := null;
      cond_attr   : a_cond_attr_t := null );
  ) return address;
```

Examples

The TASK_ATTR_T record can be initialized using one of the overloaded TASK_ATTR_INIT subprograms. This is shown in Figure 2-1

```
with system;
with ada_krn_defs;
package one is
      -- Does an implicit allocation of the task_attr_t record

      task a is
           pragma task_attributes(ada_krn_defs.task_attr_init(
                          prio => 20,
                          ... OS threads specific fields
                          ));
      end;
(Continued)
```

```
(Continued)

      type tt;
      b: tt;
          pragma task_attributes(b, ada_krn_defs.task_attr_init(
                              prio => 30,
                              ... OS threads specific fields
                              ));
end one;

with system;
with ada_krn_defs;
package two is              -- No implicit allocation is done
      a_attr_rec: ada_krn_defs.task_attr_t;
      a_attr: system.address :=
           ada_krn_defs.task_attr_init(
               task_attr   => ada_krn_defs.to_a_task_attr_t(
                                   a_attr_rec'address),
                              prio => 20,
                              ... OS threads specific fields
                              );

b_attr_rec: ada_krn_defs.task_attr_t;
b_attr: system.address :=
      ada_krn_defs.task_attr_init(
           task_attr   => ada_krn_defs.to_a_task_attr_t(
                               b_attr_rec'address),
                          prio        => 30,
                          ... OS threads specific fields
                          );

            task a is
                 pragma task_attributes(a_attr);
                 -- or
                 -- pragma task_attributes(a_attr_rec'address);
            end;
            task type tt;
             b: tt;
                 pragma task_attributes(b, b_attr);
                 -- or
               -- pragma task_attributes(b, b_attr_rec'address);
         end two;
```

Figure 2-1 Example of Initializing the TASK_ATTR_T Record (Continued)

References

Pragmas, *SPARCompiler Ada Programmer's Guide*

2.1.1.3 Ada Task Master

A single task master object exists to provide mutual exclusion for operations performed across multiple task objects (for example, aborting Ada tasks).

Types

None. There is one master object and its implied in the services.

Attributes

None

Services

Since the Ada task master services shouldn't be called directly, we only list them here. Consult ada_krn_i.a in standard for more details.

Task masters synchronization services

```
MASTERS_LOCK
MASTERS_TRYLOCK
MASTERS_UNLOCK
```

2.1.1.4 Ada “new” Allocation

An object is created for each Ada new allocator. This object is freed via Ada's UNCHECKED_DEALLOCATION. The Ada Kernel provides services to support Ada's allocation / deallocation needs.

Types

ADDRESS

The ADDRESS of the object is returned when its been allocated. This same ADDRESS is passed to deallocate the object.

Attributes

None

Services

The Ada Kernel has the following allocation services:

```
function alloc(size: natural) return address;
    -- Returns NO_ADDR if alloc is unsuccessful.
procedure free(a: address);
```

2.1.1.5 Kernel Scheduling

Services are provided to control the kernel scheduling policies.

Types

None. There is one kernel scheduling object and it is implied in the services.

Attributes

None

Services

The Ada Kernel has the following scheduling services:

```
function kernel_get_time_slicing_enabled return boolean;
procedure kernel_set_time_slicing_enabled(new_value: boolean);
```

Caution – The above scheduling services aren't supported for all implementations of the Ada Kernel.

2.1.1.6 Callout

Services are provided that allow a subprogram to be called at a program, task or idle event.

Types

`CALLOUT_EVENT_T`

All versions of the Ada Kernel are expected to support at least the program events: `EXIT_EVENT` and `UNEXPECTED_EXIT_EVENT`.

Attributes

None

Services

The following service installs a callout for the specified program, task or idle event. It returns `FALSE` if the service isn't supported or its unable to do the install.

```
function callout_install(event: callout_event_t; proc:
address)         return boolean;
```

`V_XTASKING.INSTALL_CALLOUT` in VADS EXEC layers directly upon the `CALLOUT_INSTALL` service. Consult its documentation for more details.

References

“package V_XTASKING — provides Ada task operations” on page 4-75

2.1.1.7 Task Storage

Some versions of the Ada Kernel support user defined storage on a per task basis. (Currently only supported by the VADS MICRO.)

Types

`TASK_STORAGE_ID`
The ID or handle of a user defined object stored in every task.

Attributes

None.

Services

The following task storage allocation services are currently supported only for VADS MICRO:

```
function task_storage_alloc(size: natural) return task_storage_id;
-- If service isn't supported or unable to allocate memory, it
-- returns NO_TASK_STORAGE_ID.

function task_storage_get(tsk: task_id; storage:
task_storage_id)            return address;

function task_storage_get2(krn_tsk: krn_task_id;      storage:
task_storage_id) return address;
```

The VADS EXEC `V_XTASKING` services: `ALLOCATE_TASK_STORAGE`, `GET_TASK_STORAGE`, and `GET_TASK_STORAGE2` layer directly upon the above Ada Kernel services. See the `V_XTASKING` documentation for more details.

References

“package V_XTASKING — provides Ada task operations” on page 4-75

2.1.1.8 Interrupts

Services are provided to enable / disable interrupts, get interrupt enabled / disabled status, attach / detach interrupt service routine (ISR) and check if in an ISR. (On self-hosts, interrupts are Unix signals).

Types

`INTR_VECTOR_ID_T`
Signal number range

`INTR_STATUS_T`
Signal mask

`INTR_ENTRY_T`
The address of an `INTR_ENTRY_T` object is specified in an interrupt entry address clause. The `INTR_ENTRY_T` record contains two fields: interrupt vector and the task priority for executing the interrupt entry's accept body.

Constants

`DISABLE_INTR_STATUS`
Constant for disabling all asynchronous signals

`ENABLE_INTR_STATUS`
Constant for enabling all asynchronous signals

`BAD_INTR_VECTOR`
Value returned for a bad `INTR_VECTOR` passed to an interrupt service routine.

Attributes

None

Services

The Ada Kernel has the following interrupt services:

```
procedure interrupts_get_status(status: out intr_status_t);
procedure interrupts_set_status(old_status: out intr_status_t;
            new_status: intr_status_t);

function isr_attach(iv: intr_vector_id_t; isr: address)
            return address;
  -- Returns address of previously attached isr.
  -- ADA_KRN_DEFS.BAD_INTR_VECTOR is returned for a bad
  -- intr_vector parameter.

function isr_detach(iv: intr_vector_id_t) return address;
  -- Returns address of previously attached isr.
  -- ADA_KRN_DEFS.BAD_INTR_VECTOR is returned for a bad
  -- intr_vector parameter.

function isr_in_check return boolean;
  -- If in an ISR, returns TRUE.
```

The VADS EXEC V_INTERRUPTS services: ATTACH_ISR, DETACH_ISR, CURRENT_INTERRUPT_STATUS and SET_INTERRUPT_STATUS layer directly upon the Ada Kernel services. See the V_INTERRUPTS documentation for more details.

Note – No VADS EXEC service layers upon the ISR_IN_CHECK Ada Kernel service.

Interrupt Support Subprograms

The INTR_ENTRY_T record can be initialized using one of the overloaded INTR_ENTRY_INIT subprograms:

```
procedure intr_entry_init(
     intr_entry  : a_intr_entry_t;
     intr_vector : intr_vector_id_t;
     prio        : priority := priority'last);
function intr_entry_init(
     intr_entry  : a_intr_entry_t;
     intr_vector : intr_vector_id_t;
     prio        : priority := priority'last) return address;
function intr_entry_init(
     -- does an implicit "intr_entry: a_intr_entry_t :=
     --                                        new intr_entry_t;"
     intr_vector : intr_vector_id_t;
     prio        : priority := priority'last) return address;
```

Examples

`intr_entry_init()` can be used as in Figure 2-2 to define an interrupt entry:

```
with system;
with ada_krn_defs;
package one is
   -- Does an implicit allocation of the intr_entry_t record
task a is
   entry ctrl_c;
   for ctrl_c use at ada_krn_defs.intr_entry_init(
                intr_vector => 2,
                prio => priority'last);
   end;
end one;

with system;
with ada_krn_defs;
package two is
   -- No implicit allocation is done
   ctrl_c_intr_entry_rec: ada_krn_defs.intr_entry_t;
   ctrl_c_intr_entry: system.address :=
       ada_krn_defs.intr_entry_init(
           intr_entry  => ada_krn_defs.to_a_intr_entry_t(
                           ctrl_c_intr_entry_rec'address),
           intr_vector => 2,
           prio        => priority'last);
  task a is
    entry ctrl_c;
    for ctrl_c use at ctrl_c_intr_entry;
   -- OR
    -- for ctrl_c use at ctrl_c_intr_entry_rec'address;
   end;
end two;
```

Figure 2-2 Example Definition of an Interrupt Entry

References

“package V_INTERRUPTS — provides interrupt processing” on page 4-7

2.1.1.9 Time

The Ada Kernel provides time services for supporting Ada's delay statement, the predefined CALENDAR package and calendar extensions in the XCALENDAR package.

Types

DAY_T
: Type of the time's day component. The type definition for DAY_T is in the SYSTEM package.

DURATION
: Type of the time's seconds within a day. DURATION is a predefined Ada type.

Attributes

None

Services

The Ada Kernel has the following time services:

```
procedure time_set(day: day_t; sec: duration);
   -- The input time must be normalized, sec < 86400.0.
   -- The V_I_TIMEOP package in standard has subprograms
   -- for normalizing time.

procedure time_get(day: out day_t; sec: out duration);
   -- Returned time is normalized, sec < 86400.0

procedure time_delay(sec: duration);

procedure time_delay_until(day: day_t; sec: duration);
   -- The input time must be normalized, sec < 86400.0.
```

2.1.1.10 Mutex

A mutex object is used to protect a passive task's critical region. Mutexes can also be used explicitly by the user to serialize their access to shared data.

The semantics of locking/unlocking a mutex adheres to the POSIX 1003.4a standard, IEEE Threads Extension for Portable Operating Systems. See the latest draft of that standard for more details about POSIX mutexes.

An ABORT_SAFE version of the mutex services is provided in the V_I_MUTEX package found in standard. A task locking an ABORT_SAFE mutex is inhibited from being completed by an Ada abort until it unlocks the mutex.

Types

MUTEX_T
A_MUTEX_T
: MUTEX_T is the type of a mutex object. A_MUTEX_T is the access type of a mutex object. The address of a mutex object can be converted to its access type via the function, ADA_KRN_DEFS.TO_A_MUTEX_T().

Attributes

MUTEX_ATTR_T
A_MUTEX_ATTR_T
: MUTEX_ATTR_T is the type definition of the mutex attributes. A_MUTEX_ATTR_T is its access type. The function, ADA_KRN_DEFS.TO_A_MUTEX_ATTR_T() can be used to convert the address of the mutex attributes to its access type.

The address of a MUTEX_ATTR_T record is the second argument of a PASSIVE pragma. The passive task's critical region is protected by locking and unlocking a mutex. The MUTEX_ATTR_T record is used to initialize the mutex.

The mutex attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. (VADS MICRO locks the mutex by executing a test-and-set instruction or by disabling interrupts. It supports FIFO, priority or priority inheritance waiting when the mutex is locked by another task.). In the CIFO add-on product, VADS MICRO also supports priority ceiling mutexes using the priority ceiling protocol emulation algorithm documented in the POSIX 1003.4a standard.

VADS MICRO has the following variant mutex attribute record type:

INTR_ATTR_T
disables interrupts (signals) to provide mutual exclusion

The function, DEFAULT_MUTEX_ATTR, is provided to select the default mutex attributes.

To provide mutual exclusion by disabling all interrupts, use DEFAULT_INTR_ATTR. If the underlying microkernel doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised.

Services

The Ada Kernel has the following mutex services:

```
function mutex_init(mutex: a_mutex_t; attr: a_mutex_attr_t)
          return boolean;
 -- Returns TRUE if mutex was successfully initialized.

procedure mutex_destroy(mutex: a_mutex_t);

procedure mutex_lock(mutex: a_mutex_t);

function mutex_trylock(mutex: a_mutex_t) return boolean;
 -- Returns TRUE if we were able to lock the mutex without
-- waiting. Otherwise, returns FALSE without locking the mutex.
procedure mutex_unlock(mutex: a_mutex_t);
```

The Ada Kernel has the following services for mutexes that can be locked from an ISR:

```
function isr_mutex_lockable(mutex: a_mutex_t) return boolean;
   -- Returns TRUE if mutex can be locked from an ISR. This
   -- service is called for a passive task with an interrupt
   -- entry. Since the passive task's critical region will be
   -- entered from an ISR, we must be able to lock its mutex
   -- from an ISR.

 procedure isr_mutex_lock(mutex: a_mutex_t);

 procedure isr_mutex_unlock(mutex: a_mutex_t);
   -- The isr_mutex_lock/isr_mutex_unlock services must only
   -- be called from an ISR using a mutex that is lockable
   -- from an ISR.
```

The Ada Kernel has the following priority ceiling mutex services (only supported in the CIFO add-on product):

```
function ceiling_mutex_init(mutex: a_mutex_t;
      attr: a_mutex_attr_t;
   ceiling_prio: priority := priority'last) return boolean;
  -- Returns TRUE if underlying threads supports priority ceiling
   -- protocol and the mutex was successfully initialized.
   --
   -- The attr parameter can be set to DEFAULT_MUTEX_ATTR to use
   -- the default priority ceiling attributes. The VADS_MICRO
   -- ignores the attr parameter.
function ceiling_mutex_set_priority(mutex: a_mutex_t;
   ceiling_prio: priority) return boolean;
   -- Returns FALSE if not a priority ceiling mutex
```

2.1.1.11 Mutex Support Subprograms

The following subprograms are provided to initialize the MUTEX_ATTR_T record:

fifo_mutex_attr_init()
prio_mutex_attr_init()
prio_inherit_mutex_attr_init()
prio_ceiling_mutex_attr_init()
intr_attr_init()

If the underlying microkernel doesn't support the type of mutex being initialized, the PROGRAM_ERROR exception is raised.

Following are the overloaded subprograms for initializing the MUTEX_ATTR_T record:

```
procedure fifo_mutex_attr_init(
     attr            : a_mutex_attr_t);
function fifo_mutex_attr_init(
     attr            : a_mutex_attr_t) return a_mutex_attr_t;
function fifo_mutex_attr_init(
     attr            : a_mutex_attr_t) return address;
function fifo_mutex_attr_init return a_mutex_attr_t;
     -- does an implicit
     --      "attr: a_mutex_attr_t := new mutex_attr_t;"
 function fifo_mutex_attr_init return address;
     -- does an implicit
     --      "attr: a_mutex_attr_t := new mutex_attr_t;"
 procedure prio_mutex_attr_init(
      attr            : a_mutex_attr_t);
 function prio_mutex_attr_init(
     attr            : a_mutex_attr_t) return a_mutex_attr_t;
function prio_mutex_attr_init(
     attr            : a_mutex_attr_t) return address;
 function prio_mutex_attr_init return a_mutex_attr_t;
     -- does an implicit
     --      "attr: a_mutex_attr_t := new mutex_attr_t;"
function prio_mutex_attr_init return address;
    -- does an implicit
    --      "attr: a_mutex_attr_t := new mutex_attr_t;"
procedure  prio_inherit_mutex_attr_init(
     attr            : a_mutex_attr_t);
function  prio_inherit_mutex_attr_init(
     attr            : a_mutex_attr_t) return a_mutex_attr_t;
function  prio_inherit_mutex_attr_init(
     attr            : a_mutex_attr_t) return address;
function prio_inherit_mutex_attr_init return a_mutex_attr_t;
     -- does an implicit
     --      "attr: a_mutex_attr_t := new mutex_attr_t;"
 function prio_inherit_mutex_attr_init return address;
     -- does an implicit
     --      "attr: a_mutex_attr_t := new mutex_attr_t;"
procedure prio_ceiling_mutex_attr_init(
     attr                    : a_mutex_attr_t;
     ceiling_prio    : priority := priority'last);
function prio_ceiling_mutex_attr_init(
     attr                    : a_mutex_attr_t;
     ceiling_prio    : priority := priority'last) return
a_mutex_attr_t;
     function prio_ceiling_mutex_attr_init(
     attr                    : a_mutex_attr_t;
    ceiling_prio    : priority := priority'last) return address;
                                                        (Continued)
```

(Continued)

```
function prio_ceiling_mutex_attr_init(
     -- does an implicit "attr: a_mutex_attr_t := new
     -- mutex_attr_t;"
     ceiling_prio    : priority := priority'last) return
        a_mutex_attr_t;
function prio_ceiling_mutex_attr_init(
        -- does an implicit "attr: a_mutex_attr_t := new
mutex_attr_t;"
        ceiling_prio    : priority := priority'last) return
address;
procedure intr_attr_init(
     attr           : a_mutex_attr_t;
     disable_status  : intr_status_t := DISABLE_INTR_STATUS);
function intr_attr_init(
    attr           : a_mutex_attr_t;
    disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                          return a_mutex_attr_t;
function intr_attr_init(
     attr           : a_mutex_attr_t;
     disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                            return address;
function intr_attr_init(
     -- does an implicit "attr: a_mutex_attr_t :=
                                            new mutex_attr_t;"
     disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                          return a_mutex_attr_t;
function intr_attr_init(
     -- does an implicit "attr: a_mutex_attr_t :=
                                            new mutex_attr_t;"
     disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                            return address;
```

Examples

The above init subprograms can be used as follows in a PASSIVE pragma:

```
 with system;
 with ada_krn_defs;
 package one is
   task a is
      pragma passive(ABORT_SAFE,
ada_krn_defs.fifo_mutex_attr_init);
   end;
    prio_mutex_attr_rec: ada_krn_defs.mutex_attr_t;
    prio_mutex_attr: system.address :=
        ada_krn_defs.prio_mutex_attr_init(
            ada_krn_defs.to_a_mutex_attr_t(
               prio_mutex_attr_rec'address));
   task b is
       pragma passive(ABORT_SAFE, prio_mutex_attr);
       -- or
         -- pragma passive(ABORT_SAFE,
prio_mutex_attr_rec'address);
      end;
   end one;
```

Figure 2-3 Initialize Subprograms in Passive Tasks

References

Section 2.2, “Passive Tasks,” on page 2-41

2.1.1.12 Condition Variable

Condition variables are used to wait until a particular condition is TRUE. A condition variable must be used in conjunction with a mutex.

If the guard to the called entry in a passive task is closed, the calling task waits on a condition variable. Condition variables are used to supplement mutexes in the implementation of CIFO and the Sporadic Server. Condition variables can also be used explicitly by the user.

The semantics of waiting on or signaling a condition variable and its interaction with a mutex adheres to the POSIX 1003.4a standard, “IEEE Threads Extension for Portable Operating Systems”. See the latest draft of that standard for more details about POSIX condition variables.

An ABORT_SAFE version of the mutex and condition variable services is provided in package V_I_MUTEX found in standard. A task locking an ABORT_SAFE mutex is inhibited from being completed by an Ada abort until it unlocks the mutex. However, if a task is aborted while waiting at a condition variable (after an implicit mutex unlock), it is allowed to complete. The V_I_MUTEX services also address the case where multiple mutexes are locked. A task is inhibited from being completed until all the mutexes are unlocked or it does a condition variable wait with only one mutex locked.

Types

MCOND_T
A_COND_T

COND_T is the type of a condition variable object. A_COND_T is the access type of a condition variable object. The address of a condition variable object can be converted to its access type via the function, ADA_KRN_DEFS.TO_A_COND_T().

Attributes

COND_ATTR_T
A_COND_ATTR_T

COND_ATTR_T is the type definition of the condition variable attributes. A_COND_ATTR_T is its access type. The function, ADA_KRN_DEFS.TO_A_COND_ATTR_T() can be used to convert the address of the condition variable attributes to its access type.

The condition variable attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. VADS MICRO supports FIFO or priority waiting.

The function, DEFAULT_COND_ATTR, is provided to select the default condition variable attributes.

Services

The Ada Kernel has the following condition variable services:

```
function cond_init(cond: a_cond_t; attr: a_cond_attr_t) return boolean;
   -- Returns TRUE if condition variable was successfully initialized.
procedure cond_destroy(cond: a_cond_t);
procedure cond_wait(cond: a_cond_t; mutex: a_mutex_t);
   -- COND_WAIT must be called with the mutex already locked by the
    -- calling task. COND_WAIT atomically releases the mutex and causes
   -- the calling task to block on the condition variable. The
   -- blocked task may be awakened by COND_SIGNAL(),
   -- COND_SIGNAL_UNLOCK(), COND_BROADCAST(), or by some OS
   -- Threads specific stimulus (for Sun Threads it may also
   -- be awakened when the task is interrupted by delivery of a signal
   -- or a fork()). Any change in value of a condition associated
   -- with the condition variable cannot be inferred by the return
   -- of COND_WAIT() and any such condition must be reevaluated.
   -- COND_WAIT() always returns with the mutex locked by the calling
   -- task.
```

```
(Continued)

  function cond_timed_wait(cond: a_cond_t; mutex: a_mutex_t;
      sec: duration) return boolean;
   -- COND_TIMED_WAIT() is similar to COND_WAIT(), except that
   -- the calling task will only block for the amount of time specified
   -- by the sec parameter. If the condition variable
   -- wasn't signalled, COND_TIMED_WAIT() returns FALSE. For
   -- all cases, COND_TIMED_WAIT() returns with the mutex
   -- locked by the calling task.
procedure cond_signal(cond: a_cond_t);
procedure cond_broadcast(cond: a_cond_t);
   -- COND_SIGNAL() unblocks one task that is blocked on
   -- the condition variable. COND_BROADCAST() unblocks all
   -- tasks that are blocked on the condition variable. If
   -- no tasks are blocked on the condition variable then
   -- COND_SIGNAL() or COND_BROADCAST() have no effect. Both
   -- procedures should be called under the protection of the
   -- same mutex that is used with the condition variable being
   -- signalled. Otherwise the conditon variable may be
   -- signalled between the test of the associated condition
   -- and blocking in COND_WAIT(). This can cause an infinite wait.
procedure cond_signal_unlock(cond: a_cond_t; mutex: a_mutex_t);
   -- COND_SIGNAL_UNLOCK has the same semantics as making the
   -- following two calls:
   --    COND_SIGNAL(cond);
   --    MUTEX_UNLOCK(mutex);
   --     -- To improve performance, the Ada Kernel implementation may
   -- treat the above condition variable signalling and the mutex
   -- unlocking sequence as an atomic operation.
```

The Ada Kernel has the following service for a condition variable that can be called only from an ISR:

```
procedure isr_cond_signal(cond: a_cond_t);
   -- ISR_COND_SIGNAL() must only be called from an ISR. It
   -- has the same semantics as COND_SIGNAL(). The condition
   -- variable being signalled must be protected by an ISR
   -- lockable mutex.
   --     -- At the completion of the accept body in a passive task
   -- called from an ISR, this service is called to signal
   -- an Ada task waiting on an entry whose guard was changed
   -- from closed to open.
```

Condition Variable Support Subprograms

The following subprograms are provided to initialize the COND_ATTR_T record:

```
fifo_cond_attr_init()
prio_cond_attr_init()
```

If the underlying microkernel doesn't support the type of condition variable being initialized, then, the PROGRAM_ERROR exception is raised.

Here are the overloaded subprograms for initializing the COND_ATTR_T record:

```
procedure fifo_cond_attr_init(
     attr            : a_cond_attr_t);
function fifo_cond_attr_init(
     attr            : a_cond_attr_t) return a_cond_attr_t;
function fifo_cond_attr_init return a_cond_attr_t;
     -- does an implicit
     --      "attr: a_cond_attr_t := new cond_attr_t;"
procedure prio_cond_attr_init(
     attr            : a_cond_attr_t);
function prio_cond_attr_init(
     attr            : a_cond_attr_t) return a_cond_attr_t;
function prio_cond_attr_init return a_cond_attr_t;
     -- does an implicit
     --      "attr: a_cond_attr_t := new cond_attr_t;"
```

2.1.1.13 Binary Semaphore

A binary semaphore is an object that can be in one of two states, full or empty. If a task waits on a full semaphore then it makes the semaphore empty and continues executing. If a task waits on an empty semaphore then it blocks until its signalled. When a semaphore is signalled, the next available task is unblocked. If no tasked was blocked on the semaphore, the semaphore becomes full.

Binary semaphores are used by the VADS EXEC V_SEMAPHORES services. The overhead added by the VADS EXEC layer can be eliminated by directly using the Ada Kernel binary semaphores.

Types

SEMAPHORE_T
A_SEMAPHORE_T
: SEMAPHORE_T is the type of a binary semaphore object. A_SEMAPHORE_T is the access type of a binary semaphore object. The address of a binary semaphore object can be converted to its access type via the function, ADA_KRN_DEFS.TO_A_SEMAPHORE_T().

SEMAPHORE_STATE_T
: Binary semaphore's state: SEMAPHORE_FULL or SEMAPHORE_EMPTY.

Constants

SEMAPHORE_FULL
SEMAPHORE_EMPTY

Attributes

SEMAPHORE_ATTR_T
A_SEMAPHORE_ATTR_T
: SEMAPHORE_ATTR_T is the type definition of the binary semaphore attributes. A_SEMAPHORE_ATTR_T is its access type. The function, ADA_KRN_DEFS.TO_A_SEMAPHORE_ATTR_T() can be used to convert the address of the binary semaphore attributes to its access type.

  The A_SEMAPHORE_ATTR_T access value is passed to the VADS EXEC service, V_SEMAPHORES.CREATE_SEMAPHORE() which returns a BINARY_SEMAPHORE_ID.

The semaphore attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. (VADS MICRO supports only FIFO queuing when the task waits on a semaphore.)

The function, DEFAULT_SEMAPHORE_ATTR, is provided to select the default semaphore attributes.

Services

The Ada Kernel has the following binary semaphore services:

```
function semaphore_init(s: a_semaphore_t; init_state: semaphore_state_t;
    attr: a_semaphore_attr_t) return boolean;
    -- Returns TRUE if semaphore was successfully initialized.
procedure semaphore_destroy(s: a_semaphore_t);
procedure semaphore_wait(s: a_semaphore_t);
function semaphore_trywait(s: a_semaphore_t) return boolean;
   -- Returns TRUE if the semaphore was FULL.
function semaphore_timed_wait(s: a_semaphore_t;    sec: duration) return
boolean;
   -- Returns TRUE if we didn't timeout waiting for the
   -- semaphore to be FULL or signalled.
procedure semaphore_signal(s: a_semaphore_t);
function semaphore_get_in_use(s: a_semaphore_t) return boolean;
   -- Returns TRUE if any task is waiting on the semaphore. If the
   -- Ada Kernel is unable to detect this condition, it returns
   -- TRUE.
   --   -- SEMAPHORE_GET_IN_USE() is called by the VADS EXEC
   -- V_SEMAPHORES.DELETE_SEMAPHORE() service for a binary
   -- semaphore.
```

References

“package V_SEMAPHORES — provides binary and counting semaphores” on page 4-59

2.1.1.14 Counting Semaphore

A counting semaphore is an object with a non-negative count. If a task waits on a semaphore with a non-zero count, it decrements the count and continues executing. If a task waits on a semaphore with a zero count, then it blocks until its signalled. When a semaphore is signalled, the next available task is unblocked. If no tasked was blocked on the semaphore, the semaphore's count is incremented.

Counting semaphores are used by the VADS EXEC V_SEMAPHORES services. The overhead added by the VADS EXEC layer can be eliminated by directly using the Ada Kernel's counting semaphores.

Types

COUNT_SEMAPHORE_T
A_COUNT_SEMAPHORE_T

COUNT_SEMAPHORE_T is the type of a counting semaphore object. A_COUNT_SEMAPHORE_T is the access type of a counting semaphore object. The address of a counting semaphore object can be converted to its access type via the function, ADA_KRN_DEFS.TO_A_COUNT_SEMAPHORE_T().

Attributes

COUNT_SEMAPHORE_ATTR_T
A_COUNT_SEMAPHORE_ATTR_T

COUNT_SEMAPHORE_ATTR_T is the type definition of the counting semaphore attributes. A_COUNT_SEMAPHORE_ATTR_T is its access type. The function, ADA_KRN_DEFS.TO_A_COUNT_SEMAPHORE_ATTR_T() can be used to convert the address of the counting semaphore attributes to its access type.

The A_COUNT_SEMAPHORE_ATTR_T access value is passed to the VADS EXEC service, V_SEMAPHORES.CREATE_SEMAPHORE() which returns a COUNT_SEMAPHORE_ID.

The count_semaphore attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. (VADS MICRO uses a mutex to protect the count. It waits on a condition variable. The COUNT_SEMAPHORE_ATTR_T is a subtype of MUTEX_ATTR_T. The

COND_ATTR_T is derived from the MUTEX_ATTR_T. A FIFO condition variable is used for a FIFO mutex. A priority condition variable is used for either a priority, priority inheritance, or priority ceiling mutex.)

VADS MICRO has the following variant counting semaphore attribute record type:

COUNT_INTR_ATTR_T
: interrupts are disabled when accessing the semaphore count

The function, DEFAULT_COUNT_SEMAPHORE_ATTR, is provided to select the default counting semaphore attributes.

To protect counting semaphore operations by disabling all interrupts, use DEFAULT_COUNT_INTR_ATTR. If the underlying microkernel doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised. However, if the DEFAULT_COUNT_SEMAPHORE_ATTR is interrupt safe, then DEFAULT_COUNT_INTR_ATTR returns DEFAULT_COUNT_SEMAPHORE_ATTR and does not raise PROGRAM_ERROR.

Alternatively, the counting semaphore attributes can be initialized to select the disable interrupts options by using one of the overloaded COUNT_INTR_ATTR_INIT subprograms. See “Counting Semaphore Support Subprograms” on page 2-35.

Services

The Ada Kernel has the following counting semaphore services:

```
function count_semaphore_init(
  s           : a_count_semaphore_t;
  init_count  : integer;
  attr        : a_count_semaphore_attr_t) return boolean;
  -- Returns TRUE if semaphore was successfully initialized.
procedure count_semaphore_destroy(s: a_count_semaphore_t);
function count_semaphore_wait(s: a_count_semaphore_t;
  wait_time: duration) return boolean;
  -- Waits on a counting semaphore.
  --
 -- If semaphore's count > 0, decrements the count and returns TRUE.
  -- Otherwise, returns according to the wait_time parameter:
  --  < 0.0         - the calling task blocks until the semaphore
  --                  is signalled. It always returns TRUE.

  --  = 0.0         - immediately returns FALSE.
  --  > 0.0         - returns TRUE if we didn't timeout waiting for
  --                  the semaphore to be signalled. For a
  --                  timeout, returns FALSE.
procedure count_semaphore_signal(s: a_count_semaphore_t);
function count_semaphore_get_in_use(s: a_count_semaphore_t)
                                                  return boolean;
  -- Returns TRUE if any task is waiting on the semaphore. If the
  -- Ada Kernel is unable to detect this condition, it returns
  -- TRUE.
  --
  -- SEMAPHORE_GET_IN_USE() is called by the VADS EXEC
  -- V_SEMAPHORES.DELETE_SEMAPHORE() service for a counting
  -- semaphore.
```

Counting Semaphore Support Subprograms

The counting semaphore attributes can be initialized to select the disable interrupts options by using one of the overloaded `COUNT_INTR_ATTR_INIT` subprograms.

```
   procedure count_intr_attr_init(
       attr            : a_count_semaphore_attr_t;
       disable_status  : intr_status_t := DISABLE_INTR_STATUS);
  function count_intr_attr_init(
       attr            : a_count_semaphore_attr_t;
       disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                 return a_count_semaphore_attr_t;
function count_intr_attr_init(
       -- does an implicit
       --  "attr: a_count_semaphore_attr_t :=
       --                             new count_semaphore_attr_t;"
       disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                 return a_count_semaphore_attr_t;
```

References

“package V_SEMAPHORES — provides binary and counting semaphores” on page 4-59

2.1.1.15 Mailbox

A mailbox object is used to queue fixed length messages between tasks or between ISRs and tasks. Any task or ISR can write messages to a mailbox object. Any task can read messages from a mailbox. If no message is in the mailbox, the reader can optionally wait until a message is written, return immediately with no message or wait up to a specified amount of time for a message.

Mailboxes are used by the VADS EXEC V_MAILBOXES services. The overhead added by the VADS EXEC layer can be eliminated by directly using the Ada Kernel mailboxes.

Types

MAILBOX_T
A_MAILBOX_T

MAILBOX_T is the type of a mailbox object. A_MAILBOX_T is the access type of a mailbox object. The address of a mailbox object can be converted to its access type via the function, ADA_KRN_DEFS.TO_A_MAILBOX_T().

Attributes

MAILBOX_ATTR_T
A_MAILBOX_ATTR_T

MAILBOX_ATTR_T is the type definition of the mailbox attributes. A_MAILBOX_ATTR_T is its access type. The function, ADA_KRN_DEFS.TO_A_MAILBOX_ATTR_T() can be used to convert the address of the mailbox attributes to its access type.

The A_MAILBOX_ATTR_T access value is passed to the VADS EXEC service, V_MAILBOXES.CREATE_SEMAPHORE().

The mailbox attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. (VADS MICRO uses a mutex to protect the mailbox. It waits on a condition variable. The MAILBOX_ATTR_T is a subtype of MUTEX_ATTR_T. The COND_ATTR_T is derived from the

MUTEX_ATTR_T. A FIFO condition variable is used for a FIFO mutex. A priority condition variable is used for either a priority, priority inheritance, or priority ceiling mutex.)

VADS MICRO has the following variant mailbox attribute record type:

MAILBOX_INTR_ATTR_T
: interrupts are disabled when accessing the mailbox

The function, DEFAULT_MAILBOX_ATTR, is provided to select the default mailbox attributes.

To protect mailbox operations by disabling all interrupts, use DEFAULT_MAILBOX_INTR_ATTR. If the underlying microkernel doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised. However, if the DEFAULT_MAILBOX_ATTR is interrupt safe, then, DEFAULT_MAILBOX_INTR_ATTR returns DEFAULT_MAILBOX_ATTR and doesn't raise PROGRAM_ERROR.

Alternatively, the mailbox attributes can be initialized to select the disable interrupts options by using one of the overloaded MAILBOX_INTR_ATTR_INIT subprograms. See “Mailbox Support Subprograms” on page 2-39.

Services

The Ada Kernel has the following mailbox services:

Mailbox Support Subprograms

```
function mailbox_init(
      m           : a_mailbox_t;
      slots_cnt   : positive;
      slot_len    : natural;
      attr        : a_mailbox_attr_t) return boolean;
      -- MAILBOX_INIT() allocates memory for slots_cnt messages
     -- where each message has a fixed length of slot_len bytes.
      --
      -- Returns TRUE if mailbox was successfully initialized.

procedure mailbox_destroy(m: a_mailbox_t)

function mailbox_read(m: a_mailbox_t; msg_addr: address;
      wait_time: duration) return boolean;
      -- Reads a message from a mailbox. Returns TRUE if message
was
      -- successfully read.
      --
      -- If no message is available for reading, then returns
      -- according to the wait_time parameter:
     --  < 0.0      - returns when message was successfully read.
    --             This may necessitate suspension of current task
      --                    until another task does mailbox write.
      --  = 0.0          - returns FALSE immediately
      --  > 0.0         - if the mailbox read cannot be completed
      --                    within "wait_time" amount of time,
      --                    returns FALSE

function mailbox_write(m: a_mailbox_t; msg_addr: address)
      return boolean;
     -- Writes a message to a mailbox. Returns FALSE if no slot is
      -- available for writing.

function mailbox_get_count(m: a_mailbox_t) return natural;
      -- Returns number of unread messages in mailbox.

function mailbox_get_in_use(m: a_mailbox_t) return boolean;
      -- Returns TRUE if any task is waiting to read from the
      -- mailbox. If the Ada Kernel is unable to detect this
      -- condition, it returns TRUE.
      --
      -- MAILBOX_GET_IN_USE() is called by the VADS EXEC
      -- V_MAILBOXES.DELETE_MAILBOX() service.
```

The mailbox attributes can be initialized to select the disable interrupts options by using one of the overloaded MAILBOX_INTR_ATTR_INIT subprograms.

```
procedure mailbox_intr_attr_init(
       attr            : a_mailbox_attr_t;
       disable_status  : intr_status_t := DISABLE_INTR_STATUS);

         function mailbox_intr_attr_init(
       attr            : a_mailbox_attr_t;
       disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                    return a_mailbox_attr_t;

  function mailbox_intr_attr_init(
       -- does an implicit
       --  "attr: a_mailbox_attr_t :=
       --                           new mailbox_attr_t;"
      disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                    return a_mailbox_attr_t;
```

References

“package V_MAILBOXES — provides mailbox operations” on page 4-25

2.2 Passive Tasks

Passive tasks are a compiler/runtime optimization that reduces the overhead associated with an Ada task. The use of passive tasks usually results in improved performance for the Ada application.

An Ada task under SC Ada is implemented through services provided by the SC Ada RTS. These services create tasks, control rendezvous between tasks, and provide a variety of other capabilities. The Ada RTS provides each Ada task with a thread of control and with its own stack storage space.

These Ada tasks are called active tasks in this section, in contrast to passive tasks.

Passive tasks are implemented differently from active tasks. Passive tasks are simply subroutines, and an entry call to a passive task is the same as a simple subprogram call. A passive task is said to exist only while it is in rendezvous with an active task. A passive task does not have a thread of control or its own stack storage space. While an active task is in rendezvous with a passive task, the passive task uses the thread of control and stack storage space from the active task.

Passive tasks are in essence little more than critical regions guarding a sequence of code. The sequence of code is the accept body. Passive tasks use mutexes to guard the critical region.

Passive tasks increase application performance in two ways. Passive task rendezvous is significantly simpler and faster than active task rendezvous. The reduction in the number of active tasks within an application increases kernel performance by reducing the number of tasks on the entry queues, run queues and by reducing the amount of memory consumed by the kernel.

2.2.1 Pragma passive

A task is marked as a passive task via the implementation-defined `pragma PASSIVE`. The pragma can have zero, one or two parameters as follows:

```
pragma PASSIVE;
pragma PASSIVE(ABORT_UNSAFE);
pragma PASSIVE(ABORT_SAFE);
pragma PASSIVE(ABORT_UNSAFE, mutex_attr'address);
pragma PASSIVE(ABORT_SAFE, mutex_attr'address);
```

An active task calling an ABORT_SAFE passive task entry is inhibited from being completed by an Ada abort until it finishes execution of the passive task's accept body. This inhibits the aborted task from holding a lock on a mutex that is never released.

Alternatively, if an active task calling an ABORT_UNSAFE passive task entry is aborted, the lock is never released and other active tasks are indefinitely blocked if they call an entry in the passive task.

Previous releases supported only the ABORT_UNSAFE option. The ABORT_SAFE option is slightly slower. If the first parameter is omitted, the default is ABORT_UNSAFE.

The second parameter is the address of a mutex attributes record. The passive task's critical region is protected by locking a mutex. The mutex attributes record is used to initialize the mutex. Omitting the second argument selects the default mutex attributes. For VADS MICRO, the default is to lock the mutex via a test-and-set instruction and to be FIFO queued when blocked and waiting for the mutex. (In earlier releases, this was specified via `pragma PASSIVE(SEMAPHORE)`.)

The mutex attributes are defined in the Ada Kernel's ADA_KRN_DEFS package. MUTEX_ATTR_T is the type definition of the mutex attributes.

The mutex attributes are microkernel dependent. See ada_krn_defs.a in standard for the different options supported. (VADS MICRO locks the mutex by executing a test-and-set instruction or by disabling interrupts. It supports FIFO, priority or priority inheritance waiting when the mutex is locked by another task.). In the CIFO add-on product, VADS MICRO also supports priority ceiling mutexes using the priority ceiling protocol emulation algorithm documented in the POSIX 1003.4a standard

The function, DEFAULT_MUTEX_ATTR, is provided to select the default mutex attributes.

To provide mutual exclusion by disabling all interrupts, use DEFAULT_INTR_ATTR. (In earlier SC Ada releases this was specified via `pragma PASSIVE(INTERRUPT)`.) If the underlying microkernel doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised.

ada_krn_defs.a has the following functions for initializing the mutex attributes:

```
 function intr_attr_init(
     disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                      return address;
 function fifo_mutex_attr_init return address;
 function prio_mutex_attr_init return address;
 function prio_inherit_mutex_attr_init return address;
 function prio_ceiling
_mutex_attr_init return address;
```

Each of the above attribute initialization functions does an implicit allocation of the MUTEX_ATTR_T record and returns its address. ada_krn_defs.a has additional overloaded subprograms for each of the initialization functions.

These initialization functions are supported for all versions of the Ada Kernel. If the mutex type isn't supported by the underlying microkernel, the PROGRAM_ERROR exception is raised.

Figure 2-4 is an example of a passive task. It is part of a package providing buffer management services. It's ABORT_UNSAFE and uses the default mutex attributes.

```
package buffer_Pack
        type element_type is ...;

       task type buffer is
                entry Put( element : element_type );
                entry Get( element : out element_type );
                pragma PASSIVE ;
        end buffer;
end buffer_pack;
```

Figure 2-4 Example of a Passive Task

Figure 2-5 and Figure 2-6 show examples of passive tasks using attribute initialization functions.

```
with ADA_KRN_DEFS;
 package prio_pack is
     task prio_task is
         entry e1;
         pragma PASSIVE(ABORT_SAFE,
             ADA_KRN_DEFS.PRIO_MUTEX_ATTR_INIT);
     end;
 end prio_pack;
```

Figure 2-5 Example of Passive Priority Queuing Task

Figure 2-7 is an example of two passive tasks whose critical regions are protected by disabling all interrupts.

```
with ADA_KRN_DEFS;
package interrupt_pack is
  task intr_task_1 is
    entry intr;
   pragma PASSIVE(ABORT_UNSAFE, ADA_KRN_DEFS.DEFAULT_INTR_ATTR);
  end;
  task intr_task_2 is
    entry intr;
    pragma PASSIVE(ABORT_UNSAFE, ADA_KRN_DEFS.INTR_ATTR_INIT(
           DISABLE_STATUS => ADA_KRN_DEFS.DISABLE_INTR_STATUS));
    end;
end interrupt_pack;
```

Figure 2-6 Example of Passive Interrupt Tasks

References

mutex operations, Section 2.1.1.10, “Mutex,” on page 2-22

2.2.2 Passive Task Portability

The compiler performs only the passive task optimization for task specifications marked with `pragma PASSIVE`. The compiler enforces a set of restrictions that force programs using passive tasks to execute identically whether or not the pragma is supported. Since Ada compilers usually ignore unsupported pragmas, porting code that uses `pragma PASSIVE` to other compilers should be easy.

Previous versions of SC Ada supported `pragma PASSIVE` in a slightly different form. Some passive task bodies that are accepted by the older versions of SC Ada are not accepted by this and future versions. Code constructs that are no longer supported include:

- Passive tasks containing multiple `accept` statements.
- Passive tasks with `for` loops as the outermost statement

Recode tasks containing multiple `accept` statements to use a selective wait. Recode tasks using `for` loops to use unbounded loops.

Figure 2-7 is an example of a passive task to demonstrate the transformation to turn a passive task containing multiple `accept` statements into a passive task with a guarded `select` statement. The “Old Version” passive task body was supported under previous versions of SC Ada. The “New Version” passive task body is supported under the current version.

```
task Semaphore is
   entry Seize;
   entry Release;
   pragma PASSIVE; end;
-- Old Version
task body Semaphore is
begin
   loop
      accept Seize;
      accept Release;
   end loop;
 end;
```

```
-- New Version
task body Semaphore is
Seized: Boolean := FALSE;
 begin
    loop
       select
       when not Seized =>
          accept Seize do
          Seized := TRUE;
             end;
          when Seized =>
         accept Release do
          Seized := FALSE;
           end;
       end select;
    end loop;
 end;
```

Figure 2-7 Example of Passive Task Transformation

2.2.3 Passive Task Restrictions

A number of restrictions exist on the structure of a passive task. Some restrictions exist so that a task behaves in the same manner whether it is passive or active. Other restrictions are required to simplify the implementation or to allow unambiguous semantics.

If any of the restrictions are violated, the compiler emits warning messages and continues normal compilation. The compiler can skip illegal constructs or generate code to raise `TASKING_ERROR`, so it is advisable to heed the warnings and modify the code to eliminate the warnings.

Passive task bodies must have the structure as in Figure 2-8:

```
task body PT is
   <decls>
begin
   loop
      <accept or select stm>
   end loop;
end PT;
```

Figure 2-8 Example of Passive Task Body Structure

See the next section for a detailed discussion of the error handling for passive tasks. The following restrictions are in effect for passive tasks:

- The `loop` statement is required. Note that tasks coded in this fashion never terminate normally.
- The task body itself cannot have an exception handler. Provide handlers in `accept` statements in the passive task. Unhandled exceptions in the passive task `accept` body cause the SC Ada runtime system to mark the passive task as uncallable and subsequent `entry` calls are refused.
- The <`accept` or `select stm`> can be an `accept` statement or a selective wait. If it is a selective wait, it cannot contain `terminate` or `delay` alternatives and it cannot contain an `else` clause.
- The declarations in the passive task body can contain almost any Ada construct. Certain record type declarations are not supported with passive tasks. No other program units (such as subprograms, packages or tasks) or other “later declarative items” can be declared in a passive task.
- Passive tasks can be named or anonymous task types.
- Passive tasks and passive task types must be declared immediately in library level packages.
- Objects of named passive task types can appear in any legal context, including as record components or array elements. Passive task objects can be created with allocators.
- Terminate passive tasks only through the `abort` statement or by unhandled exceptions.

- When a passive task terminates, all further attempts to rendezvous with the passive task raise `TASKING_ERROR` in the calling task. Tasks queued on the passive task entries have `TASKING_ERROR` raised in them.
- Storage associated with passive tasks cannot be reclaimed even if the task is created as the result of an allocator. This is a limitation of the current release.
- The entries in passive `select` statements can be guarded. This is true except for `accept` statements in the `select` that accept interrupt entries. Passive interrupt entries cannot be guarded; they must be open.
- Passive task entries cannot declare entry families in the current release. Support for entry families may be added in future releases.
- `delay` statements can appear in a passive task body, however when executed, they cause the calling active task to delay during rendezvous. Avoid this use of `delay` statements.

2.2.4 Compiler Error Messages for Passive Tasks

The compiler emits two warning messages when it detects a violation of the passive task restrictions. The first message specifies the restriction and the second gives the recovery action taken by the compiler.

We highly recommend that you compile units containing passive tasks with compiler warning messages enabled. The compiler recovery action can include generating code to raise `TASKING_ERROR`, causing the program to fail during execution.

If the compiler detects an illegal `pragma PASSIVE` in a task specification, the pragma is ignored. Code is generated for the task as an active task. The application containing the task runs as designed, however its performance suffers.

If the compiler detects an error in a passive task body before generating any code for the body, it generates code for "dummy" `accept` bodies. These dummy `accept` bodies are always closed, so normal `entry` calls made to them block forever, while conditional or timed `entry` calls always fail. The application containing the task runs, but can hang, terminate with deadlocked tasks or experience another serious runtime error.

If the compiler detects an error in a passive task body after code generation for the body has begun, it ignores the offending construct and instead generates code to raise TASKING_ERROR. It continues generating code for the rest of the passive task body. The application containing the passive task finds that the passive task terminated during rendezvous and further attempts only raise TASKING_ERROR.

2.2.5 Examples of Passive Tasks Errors

Figure 2-9 is an example of the warning messages produced during the compilation of a passive task specification containing an invalid pragma PASSIVE. The compiler continues the compilation normally after rejecting the pragma. If the program that contains this package is linked, the task bv0113a_pack.pt1 is an active task.

```
1:package bv0113a_pack is
2:     task pt1 is
3:       entry e1;
4:       pragma passive( illegal_argument );
A ----------------------------^
A:warning: RM Appendix F: agruments should be ABORT_(UN)SAFE or
   task attributes
A:warning: RM Appendix F: pragma PASSIVE ignored; task will be an
   active task
5: end pt1;
6:end;
```

Figure 2-9 Example of Passive Task Warning Messages

Figure 2-10 is an example of a passive task body that contains an illegal `select` statement. `delay` alternatives are not supported with passive tasks. The compiler detected the error before it began code generation for the passive task body. The compiler issued dummy `accept` bodies instead of generating code for the passive task body as supplied.

```
  1:with report;
  2:package body bv0107a_pack is
  3:     task body pt1 is
A ------^
A:warning: RM Appendix F: errors in passive task body; dummy
accept bodies emitted
  4:     begin
  5:       loop
  6:         select
  7:           accept e1 do
  8:             report.failed( "entry e1 accepted" );
  9:           end;
  10:        or
  11:          delay 1.0;
A --------------^
A:warning: RM Appendix F: DELAY is not a legal alternative in
passive task select
  12:          report.failed( "delay alternative selected" );
  13:        end select;
  14:      end loop;
  15:    end;
  16:end;
```

Figure 2-10 Example of Passive Task with Illegal `Select` Statement

Figure 2-11 is a case in which the compiler does not detect the invalid passive task body until after it began code generation for the passive task `accept` statement. In this case the inner `accept` of `entry e2` is replaced with code that raises `TASKING_ERROR`. This raises `TASKING_ERROR` when any other task attempts to rendezvous with `entry e1`.

```
    1:with report;
    2:package body bv0104a_pack is
    3: task body pt1 is
    4: begin
    5:   loop
    6:     accept e1 do
    7:       accept e2 do
A --------------^
A:warning: RM Appendix F: nested passive accepts not supported
B:warning: RM Appendix F: TASKING_ERROR will be raised
   8:         report.failed( "nested entry pt1.e1.e2 accepted");
   9:       end;
  10:     end;
  11:   end loop;
  12: end;
```

Figure 2-11 Example of Invalid Passive Task Body

2.2.6 Ada Interrupt Entries as Interrupt Handlers

Section 13.5.1 in the *Ada Reference Manual* defines the syntax and semantics for an interrupt entry. The Ada implementation is defined there with the following interpretations and restrictions:

- An interrupt entry cannot have any parameters.
- A passive task that contains one or more interrupt entries must always be trying to accept each interrupt entry, unless it is handling the interrupt. The task must be executing either an `accept` for the entry (if only one exists) or a `select` statement where the interrupt entry `accept` alternative is open as defined by the *Ada Reference Manual*, 9.7.1(4). This is not a restriction on normal tasks, such as signal ISRs.
- An interrupt acts as a conditional entry call in that interrupts are not queued.
- No additional requirements are imposed for a `select` statement containing both a `terminate` alternative and an `accept` alternative for an interrupt entry.

- Direct calls to an interrupt entry from another task are allowed and are treated as a normal task rendezvous.
- Interrupts are not queued.

The address clause for an interrupt entry does not specify the priority of the interrupt. It points to an INTR_ENTRY_T record defined in ADA_KRN_DEFS. The INTR_ENTRY_T record contains two fields: the interrupt vector and the task priority for executing the interrupt entry's accept body.

In previous releases the address clause specified the interrupt vector. To preserve backwards compatibility, the parameter, OLD_STYLE_MAX_INTR_ENTRY was added to the configuration table in v_usr_conf_b.a. If the value in the address clause is <= OLD_STYLE_MAX_INTR_ENTRY, it contains the interrupt vector value and not a pointer to an ADA_KRN_DEFS.INTR_ENTRY_T record. Setting OLD_STYLE_MAX_INTR_ENTRY to MEMORY_ADDRESS(0) disables the old way of interpretation.

The default value for OLD_STYLE_MAX_INTR_ENTRY is MEMORY_ADDRESS(511).

ada_krn_defs.a has the following function for initializing the interrupt entry:

```
function intr_entry_init(
     intr_vector : intr_vector_id_t;
     prio        : priority := priority'last) return address;
```

The above function does an implicit allocation of the INTR_ENTRY_T record and returns its address. ada_krn_defs.a has additional overloaded subprograms for initializing the INTR_ENTRY_T record.

For OLD_STYLE_MAX_INTRY_ENTRY = MEMORY_ADDRESS(511), the following two interrupt entries are identical:

```
task a is
     entry ctrl_c;
     for ctrl_c use at ada_krn_defs.intr_entry_init(
                              intr_vector => 2,
                              prio => priority'last -1);
 end;
```

or

```
 task a is
     pragma priority(priority'last -1);
     entry ctrl_c;
     for ctrl_c use at system.memory_address(2);
 end;
```

Note that for the old style interrupt entry, the task priority for executing the interrupt entry's accept body is always the priority of the attached task containing the interrupt entry (per POSIX 1003.5). The priority can not differ as it can for the new style.

Interrupt entries are defined in normal Ada tasks (referred to as *Signal ISRs*) or in tasks to which pragma PASSIVE is applied (referred to as *passive ISRs*).

For an interrupt entry in a passive task, a check is made during elaboration to see if the passive task's mutex can be locked from an ISR. If the mutex isn't lockable, the PROGRAM_ERROR exception is raised. Normally, a passive task with an interrupt entry protects its critical region by disabling interrupts. This is achieved by setting the second parameter of pragma PASSIVE to ADA_KRN_DEFS.DEFAULT_INTR_ATTR to disable all interrupts or by using the mutex attribute initialization function, ADA_KRN_DEFS.INTR_ATTR_INIT to disable some of the interrupts

Figure 2-12 is an example of a passive task with interrupt entries:.

```
with ADA_KRN_DEFS;
 with SYSTEM;
 package interrupt_entry_pack is
     task intr_task_1 is
         entry ctrl_c;
         -- old style passive tasks
         for ctrl_c use at system.memory_address(2);
        pragma PASSIVE(ABORT_UNSAFE,
ADA_KRN_DEFS.DEFAULT_INTR_ATTR);
     end;
    task intr_task_2 is
         entry usr1;
         for usr1 use at ada_krn_defs.intr_entry_init(
                                intr_vector => 16,
                                prio => priority'last);
       pragma PASSIVE(ABORT_UNSAFE, ADA_KRN_DEFS.INTR_ATTR_INIT(
                  DISABLE_STATUS =>
ADA_KRN_DEFS.DISABLE_INTR_STATUS));
     end;
 end interrupt_entry_pack;
```

Figure 2-12 Passive Interrupt Entries

The `accept` body for a passive interrupt entry executes to handle the interrupt. The `accept` body executes immediately when the interrupt occurs (without any task rescheduling). Interrupts are disabled according to the CPU interrupt processing mechanism. A direct consequence is that if the `accept` for an interrupt entry is in a `select`, it must always be an `open` alternative. The program is abandoned with an unhandleable `TASKING_ERROR` exception if the passive task is not trying to accept the interrupt entry when the interrupt occurs. Since the `accept` body of the passive ISR is handling an interrupt, it has the same restrictions as a conventional ISR with respect to the kernel services it can call.

References

queued interrupts (13.5.1(2)) and `select` statement (13.5.1(6)), *Ada Reference Manual*

2.3 When a Program Exits or Deadlocks

Normally, a program exits after the main subprogram returns and when the following two conditions are satisfied:

- No task is ready to run
- No task is suspended at an Ada `delay` statement, at a call to `XCALENDAR.DELAY_UNTIL`or at a timed entry call or at a `select` statement with an open delay alternative

However, to accommodate interrupt entries and attached ISRs, either of the following conditions inhibits a program from exiting:

- A task is suspended at an `accept` or `select` with an open interrupt entry. Interrupt entries at a `select with terminate` are considered closed. This is not applicable to interrupt entries in a `PASSIVE` task.
- The Ada RTS `EXIT_DISABLE_FLAG` is `TRUE`. This flag is initialized to `FALSE`. Normally, it is set to `TRUE` by the application program if it attaches an ISR or has `PASSIVE` tasks with interrupt entries. The VADS EXEC services in `V_XTASKING`, `CURRENT_EXIT_DISABLED`, and `SET_EXIT_DISABLED` can read or set this flag. Alternatively, this flag can be referenced via `v_i_tasks` in `standard` (`GET_EXIT_DISABLED_FLAG` and `SET_EXIT_DISABLED_FLAG`).

Note – In previous versions, signals mapped to an interrupt entry at a simple `accept` did not inhibit the program from exiting. If you still want that effect, change the simple `accept` to a "`select` or `terminate`" as illustrated in the example below.

```
loop
   select
      accept ctrl_c do
         -- ctrl_c logic, such as, the following call to terminate
         -- the program
         v_i_tasks.terminate_program(0);
      end;
   or
      terminate;
   end select;
end loop;
```

A program deadlocks if the main subprogram does not return, and the above program exit conditions are satisfied, and neither of the interrupt conditions for inhibiting program exit is satisfied.

Furthermore, the kernel manages the SPARC register windows. All traps are disabled (ET=0) during register window manipulation, such as modifying the WIM register, saving / restoring a register window or on entry to a trap handler.

2.4 SC Ada Archive Interface Packages

SC Ada uses an archive to provide many of the runtime services that are used by the compiler. We supply interfaces to many of these routines through the `V_I_*` packages in `standard`.

Note – Most of the services described listing of the `standard.library` are provided by a higher level interface in the VADS EXEC library. It is possible to eliminate that extra layer of software by calling these services directly. One note of caution, however — using the VADS EXEC services better protects you from changes in future versions of SC Ada; SunSoft is committed to preserving the VADS EXEC interfaces.

The following packages are described in the *SPARCompiler Ada Reference Guide* under the `standard.library`.

```
V_I_ALLOC[note 1]    V_I_MBOX[note 1]    V_I_TASKOP
V_I_BITS             V_I_MEM             V_I_TASKS
V_I_CALLOUT[note 1]  V_I_MUTEX[note 3]   V_I_TIME
V_I_CIFO             V_I_PASS            V_I_TIMEOP
V_I_CSEMA[note 1]    V_I_RAISE           V_I_TYPES
V_I_EXCEPT[note 2]   V_I_SIG             V_I_SEMA[note 1]
V_I_INTR[note 1]                         V_SEMA[note 1]
V_I_LIBOP                                V_TAS
```

Note 1: These packages preserve backward compatibility with earlier SC Ada releases by layering upon the Ada Kernel's type definitions and subprograms found in the `ADA_KRN_DEFS` and `ADA_KRN_I` packages.

Note 2: package V_I_EXCEPT contains the interface to the Ada exception services to:

[a] get the id and pc of the current Ada exception

[b] return the string name of an exception id

[c] install a callout to be called whenever an exception is raised

package V_I_EXCEPT also contains the interface to the core dump services to:

[a] produce a "core" file from anywhere in your program

[b] enable the generation of a "core" file for an unhandled Ada exception

[c] enable exception traceback regs to be saved for a unhandled core dump

Note 3: The V_I_MUTEX package interfaces to the mutex and condition variable services that are Ada tasking ABORT_SAFE. After locking a mutex the task is inhibited from being completed by an Ada abort until it unlocks the mutex. However, if the task is aborted while waiting at a condition variable (after an implicit mutex unlock), it is allowed to complete. The V_I_MUTEX services also address the case where multiple ABORT_SAFE mutexes can be locked. A task is inhibited from being completed until all the mutexes are unlocked or it does a condition variable wait with only one mutex locked. There are services to init, destroy, lock, trylock and unlock an ABORT_SAFE mutex. There are services to init, destroy, wait on, timed wait on, signal and broadcast an ABORT_SAFE condition variable. In the CIFO add-on product, there are also services to init, set priority of and get priority of an ABORT_SAFE priority ceiling mutex.

2.5 Tasking

From the runtime perspective, the semantics of tasks are complicated. They are implemented by a collection of services in the Ada RTS, as well as by code generated in the compiler.

Figure 2-13 is a tasking example. The concept is taken from section 9.12 of the *Ada Reference Manual*. Subsequent to it are discussions of its runtime interactions, including creation, activation, start-up `delay` statements, `entry` calls, `accept` and `select` statements, completion, and termination.

```
 1:with text_io;
 2:procedure buffer is
 3:   task buffer is
 4:      entry read(c: out character);
 5:      entry write(c: in character);
 6:   end;
 7:   task producer is
 8:   end;
 9:   task consumer is
10:   end;
11:   task body producer is
12:   begin
13:      ...
14:   buffer.write(c);
15:      ...
16:   end;
17:   task body consumer is
18:      ...
19:   begin
20:      ...
21:         select buffer.read(c);
22:            ...
23:         else delay(0.001);
24:         end  select;
25:      ...
26:   end;
27:   task body buffer is
28:   begin
29:      ...
30:         select when count < pool_size =>
31:            accept write(c: in character) do ...  end;
32:            ...
33:         or  when count > 0 =>
```

(Continued)

```
34:            accept read(c: out character) do ...  end;
35:            ...
36:         or terminate;
37:         end select;
38:      ...
39:   end buffer;
40:begin
41:   ...
42:   while buffer'callable loop
43:      delay(0.001);
44:   end loop;
45:   ...
46:end;
```

Figure 2-13 Example of Tasking

2.5.1 Task Creation

Tasks come into being in two stages, creation and activation. Tasks are created by the elaboration of declarations of objects either defined as tasks or containing an instance of a task type. Both tasks and task-type instances are treated identically by the runtime.

In Figure 2-13, the calls emitted by the compiler for lines 3-6, creating the buffer task, are:

```
    function ts_init_activate_list return a_list_ids;
    function ts_create_master return master_id;
    function ts_create_task_and_link(
         master            : master_id;
         prio              : integer;
         stack_size        : integer;
         start             : address;
         entry_count       : integer;
         activation_list   : a_list_id;
         generic_param     : address;
         task_attr         : ada_krn_defs.a_task_attr_t;
        has_pragma_prio   : boolean) return system.task_id;
```

where

`a_list_id`
is a pointer to task activation list head

`master_id`
is a pointer to master structure task_id

`tast_id`
is a pointer to task control data structure

The interface to the above and all the Ada tasking routines called by the compiler is provided in the file `v_i_taskop.a` found in the standard directory. To see the actual code emitted by compiler in calling the subprograms, enter the debugger and use the `li` (list instruction) command.

The call to `TS_INIT_ACTIVATE_LIST` initializes a task activation list for this scope (for all the tasks created directly in the declarative part of the test procedure).A pointer to the list head is returned.

The call to `TS_CREATE_MASTER` initializes a master structure. This structure keeps track of all the tasks that must terminate before you can complete this scope (in this example, complete the program). A pointer to the master structure is returned.

The call to `TS_CREATE_TASK_AND_LINK` creates a task control data structure. A pointer to this structure is returned. The compiler assigns parameter values with `STACK_SIZE`, priority, and `TASK_ATTR` given by default or by Ada pragmas. The task is linked to the activation list but is not activated yet.

The return value from this task creation function is the task descriptor. The compiled code stores this descriptor in the storage class implied by the scope of the object declaration. It uses this descriptor as the task value. When the task must be named by the generated code to the RTS, this descriptor passes to the RTS. This descriptor is really the pointer to the task record, an RTS data structure. The generated code does not take advantage of this fact.

The SC Ada debugger knows of this new task, so `lt` elicits the list:

```
Q#      TASK            ADDR      STATUS
        buffer'2        04cd14    not yet active
*       <main program>  0440a0    executing
```

The other tasks are created in a similar fashion, for PRODUCER by the code at line 7 and CONSUMER by the code at line 9. Now `lt` gives:

```
Q#      TASK            ADDR      STATUS
        producer        0509e4    not yet active
        buffer'2        04cd14    not yet active
        <idle task>     0468f8    not yet active
*       <main program>  0440a0    executing
```

2.5.2 Task Activation

At the `begin` that follows a declarative part that contains tasks, the program calls TS_ACTIVATE_LIST. The activation list is the one used for the declarative part. The RTS activates the tasks on the list and returns. The compiler calls TS_ACTIVATION_EXCEPTIONS immediately following the call to TS_ACTIVATE_LIST. This makes the activating task wait for the children that are just activated to run and elaborate their declarations. Each child calls TS_ACTIVATION_COMPLETE, which increments a count of successfully activated tasks. The last child to do this awakens the activating task.

At line 40, the following calls are emitted

```
 procedure ts_activate_list(
         activation_list : a_list_id;
         is_allocator    : integer);
function ts_activation_exceptions return act_status_t;
```

where:

```
type act_status_t is (
          act_ok,
          act_elab_err,
          act_except,
          act_elab_err_act_except);
```

If TS_ACTIVATION_EXCEPTIONS returns ACT_ELAB_ERR, then TASKING_ERROR exception is raised. If TS_ACTIVATION_EXCEPTIONS returns ACT_EXCEPT or ACT_ELAB_ERR_ACT_EXCEPT, then PROGRAM_ERROR exception is raised.

The compiler emits the following call for TS_ACTIVATION_COMPLETE:

```
procedure ts_activation_complete(act_status : act_status_t);
```

When all the tasks from the above example activate and elaborate correctly, the following output is given by `lt` at an instruction breakpoint following the call to TS_ACTIVATE_EXCEPTIONS (just after source instruction 40):

```
Q#      TASK            ADDR    STATUS
D1      consumer        0546b4  suspended at delay
            on delay queue, until day: 0 sec: 0.451
R1      producer        0509e4  ready
        buffer'2        04cd14  suspended at select (terminate
                                   possible)
            open entries:  write  read
        <idle task>     0468f8  not yet active
*       <main program>  0440a0  executing
```

The elaboration of the declarative part of a task body can cause an exception. In this case, TS_ACTIVATION_COMPLETE is called by an anonymous exception handler with a parameter indicating abnormal activation. The following calls are emitted for this implicit anonymous handler

```
procedure ts_exception_master(master : master_id);
procedure raise_exception(identifier : system.address);
```

Where the interface to RAISE_EXCEPTION is provided in `v_i_raise.a` found in standard. The external name assigned to the RAISE_EXCEPTION procedure is "RAISE".

The handler saves the exception and calls the TS_EXCEPTION_MASTER service to await termination of any subtasks of the current task (none are in our example PRODUCER). Then it raises the exception again.

This awakens the activating task (which in this case is the main program) even though some of the sibling activated tasks may not have called TS_ACTIVATION_COMPLETE yet. The newly activated tasks are completed

and terminated by the TS_ACTIVATION_EXCEPTIONS service executing for that activating main program; it returns to the main program with a nonzero value:

```
0  all is ok during activation
1  elaboration error, raising TASKING_ERROR
2  activation error, raising PROGRAM_ERROR
```

An lt, issued from an instruction breakpoint immediately following TS_EXCEPTION_MASTER in the preceding code, shows the following after an exception is raised in the declarative part:

```
Q#  TASK            ADDR     STATUS
D1  consumer        0546b4   suspended at delay
           on delay queue, until day 0 sec: 0.161
    producer        0509e4   terminated
    buffer'2        04cd14   suspended at select (termination
possible)
            open entries:  write
*   <main program>  0440a0    executing
```

2.5.3 Task Start-up

The code for task start-up precedes the text for the task body. The code for PRODUCER can be displayed by typing the command li 11 in the debugger.

The task body code has the same procedure start-up as other subprograms, getting stack space, checking for stack limits and setting up the addressing environment for reaching entities in other parts of the program (these are copied from the caller stack frame).

The only purely tasking activity before elaboration is the call to TS_TID to get and record the ID of this task. This value is the task data structure address in the kernel space.

After any elaboration for the task is complete, a call to TS_ACTIVATION_COMPLETE informs the parent task of the success of the activation. If this is the last task on the activation list, the activating task (the main program here) is placed on the run queue for further execution.

2.5.4 `Delay` *Statements*

Simple `delay` statements (that is, those not in the `else` part of a `select`) are implemented as calls to the `TS_DELAY` service:

```
procedure ts_delay(delay_val : in duration);
```

Where `DELAY_VAL` is the internal representation for duration in units of 0.1 milliseconds.

The fixed-point number is pushed as the parameter to `TS_DELAY`. The following `lt` output illustrates the main program after it requests a delay at line 43:

```
Q#    TASK            ADDR     STATUS
      consumer       054664    in rendezvous
       producer        0509e4     suspended calling
buffer'2[04cd14].write
*     buffer'2       04cd14    executing
            in rendezvous with consumer[05b7f8] at entry entry_0
D1    <main program> 0440a0    suspended at delay
              on delay queue, until day: 0 sec: 0.8441
```

Tasks requesting delays are put on a `DELAY_QUEUE`. Each timer interrupt checks each task on this queue to see if `CURRENT_TIME` has passed its time to awaken; then each such task is queued on the run queue.

2.5.5 Task Entry Calls

The compiler translates unconditional and untimed entry calls into calls to TS_CALL. TS_CALL takes three parameters: the task descriptor of the task being called, the entry ID of the entry being called (when the compiler sees a task specification, it assigns integers, starting at one, to the declared entries), and the address of a parameter block for the call (parameter blocks are made to look like the stack memory for subprogram parameters).

`task` PRODUCER contains a simple entry call that provides characters to `task` BUFFER.

The entry call has the following subprogram interface.

```
      procedure ts_call (
         called_task        : in task_id;
         called_entry       : in integer;
         param_block        : in address);
```

The TS_CALL routine tries to do an immediate rendezvous if possible. Rendezvous is possible if the called task (BUFFER) is suspended at an `accept` or at a `select` statement and is waiting at the entry being called. For immediate rendezvous, control transfers to the called task. This is almost like calling it as a subprogram, except that when the rendezvous completes, both the called task and the calling task can execute.

Following is the `lt` output during a rendezvous:

```
Q#  TASK            ADDR    STATUS
D2  consumer        0546b4  suspended at delay
        on delay queue, until day: 0 sec: 0.571
    producer        0509e4  in rendezvous buffer'2[04cd14].write
*   buffer'2        04cd14  executing
        in rendezvous with producer[0509e4] at entry write
    <idle task>     0468f8  not yet active
D1  <main program>  0440a0  suspended at delay
        on delay queue, until day: 0 sec: 0.571
```

If the call cannot be done immediately, it is because the called task is not waiting at an `accept` or `select`, or because it is not waiting for a call of the entry that we are calling. The called task becomes suspended on the entry

queue, waiting for the called task to accept that entry. The following `lt` illustrates what happens when PRODUCER suspends waiting for BUFFER to accept a WRITE:

```
Q#  TASK            ADDR    STATUS
D2  consumer        0546b4   suspended at delay
        on delay queue, until day: 0 sec: 0.121
    producer        0509e4   suspended calling buffer'2[04cd14].write
*   buffer'2        04cd14   executing
    <main program>  0440a0   awaiting activations
```

In our example, eventually BUFFER accepts PRODUCER. An `lt` output at that time is identical to an immediate rendezvous, except that the status of PRODUCER shows that it is suspended:

```
Q#  TASK            ADDR       STATUS
    producer        0509e4  suspended   calling
buffer'2[04cd14].write
```

Conditional entry calls are implemented with the TS_CONDITIONAL_CALL service. It is the same as a TS_CALL except that if immediate rendezvous is not possible, it returns FALSE. Otherwise, it returns TRUE after the rendezvous.

Timed entry calls are implemented with the TS_TIMED_CALL service. Its additional parameter passes a delay duration. If immediate rendezvous is not possible, it suspends after setting up a delay for the requested duration. When a timer interrupt follows, a task still on the DELAY_QUEUE can be awakened as though from a delay.

The conditional and timed entry calls have the following subprogram interfaces:

```
    function ts_conditional_call (
         called_task        : in task_id;
         called_entry       : in integer;
         param_block        : in address) return boolean;
    function ts_timed_call (
         timeout            : in duration;
         called_task        : in task_id;
         called_entry       : in integer;
         param_block        : in address) return boolean;
```

2.5.6 `Accept` *and* `Select` *Statements*

The example has no simple `accept` statements, but these points are similar to those of the more complex `select` statement.

`Select` statement code begins with evaluation of the guards for the `accept` alternatives. Compiled code builds a list of the open alternatives in a data structure called an `entry` list. An `entry` list is an array of integers. The first integer corresponds to the first alternative in the `select` statement; the second integer corresponds to the second alternative, and so on. If the guard for an `entry` is closed, a zero is put in the `entry` list element corresponding to the alternative. If the guard is open, the integer corresponding to the `entry` being accepted is put in the element corresponding to the alternative.

After building the `ENTRY_LIST`, a call is generated to one of the `TS_SELECT` routines:

```
ts_select            simple selects (no else part)
ts_select_terminate  an else part with a terminate
ts_select_else       an else part (conditional accept)
ts_select_delay      an else part with a delay
```

In our case, `TS_SELECT_TERMINATE` is called, with the address and length of `ENTRY_LIST`, a boolean that is `TRUE` if the `terminate` alternative is open, and space reserved for two `OUT` parameters (the result of the `select` process and the associated parameter block).

`procedure TS_SELECT` examines its `entry` queue to see if any task is waiting for any open `entry`. If so, immediate rendezvous is possible with the first such task. Otherwise, the task suspends until another task calls an open `entry` (for all `select`s) or until its delay expires (for `select`s with `delay` alternatives), or until all other dependent tasks are ready to terminate (for `select`s with open `terminate` alternatives). `select`s with `else` parts fall immediately to their `else` part unless immediate rendezvous is possible.

The following `lt` output illustrates our `BUFFER` task waiting at its `select` statement:

```
Q#  TASK            ADDR    STATUS
R2  consumer        0546b4  ready
*   producer        0509e4  executing code
   buffer'2      04cd14  suspended at select (terminate possible)
        open entries:  write  read
    <idle task>     0468f8  not yet active
R1  <main program>  0440a0  ready
```

When the rendezvous takes place, control is returned back to the acceptor task after its call to a `TS_SELECT` subprogram. At the end of the accept body, the `TS_FINISH_ACCEPT` procedure is called to allow both the acceptor and caller tasks to execute in parallel. If an unhandled exception is raised in the accept body, its also propagated back to the caller task.

The accept, select, and finish accept calls have the following subprogram interfaces:

```
function ts_accept(
         accepting_entry    : in    integer) return address;
    procedure ts_select(
         user_entry_list    : in  a_entry_record_t;
         elist_len          : in  integer;
         param_block        : out address;
         result             : out integer);
    procedure ts_select_terminate(
         user_entry_list    : in  a_entry_record_t;
         elist_len          : in  integer;
         termin_open        : in  integer;
         param_block        : out address;
         result             : out integer);
    procedure ts_select_else(
         user_entry_list    : in  a_entry_record_t;
         elist_len          : in  integer;
         param_block        : out address;
         result             : out integer);
    procedure ts_select_delay(
         user_entry_list    : in  a_entry_record_t;
         elist_len          : in  integer;
         dlist_len          : in  integer;
         param_block        : out address;
         result             : out integer);
    procedure ts_finish_accept(
         exception_occurred : in  integer;
         exception_string   : in  address);
```

where

`a_entry_record_t`
is a pointer to entry list

2.5.7 Task Completion and Termination

Tasks come to an end in two stages. First, they complete, and then they terminate. After a task completes, it does not run again. A completed task terminates when all dependent tasks either complete or agree to terminate.

The following call is emitted at the end of `PRODUCER`, a task that has no descendants and executes to completion:

```
procedure ts_complete_task;
```

The TS_COMPLETE_TASK service takes tasks all the way through to termination, checking, and possibly waiting for any dependent tasks.

In our example, we can breakpoint just after all the sub-tasks terminate or are waiting at a terminate alternative:

```
Q#  TASK             ADDR    STATUS
    consumer         0546b4  terminated
    producer         0509e4  terminated
   buffer'2      04cd14  suspended at select (terminate possible)
        open entries:  write
    <idle task>      0468f8  not active
*   <main program>   0440a0  executing
```

BUFFER cannot terminate yet because the main program is still executing; it can still call one of the open entries of BUFFER. The code for the main program tries to shut down all the dependent tasks with a call to the TS_COMPLETE_MASTER service.

```
procedure ts_complete_master(master : master_id);
```

The main program returns for completion of the whole program, as is described under program exit.

References

a.prof, *SPARCompiler Ada Reference Guide*

2.6 Fast Rendezvous Optimization

Normally the accept body of an Ada rendezvous is only executed in the context of the acceptor task. The fast rendezvous optimization also executes the accept body in the context of the caller task. This optimization reduces the number of thread context switches that need to be executed by the underlying microkernel

---

Note – If you are using the CIFO archive instead of the default, the Fast Rendezvous optimization is inhibited.

Here's an overview of the optimization: if the acceptor task gets to the accept statement before the caller task makes the call, the acceptor task saves its register and stack context, switches to a wait stack and does an ADA_KRN_I.TASK_WAIT. When the caller task gets around to doing the accept call, it saves its register and stack context, restores the acceptor task's register and stack context and returns to execute the accept body. When the end of the accept body is reached, the caller task overwrites the current register and stack context into the acceptor task's area, does an ADA_KRN_I.TASK_SIGNAL of the acceptor task, restores the caller task's register and stack context and returns to the code in the caller task. Eventually, when the signaled acceptor task is scheduled to run, it restores the acceptor task's register and stack context (this context was updated by the caller task to be at the point where the call was made to finish the accept body) and returns to the code in the acceptor task after the call was made to finish the accept body.

Two configuration parameters have been added to v_usr_conf on behalf of the fast rendezvous optimization:

FAST_RENDEZVOUS
: setting this parameter to TRUE enables the fast rendezvous optimization. This parameter would only need to be set to FALSE, for multiprocessor Ada, where the accept body must execute in the acceptor task bound to a processor. It defaults to TRUE.

WAIT_STACK_SIZE
: This parameter specifies how much stack is needed for when the acceptor task switches from its normal task stack to a special stack it can use to call ADA_KRN_I.TASK_WAIT.

When using the debugger, the fast rendezvous optimization (accept body is executed by the caller task) has a few subtle differences from the normal rendezvous case (accept body is executed by the acceptor task).

Here's an example to illustrate the differences. There are two tasks doing a repetitive rendezvous. The caller task is RENDEZVOUS_SEND. The acceptor task is RENDEZVOUS_RECEIVE. A breakpoint has been placed in the acceptor body. There are two cases, either the breakpoint is reached when the acceptor task (RENDEZVOUS_RECEIVE) is executing the accept body or the caller task (RENDEZVOUS_SEND) is executing the acceptor body. Here's the debugger output for the two cases.

Case 1: at breakpoint when the acceptor task is executing the accept body (normal rendezvous)

```
[1]  stopped at "/vc/task_rend2.a":15 in rendezvous_receive
>lt
 Q  TASK                ADDR       STATUS
    rendezvous_send     01006e63c  in rendezvous
         rendezvous_receive[010068fbc].receive_item
 *  rendezvous_receive  010068fbc  executing
         in rendezvous with rendezvous_send[01006e63c] at
                                    entry receive_item
>lt all
 Q  TASK                ADDR       STATUS
    rendezvous_send     01006e63c  in rendezvous
         rendezvous_receive[010068fbc].receive_item
         thread id = 01006e7c0
 *  rendezvous_receive  010068fbc  executing
         in rendezvous with rendezvous_send[01006e63c] at
                                    entry receive_item
         ENTRY         STATUS   TASKS WAITING
         receive_item           - no tasks waiting -
         thread id = 010069140
```

Case 2: at breakpoint when the caller task is executing accept body (fast rendezvous)

```
[1]  stopped at "/vc/task_rend2.a":15 in rendezvous_receive
>lt
 Q  TASK                ADDR       STATUS
    rendezvous_send     01006e63c  doing rendezvous
         for rendezvous_receive[010068fbc].receive_item
 *  rendezvous_receive  010068fbc  executing
         in rendezvous via rendezvous_send[01006e63c] at
                                    entry receive_item
>lt all
 Q  TASK                ADDR       STATUS
    rendezvous_send     01006e63c  doing rendezvous
         for rendezvous_receive[010068fbc].receive_item
         thread id = 01006e7c0
 *  rendezvous_receive  010068fbc  executing
         in rendezvous via rendezvous_send[01006e63c] at
                                    entry receive_item
         ENTRY         STATUS   TASKS WAITING
         receive_item           - no tasks waiting -
         thread id = 010069140
```

Here are the subtle differences for the fast rendezvous, case 2:

- Even though the breakpoint occurred in the RENDEZVOUS_SEND task, we still display RENDEZVOUS_RECEIVE as the current breakpointed task. You can select the caller task and still get the caller's callstack and see where it was making the rendezvous call from.
- The STATUS for RENDEZVOUS_SEND is “doing rendezvous” instead of “in rendezvous”. “doing” instead of “in” indicates that the caller task is executing the accept body.
- The second line for RENDEZVOUS_RECEIVE is “in rendezvous via” instead of “in rendezvous with”. Using “via” instead of “with” indicates that the caller task is executing the accept body.
- The only misleading piece of information is the current underlying thread that is executing. The debugger says that RENDEZVOUS_RECEIVE is the currently executing task. From this you would assume that its thread, 010069140, is the current one. However, for the fast rendezvous case, it is really RENDEZVOUS_SEND's thread, 01006e7c0.

"A place for everything and everything in its place."

Samuel Smiles

Memory Management and Allocation 3

This section describes the SC Ada implementation of the Ada memory requirements and the dynamic memory allocation / deallocation support available to the SC Ada user.

3.1 Memory Management/Requirements Implementation

The Ada language has many explicit and implicit memory requirements. Explicit requirements include object declarations and the new allocator. Implicit requirements include queues and blocks for tasking control and intermediate storage for initializations. This section describes how SC Ada implements these memory requirements.

Memory requirements are met from one of three areas: static data, the program heap, and the program stack. Use of static data is restricted to what can be allocated at compile time. Typically, the program stack is restricted to local usage because stack offsets must be known. The program heap is the most flexible. Use it for any memory requirement, but excessive heap use degrades performance.

3.1.1 Explicit Memory Requirements

Table 3-1 lists the explicit memory requirements of Ada and describes SC Ada implementation.

Table 3-1 Explicit Memory Requirements

Explicit Memory Requirement	Implementation
Objects Declared in Package Specifications or Bodies (not generic)	Placed in static data. Earlier versions of SC Ada placed objects > 500 bytes on the heap, but this is no longer done. The only exception to this is unconstrained objects. These are placed on the heap.
Objects Declared in local declare blocks and subprograms	Placed on the stack.
Objects Created through the use of the new allocator	Placed on the heap with one exception — when a constant object of an access type is declared in a non-generic package spec or body and initialized with a new allocator. If the initialization is static, the object is placed in static data.
Objects Declared in the specification or body of a generic package	Placement depends on how the generic is instantiated. If instantiated in a non-local context (within or as a library level package), the objects are placed in static data. If instantiated within a local context (subprogram or local declare block), objects are placed on the stack.

3.1.2 Implicit Memory Requirements

Table 3-2 lists the implicit memory requirements of Ada and describes SC Ada implementation.

Table 3-2 Implicit Memory Requirements

Implicit Memory Requirement	Implementation
Task Stacks	Comes off the heap, except for the main task, which uses the program stack. The RTS keeps track of stacks and limits for each task. This can cause serious problems when mixing Ada tasking with other languages. For example, if an Ada task makes a call to a C function that uses more stack than is allocated to the Ada task, the C function corrupts the adjacent heap memory. This corruption is very difficult to track down. This is not a serious problem if tasking is not used as the program stack is better protected.
Non-static Aggregate Assignments	Assignments to any record or array type are checked completely before any target modification is performed. Each component of the record or array type is constraint-checked. To do this, a temporary image of the destination is built on the program stack. If all components are assigned without an exception, the temporary image is copied to the true destination. This occurs even for the simplest aggregate assignment.
RTS Bookkeeping Cross-Development Environments	The RTS can have its own stack or it can make use of the current task stack, depending on the target architecture. The RTS has its own allocator for dynamic allocations, such as task control blocks.
RTS Bookkeeping Self-Host Applications	The RTS uses the current task stack for its local memory requirements and has its own allocators for dynamic allocations, such as task control blocks.

3.1.3 Heap Management

Heap memory is managed via a simple interface using `pragma INTERFACE` and `pragma EXTERNAL_NAME`. When the compiler identifies a need for heap memory, it calls a routine identified by the symbol `AA_GLOBAL_NEW`. When `UNCHECKED_DEALLOCATION` is performed on an object, a call is made to a routine identified by the symbol `AA_GLOBAL_FREE`. After this, as part of the elaboration, the compiler calls a routine identified by the symbol `AA_GLOBAL_INIT`. Supply these routines, thus implementing any memory management algorithm desired.

These heap management routines require another routine to provide them chunks of memory to manage. This routine is identified by the `GET_HEAP_MEMORY_CALLOUT` component of the configuration table in `package v_usr_conf`. The default is to call the routine `V_GET_HEAP_MEMORY`.

For self-host applications, all programs use a single central-allocation service, `sbrk(2)`. `V_GET_HEAP_MEMORY` makes a kernel call resulting in this service being called. Use of `sbrk(2)` guarantees mutex protection for allocations. In addition, we supply a package called `MALLOC` that provides mutex-protected allocation routines.

The current default heap memory implementations described above provide a fast mechanism for getting and reusing memory. They perform the coalescing of adjacent free blocks. This prevents large amounts of memory fragmentation over time that eventually exhausts memory.

Several alternatives exist to the SC Ada default allocation scheme. The first alternative uses pool allocation instead of heap allocation. This alternative is described in the documentation. The second alternative uses `package V_MEMORY` in VADS EXEC. This package does not replace the default scheme entirely so task stacks and applications of the `new` allocator still use `AA_GLOBAL_NEW`. However, this package provides pool-based allocation schemes that, with instantiated generics, create allocators and deallocators. Use these pools to implement a crude form of garbage collection since, when a pool

is deallocated, all the objects allocated from that pool are deallocated. This method is dangerous as no check exists to see if any objects in the pool are still in use.

References

"Memory Management and Underlying Operating Systems" on page 3-39
Section 3.5.9, "Pool-based Allocation: POOL," on page 3-31

3.1.4 Stack Management

For applications that do not use tasking, stack usage is very straightforward. In self-host applications, the stack is simply the process stack. For cross-development environments, the stack is the top of the heap-stack area specified in the kernel configuration.

For applications that use tasking, stack management is more complicated. The main task still uses the stack as described above. Each additional task, however, gets its stack from the heap. The RTS keeps track of the current stack pointers and stack limits for each task.

Often, it is important to know how much stack area a task requires and the maximum stack depth a task attains. SC Ada offers a utility to obtain this information. The debugger command `lt` (`lt use`) displays the starting location and the size of each task stack, including the exception stack, interrupt stack and fast rendezvous wait stack. It shows the maximum stack usage.

References

Section 3.5, "SC Adasupplied Memory Management," on page 3-16
Section 3.5.9, "Pool-based Allocation: POOL," on page 3-31

3.2 Memory Allocation Support in the SC Ada Runtime System

This section describes the support for dynamic memory allocation and deallocation in the SC Ada Runtime System and describes the ways in which memory allocation support is configured to suit application-specific requirements.

3

In Ada, memory is allocated at runtime by using a stack or a heap. Memory is allocated from a stack when a subprogram is activated. Memory is allocated from a heap when a program employs an allocator or when a program directly or indirectly calls a routine that allocates memory. For example, if a program uses tasks, the compiler generates calls to a RTS task-creation routine that allocates task storage from a heap. SC Ada supports user-space allocation (allocators) independently of kernel-space allocation (tasks); this document describes only the user-space *library* support.

This implementation of the RTS goes beyond the strict Ada requirements in that it supports pool-based allocation and deallocation of memory for user space. You can configure custom allocation support.

Normally, Ada allocators (`new`) and deallocators (`UNCHECKED_DEALLOCATION`) result in the compiler calling to the runtime library routines, `AA_GLOBAL_NEW` and `AA_GLOBAL_FREE`, respectively. (If local heaps apply, calls `AA_LOCAL_NEW` and `AA_LOCAL_FREE` are generated instead.)

The user-space allocation routines `AA_GLOBAL_NEW` and `AA_GLOBAL_FREE` are user-configurable. We supply several implementations, including a default.

`SLIM_MALLOC`
: A first-fit heap allocator that provides fast coalescing upon deallocation.

`FAT_MALLOC`
: Includes `SLIM_MALLOC` features plus:

  - Small blocks lists for performance improvement.
  - The capability to allocate and deallocate from an interrupt handler (the default for Ada).

`DBG_MALLOC`
: Includes `FAT_MALLOC` features, plus facilities for assisting debug of programs using allocation.

In addition, we supply a simple model (`SMPL_ALLOC`) as an aid to programmers who want to develop their own allocation / deallocation routines. An application can use any one of these implementations, or you can develop your own. With the SC Ada compiler and runtime system, these implementations are mutually exclusive.

For applications that use pools, package POOL in usr_conf library enables applications to dynamically create, destroy, and switch pools.

VADS EXEC provides an additional memory allocation mechanism independent of the AA_GLOBAL_NEW/AA_GLOBAL_FREE implementation. Calls to the services in the VADS EXEC package V_MEMORY are not made by the compiler to support allocators/deallocators (that is, new). The application must explicitly call V_MEMORY services, which can be used concurrently with any of the previously-described, user-space allocation implementations.

References

Section 3.5.9, “Pool-based Allocation: POOL,” on page 3-31
allocators, section 4.8 in *Ada Reference Manual*

3.3 Allocators

Consider a user program containing an access type statically defined by the following:

```
type record_type is record
  field_one: integer;
  field_two: integer;
  ...
end record;
type access_to_record is access record_type;
v: access_to_record;
```

Create an object of type RECORD_TYPE dynamically at execution time and reference it through the variable *V*. In Ada, this is done by using an allocator construct, as illustrated in this example:

```
v := new record_type;
```

Such allocators reserve a contiguous block of heap memory for each new instance of RECORD_TYPE. This memory is not used for anything except that RECORD_TYPE instance while the instance is active.

An object becomes active (allocated) by the above mechanism. It becomes inactive (deallocated) by a user action, typically, a call to `UNCHECKED_DEALLOCATION` instantiated for the appropriate type. The SC Ada RTS does *not* automatically deallocate objects except in the specific cases of local heaps and task objects.

The block of memory must be large enough to provide storage for every field or element that can be referenced legally (after constraint checks) through variable *V*. In practice, it is somewhat larger, with extra space for:

- A two-integer-sized header (8 bytes) for when the block is allocated.
- Another two access types sized locations (8 bytes) for when the block is free, which are used for links. Thus, 8 bytes is the minimum-size object allocated.
- Padding, if necessary, to align the next allocation on a double-word boundary.
- Padding, in some cases, to ensure that the block fits in a small blocks list when deallocated.

Be warned about a possible scenario shown by the following example code fragment.

```
type foo is record
    ...
end record;
type a_foo is access foo;

type foo2 is record
    ...
end record;
type a_foo2 is access foo2;

procedure dealloc_foo is new UNCHECKED_DEALLOCATION(foo, a_foo);

bar1, bar2: a_foo;
bar3: a_foo2;

begin
    bar1 := new foo;
    ...
    bar2 := bar1;
    ...
    dealloc_foo(bar1);
    bar3 := new foo2;
    ...
end;
```

After `bar3` is assigned, high likelihood exists that, despite being different types, `bar2` and `bar3` point to the same object. The SC Ada RTS does not detect the dangling reference generated here. Note that the preceding example has this same problem if `bar2` and `bar3` are of the same type. The point here is that you must be careful with access types and deallocation.

An allocator is implemented as an implicit call to an RTS routine `AA_GLOBAL_NEW`.

```
new_object_address :=
    AA_GLOBAL_NEW(storage_units_needed_for_record_type);
```

The SC Ada RTS supplies a default implementation for `AA_GLOBAL_NEW`, as well as for the other memory allocation utilities discussed in this chapter. The SC Ada default is contained in the SC Ada runtime library and is linked with the user program unless you explicitly supply an alternative implementation.

If you include a module that defines the name AA_GLOBAL_NEW, that definition supersedes the default. For the moment, it is important to know that you can redefine the memory allocation implementation and that SC Ada provides the default implementation (in some cases more than one) described here.

References

Section 3.5.1, “Simple Allocation: SMPL_ALLOC,” on page 3-16
Section 3.5.4, “Small Block Lists,” on page 3-22

3.4 SC Ada Library Memory Management Semantics

The user-space (as opposed to kernel-space), memory-management interface defines a set of subprograms called by compiler-generated code and the SC Ada runtime library itself. This section describes when these subprograms are called and the function each performs. SC Ada supplies the following specification in `standard` for its memory management interface. See Figure 3-1.

```
with system;
with v_i_types;
package v_i_alloc is

    function aa_global_new(size : in v_i_types.alloc_t)
        return system.address;
    procedure aa_global_free(a : in system.address);
    function aa_aligned_new(size, dope_size : in v_i_types.alloc_t;
        alignment : in integer) return system.address;
    function aa_local_new(size : in v_i_types.alloc_t;
        lheap: system.address) return system.address;
    procedure aa_local_free(a: in system.address;
        lheap: system.address);
    procedure extend_intr_heap(extension: in integer);
    function get_intr_heap_size return integer;
    function krn_aa_global_new(size: v_i_types.alloc_t)
        return system.address;
    procedure krn_aa_global_free(a: system .address);
    procedure extend_stack;
end v_i_alloc;
```

Figure 3-1 Example of Specification for Memory Management Interface

3.4.1 AA_GLOBAL_NEW

A call to AA_GLOBAL_NEW (*size*) returns a pointer (address) to a contiguous block of at least *size* STORAGE_UNITS. Allocate the space anywhere in memory, but the storage must not be in use for any other purpose than holding this object.

In general, the compiler calls AA_GLOBAL_NEW for each use of an allocator. Currently, one exception to this rule exists. If the corresponding access type is defined directly or indirectly in a subprogram and a representation clause is given for the type:

```
for access_type'storage_size use ...
```

In this case, the compiler calls AA_LOCAL_NEW. Future versions of SC Ada will have a second case where AA_GLOBAL_NEW is not used. The case is where an alignment representation clause is given for the type:

```
for record_type use
    record at mod ...
        ...
    end record;
```

The compiler calls AA_ALIGNED_NEW.

3.4.2 AA_ALIGNED_NEW

AA_ALIGNED_NEW supports allocation of objects on specified storage unit boundaries. For example, an object can be allocated so it aligns on a virtual page boundary. A call to AA_ALIGNED_NEW has the following form:

```
object_address := v_i_alloc.AA_ALIGNED_NEW(size, dope_size, alignment);
```

where *size* is the size of the object allocated, *dope_size* is the size of the dope vector required (usually zero for anything but unconstrained arrays), and *alignment* is the number of STORAGE_UNITS to align the object to. *dope_size*, which must be a multiple of four STORAGE_UNITS, is the amount of memory allocated and prepended to the object that is not aligned. The amount of the alignment must be a power of two. For example, the call

```
object_address := v_i_alloc.AA_ALIGNED_NEW(2000, 16, 4096);
```

allocates 2000 STORAGE_UNITS with a 16 STORAGE_UNIT dope area aligned on a 4096 STORAGE_UNIT boundary. Future versions of SC Ada will support the Ada alignment representation clause using this function.

3.4.3 AA_GLOBAL_FREE

AA_GLOBAL_FREE supports deallocation of objects allocated by AA_GLOBAL_NEW (or AA_ALIGNED_NEW). Its parameter must be a pointer that was previously returned by AA_GLOBAL_NEW. Passing an arbitrary or previously freed address to AA_GLOBAL_FREE is erroneous and leads to unpredictable results.

The predefined generic subprogram, UNCHECKED_DEALLOCATION, is implemented with calls to AA_GLOBAL_FREE if allocators for the type call AA_GLOBAL_NEW.

Instances of unconstrained array objects are implemented as an access to the start of the array with a dope vector prepended. If such an object is passed to UNCHECKED_DEALLOCATION, it looks past the dope vector to find the header stored by AA_GLOBAL_NEW. Therefore, *do not use* UNCHECKED_CONVERSION or the address attribute in supplying a value directly to AA_GLOBAL_FREE for these instances.

Access variables must not refer to deallocated objects. The compiler does not verify that access variables refer to allocated objects. The RTS and the compiler expect that any storage freed by AA_GLOBAL_FREE can be reused for other purposes.

References

Section 3.4.5, “AA_LOCAL_FREE,” on page 3-15

3.4.4 AA_LOCAL_NEW

Access types declared locally in a procedure are given special treatment if they have a STORAGE_SIZE representation specification. In these cases, the elaboration of the access type declaration pushes a request for a contiguous block of the required size on the procedure stack, along with a descriptor for the local heap. The following record defines the descriptor.

```
type local_heap_t is record
  size: integer;           -- size of the local heap in
storage_units
  head: address;           -- first storage_unit of local heap
  next: address;         -- next available storage_unit of local
heap
  free_list: address;     -- free list populated by AA_LOCAL_FREE
end record;
type a_local_heap is access local_heap_t;
```

Allocators for local heap access types are implemented as calls to AA_LOCAL_NEW. The *size* parameter of AA_LOCAL_NEW specifies the size in storage units of the object to allocate. The LHEAP parameter is a pointer of type A_LOCAL_HEAP to the appropriate local heap descriptor for that access type.

The RTS does not require that a local heap be used, but it allocates the indicated amount of storage in any case.

In its search to find a suitably-sized block to satisfy the allocation, the RTS first tries to allocate from the end of the local heap by examining the “next” field. If not enough room exists, it searches the free_list (created as blocks are deallocated into this heap). If still no block is found, a STORAGE_ERROR exception is raised.

The STORAGE_SIZE required follows the simple formula:

```
RF(SO + 2 * SI) * number of objects

Where:
    RF is a function that rounds its argument up to a multiple of
the
       size of a float type.
    SO is the size of the object
    SI is the size of an integer
```

All sizes are in SYSTEM.STORAGE_UNIT.

Here is a simple example where the compiler creates and uses a local heap:

```
procedure foo is
    type node;
    type a_node is access node;
    type node is record
        value: integer;
        link: a_node;
    end record;
    for a_node'STORAGE_SIZE use 400;

    head, cur_node: a_node;
begin
    -- head is allocated from the local heap
    head := new node;
    cur_node := head;
    for i in 1 .. 20 loop
        cur_node.value := i ** 2;
        -- each node is allocated from the local heap
        cur_node.link := new node;
        cur_node := cur_node.link;
    end loop;
    cur_node.link := null;
    ...
end foo; -- whole linked list deallocated
```

3.4.5 AA_LOCAL_FREE

The SC Ada compiler generates calls to AA_LOCAL_FREE for uses of UNCHECKED_DEALLOCATION applied to an access type whose objects are allocated by means of AA_LOCAL_NEW. The object is linked to the local heap free list. Coalescing of adjacent free objects in a local pool is not supported. It is assumed that the object pointer passed to AA_LOCAL_FREE is a pointer supplied by AA_LOCAL_NEW; this is not checked and programs that disobey this rule are erroneous.

3.4.6 EXTEND_INTR_HEAP

This is a user-callable routine that increases the number of blocks available for allocation from an interrupt handler.

References

Section 3.5.5, “Allocation from Interrupt Handlers,” on page 3-23

3.4.7 GET_INTR_HEAP_SIZE

This is a user-callable function that allows the number of blocks available for allocation from an interrupt handler to be accessed. Use this routine to detect when the number of blocks available is dangerously low and must be increased (using EXTEND_INTR_HEAP).

3.4.8 KRN_AA_GLOBAL_NEW *and* KRN_AA_GLOBAL_FREE

These routines are called by a user program to allocate and deallocate memory directly from the kernel.

These routines are provided to preserve backward compatibility with earlier SC Ada Releases. They are layered upon the Ada kernel’s ALLOC and FREE services.

3.4.9 EXTEND_STACK

This routine allowed the caller to extend the main program stack space. It is no longer supported and always raises a STORAGE_ERROR exception.

3.4.10 AA_INIT

In the SC Ada memory allocation default implementations, a call to AA_INIT must precede *any* call to AA_GLOBAL_NEW. Supply your own implementations that relax this rule. The default RTS calls AA_INIT as essentially its first operation.

Note – Since no interface is provided for this routine, do not call it from a user-level program.

If you write your own AA_INIT routine, it must not involve calls to any other RTS service, as these are not initialized yet.

3.5 SC Adasupplied Memory Management

SC Ada supplies four implementations of memory management. In order of size they are SMPL_MALLOC, SLIM_MALLOC, FAT_MALLOC, and DBG_MALLOC. SMPL_MALLOC is a simple example implementation whose source is provided as a basis for those who want to write their own allocation routines. FAT_MALLOC adds features to SLIM_MALLOC, and likewise DBG_MALLOC adds features to FAT_MALLOC. Additionally, SC Ada supplies a package that layers on SLIM_MALLOC, FAT_MALLOC or DBG_MALLOC that enables you to do "pool-based" allocation. Note, the term "heap allocation" refers to all three SLIM_MALLOC, FAT_MALLOC, and DBG_MALLOC implementations.

SC Ada has several configuration parameters in the v_usr_conf_b.a file that tune the performance and behavior of the memory allocation routines.

3.5.1 Simple Allocation: SMPL_ALLOC

Source is provided for a simple memory allocation implementation to illustrate how to write your own version of the memory allocation routines. See the files smpl_alloc.a, smpl_alloc_b.a, and smpl_alloc_s.a in the usr_conf directory. Note that because of the different block header structures and because SMPL_ALLOC does not support deallocation, package POOL cannot be layered on top of SMPL_ALLOC.

3.5.2 *Slim Heap Allocation:* SLIM_MALLOC

The archive fat_MALLOC supplies the default memory management support.

In heap allocation, all calls to AA_GLOBAL_NEW, not originating from interrupt handlers, allocate space from one global heap. For a request of *N* storage units, AA_GLOBAL_NEW allocates at least *N* storage units from the global heap. For most systems, the number of storage units rounds to an even multiple of words or longwords. On many systems, memory references at even multiples of storage units are faster than references to odd addresses. Other systems require addresses to align.

A two-word header is allocated to hold the size of the object being allocated, its status (free or allocated), and the size of the previous adjacent block for use when coalescing. This header is located adjacent to the allocated object, immediately preceding it. AA_GLOBAL_FREE uses this header. The header is described by the following data structures.

```
type block_header is record       -- Header used by all blocks
   size: integer;             -- +/- total block size incl header
                             -- If negative, then block is used.
    prev_blk_size: integer;       -- +/- previous block size incl
                                   -- header,
                                   -- If negative then block was
                                   -- allocated from an interrupt
                                   -- handler.
end record;

type free_block;                  -- Free memory block
type a_free_block is access free_block;
type free_block is record
    header: block_header;         -- Size = +block size ( >0 )
    next_free: a_free_block;      -- Forward link to next free
memory
   prev_free: a_free_block;     -- Backward link to previous free
                                   -- memory
end record
```

A method similar to the boundary-tag system obtains constant-time coalescing with adjacent free blocks, if any, into one block. AA_GLOBAL_FREE links the deallocated storage on a doubly-linked free list. The links are placed in the deallocated object, so the minimum size of an object always rounds up to the size of two access variables.

The minimum size of an allocation is the number of storage units required to hold the two-word header and the two linked-list pointers.

AA_GLOBAL_NEW searches the free list for an area large enough to satisfy each storage request as it occurs. A “first fit” algorithm is used.

The following series of illustrations in Figure 3-2 and Figure 3-3 is an example of how memory looks while in the process of doing memory allocations and deallocations. To make it easier to follow, we assume that we begin with 1000 bytes of memory and we ignore the “`start`” and “`end`” blocks used for the checking the boundary conditions. The first and second fields of every block are the size of the block and the size of the previous block respectively.

Note – This example does not show the case where more than two free blocks are in memory. In these cases, the `prev_free` and `next_free` fields are no longer identical (they form a doubly-linked circular list).

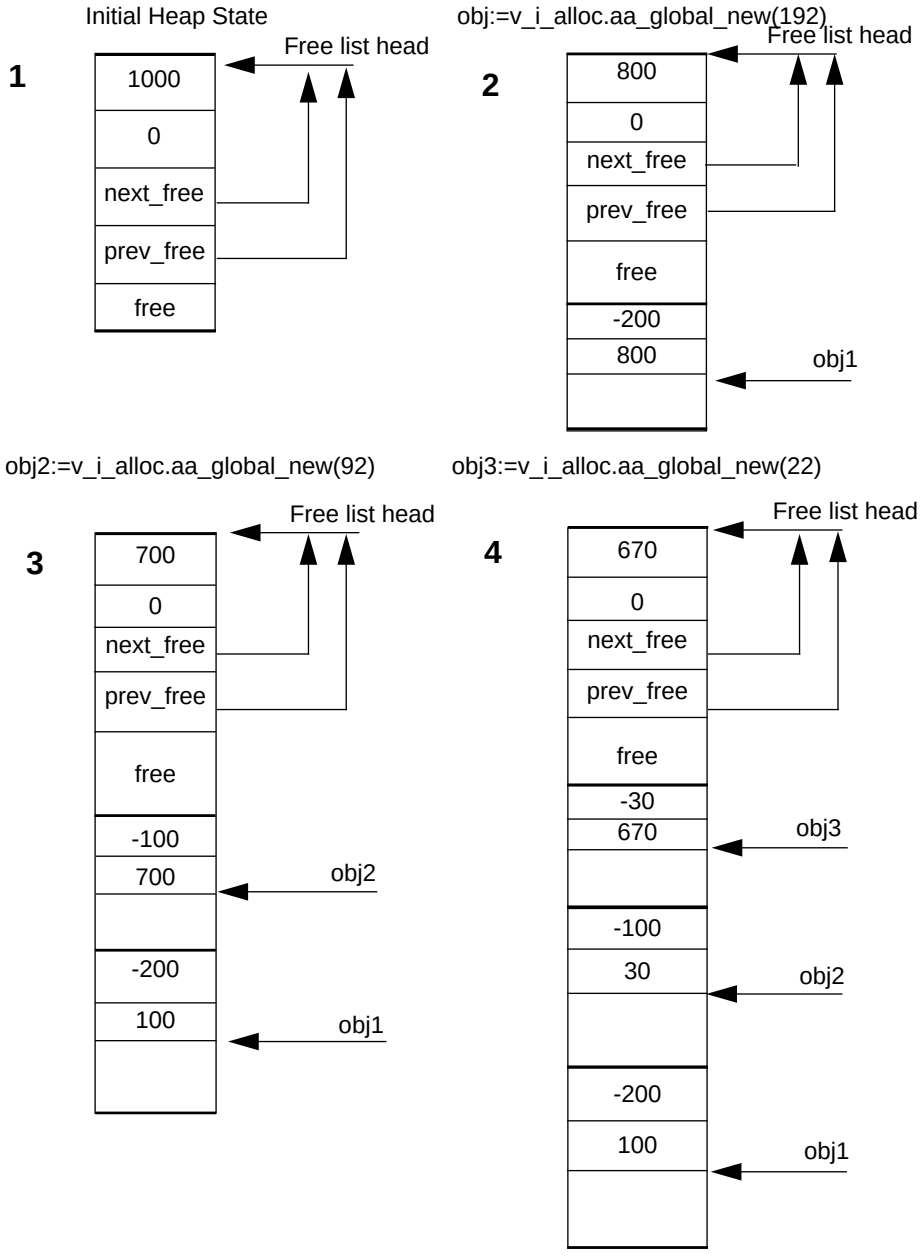


Figure 3-2 Memory Allocation and Deallocation Process-1

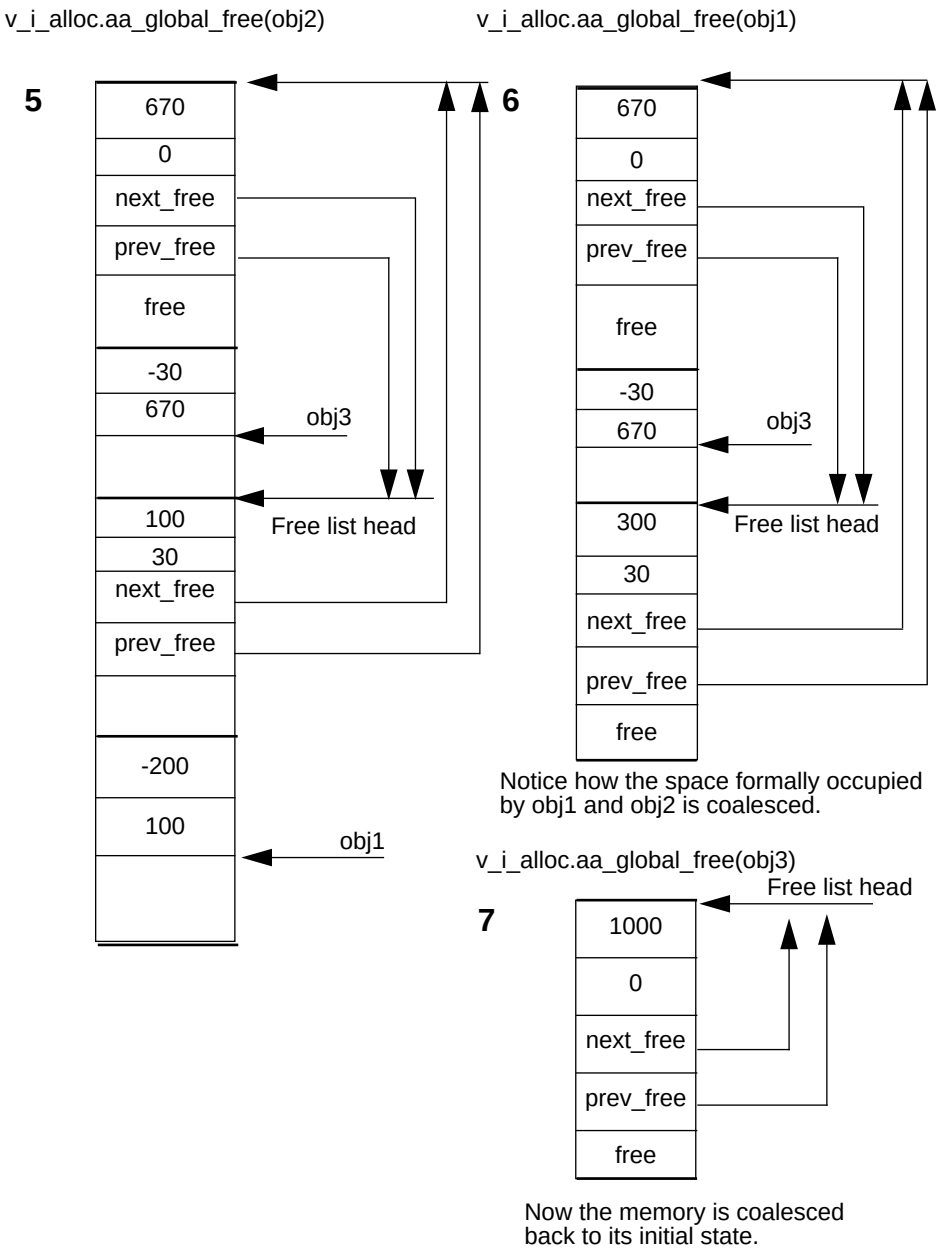


Figure 3-3 Memory Allocation and Deallocation Process-2

Heap allocation uses the user-configurable variable MIN_SIZE. If an area in the free list is larger than your request by less than MIN_SIZE storage units, the entire object is given to you even though the extra storage is wasted. However, if the waste is MIN_SIZE or larger, remaining storage is split into a new free area.

MIN_SIZE reduces memory fragmentation, whereby the free list clogs with numerous free areas too small to satisfy memory requests. We recommend that MIN_SIZE be configured in the range of 8 to 128 storage units. However, in no case, can it be smaller than the size of two linked-access variables (8 storage units) or larger than the smallest small block list.

The default value for MIN_SIZE is 8 storage units. To reconfigure this value, package V_USR_CONF in the file v_usr_conf_b.a (located in the usr_conf directory) must be changed and linked with the program.

V_USR_CONF has two additional parameters controlling heap allocation, GET_HEAP_MEMORY_CALLOUT and HEAP_EXTEND. The routine indicated by GET_HEAP_MEMORY_CALLOUT is called when the heap memory is exhausted. HEAP_EXTEND is the minimum amount of memory to request from GET_HEAP_MEMORY_CALLOUT. Typically, GET_HEAP_MEMORY_CALLOUT is called when AA_GLOBAL_NEW fails to find sufficient heap space to satisfy a memory request. In this case, the value of the size parameter for GET_HEAP_MEMORY_CALLOUT is set to the minimum of AA_GLOBAL_NEW size parameter or HEAP_EXTEND. Also, the heap area initializes at program start-up by calling GET_HEAP_MEMORY_CALLOUT using HEAP_EXTEND as the size parameter.

After the package is modified and recompiled, it is included in a program either by a with clause in the Ada source or a WITH*n* directive in the ada.lib file.

References

Section 3.5.4, “Small Block Lists,” on page 3-22

3.5.3 Fat Heap Allocation: FAT_MALLOC

FAT_MALLOC is the default memory-management archive for self-host systems. In addition to the services of SLIM_MALLOC, FAT_MALLOC provides two additional ones, small block lists and allocation from an interrupt handler. FAT_MALLOC is considerably larger and more complex than SLIM_MALLOC.

3.5.4 Small Block Lists

Space for small block lists is allocated from the heap. Configure any number of lists, each with a different element size. Each list contains elements of the same size. A small block is allocated from the list whose elements are just large enough to store the object. For example, if lists are established for blocks of size 16, 32, and 128 STORAGE_UNITs, requests of up to 16 storage units come from the first list, requests for between 17 and 32 storage units from the second list, and requests for between 33 to 128 storage units from the third list. Two cases exist where objects are allocated from the heap using a "first fit" strategy as in SLIM_MALLOC. The first case is if the object is larger than 128 STORAGE_UNITs. The second case is if the properly-sized small blocks list is empty when examined; in this case, when the object is deallocated, it returns to that small blocks list.

UNCHECKED_DEALLOCATION is used in the normal way to free space occupied by small objects. The compiler calls AA_GLOBAL_FREE to implement UNCHECKED_DEALLOCATION. The user-configurable parameter MIN_LIST_LENGTH defines the minimum number of objects to keep on each small block list. If the current number of blocks on the proper small block list is less than MIN_LIST_LENGTH, the small block returns to that list with no attempt to coalesce it with its neighbors. Otherwise, coalescing is attempted. If the block cannot be coalesced with either of its neighbors, it returns to the small blocks list. Coalescing is considered not possible if the neighbor to be coalesced is currently on a small blocks list and the number of blocks on that list is less than MIN_LIST_LENGTH. The rationale for providing a minimum list length is that the small blocks lists are of little use if small blocks are always coalesced when they are deallocated, that is, the small blocks list is empty too often.

Configure the number of small block lists to zero, in which case they are not used.

The rationale for using small blocks is that, if you know in advance that most allocations are of a specific size, allocation can be facilitated for that size. Overall performance improves both in terms of memory usage and speed.

List-based allocation increases internal fragmentation if the sizes of objects are truly random. Use it only if you know ahead of time that many allocation requests are a specific size or group of sizes or memory wastage can be tolerated.

To reconfigure individual list element sizes, change the SMALL_BLOCK_SIZES_TABLE structure in the package body V_USR_CONF in the file v_usr_conf_b.a (located in the usr_conf directory).

V_USR_CONF has the following default sizes:

```
:= (
  8, 16, 24, 32
   );
```

V_USR_CONF has three other parameters for controlling allocation: HEAP_EXTEND, GET_HEAP_MEMORY_CALLOUT, and MIN_SIZE. Their usage here is the same as for heap allocation.

References

Section 3.5.2, “Slim Heap Allocation: SLIM_MALLOC,” on page 3-17

3.5.5 Allocation from Interrupt Handlers

Although this feature is currently supported in the SC Ada RTS only, FAT_MALLOC (and DBG_MALLOC) contains code for handling memory allocation from an interrupt handler. Using SLIM_MALLOC, a deadlock arises if a task is in the process of doing a “new” operation (or calling V_I_ALLOC.AA_GLOBAL_NEW) when an interrupt occurs and the interrupt handler does a new. This is because a mutex guards the allocator and an interrupt handler cannot be suspended (except by another interrupt). To solve this problem, FAT_MALLOC provides a very simple memory allocation scheme when memory is allocated from an interrupt handler. This condition is detected by using the Ada kernel service ADA_KRN_I.ISR_IN_CHECK( ). This scheme uses a separate heap of preallocated, fixed-size blocks (user-configurable). Instead of using mutexes to protect the data structures, it disables interrupts.

This scheme allocates memory very quickly since all blocks are the same size. The blocks are tagged as allocated from an interrupt handler and can either be deallocated during task time or interrupt time. The current number of blocks available for allocation is accessible by using the function V_I_ALLOC.GET_INTR_HEAP_SIZE. Additionally, if the interrupt handler runs low or out of blocks (encounters a STORAGE_ERROR exception), a task can call V_I_ALLOC.EXTEND_INTR_HEAP to get more blocks.

Note – Do not call V_I_ALLOC.EXTEND_INTR_HEAP at interrupt time, or a deadlock can result. If an interrupt handler attempts to allocate an object that is larger than the fixed-size blocks in the interrupt heap, a STORAGE_ERROR exception is raised.

The default initial size of the interrupt heap is determined by the INITIAL_INTR_HEAP field in the MEM_ALLOC_CONF RECORD in the v_usr_conf_b.a file. Its default setting is 100 objects. The size of each object in the heap is determined by the INTR_OBJ_SIZE field — the default size is 128 storage units. Set them to any reasonable value, but keep in mind that this storage is allocated before the program starts running and affects the amount of runtime memory used.

Figure 3-4 is an example of using V_I_ALLOC.EXTEND_INTR_HEAP:

```
package RECEIVE is
end RECEIVE;
with V_INTERRUPTS;
with SYSTEM;
with V_SEMAPHORES;
with V_I_ALLOC;
package body RECEIVE is
   low_water_mark: constant integer := 10;
   please_extend_intr_heap: V_SEMAPHORES.binary_semaphore_id :=
      V_SEMAPHORES.CREATE_SEMAPHORE;
   task INTR_HEAP_EXTEND_SLAVE is
```

(*Continued*)

```
   task body INTR_HEAP_EXTEND_SLAVE is
   begin
      loop
         V_SEMAPHORES.WAIT_SEMAPHORE(
            semaphore => please_extend_intr_heap,
            wait_time => V_SEMAPHORES.WAIT_FOREVER);
         V_I_ALLOC.EXTEND_INTR_HEAP(100);
      end loop;
   end INTR_HEAP_EXTEND_SLAVE;

   procedure RECEIVE_HANDLER is
   begin
      -- interrupt handler code
      -- ...
      -- buffer.next := new buffer;
      -- ...

      -- check to see if we are running low on allocation blocks:
      --
      if V_I_ALLOC.GET_INTR_HEAP_SIZE <= low_water_mark then
         -- we are running low, tell the slave we want more
         V_SEMAPHORES.SIGNAL_SEMAPHORE(please_extend_intr_heap);
      end if;
    end RECEIVE_HANDLER;

    procedure RECEIVE_ISR is new
V_INTERRUPTS.ISR(RECEIVE_HANDLER);

    begin
       -- Attach the instantiated RECEIVE_ISR
       V_INTERRUPTS.ATTACH_ISR(16#80#, RECEIVE_ISR'address);
    end RECEIVE;
```

Figure 3-4 Example of V_I_ALLOC_INTR_HEAP

If you want to write your own allocator to allocate memory for interrupt handlers, call the Ada Kernel service, ADA_KRN_I.ISR_IN_CHECK( ), to see if the allocator was called from an interrupt handler or a task.

3.5.6 Debug Heap Allocation: DBG_MALLOC

This archive includes all of the features of the FAT_MALLOC, plus some features to debug memory allocation or display usage. Calls to AA_GLOBAL_NEW return a piece of memory WITH some extra information in the header. When calling AA_GLOBAL_FREE, this extra information is checked along with the other fields for consistency. If an inconsistency is detected, a STORAGE_ERROR exception is raised. These checks increase the probability of detecting an attempt to deallocate a dangling access value. Because of this extra checking, performance suffers.

In addition, through package ALLOC_DEBUG in the usr_conf directory, call routines that comb the entire heap for inconsistencies. The procedure is called VERIFY_HEAP. This routine raises a STORAGE_ERROR if it detects an inconsistency. package ALLOC_DEBUG has two other features of interest. First, it contains a routine — PRINT_HEAP_MAP — for printing the HEAP_MAP. The address of each block in the heap prints as well as its status (free or allocated) and size. It contains a another routine — PRINT_HEAP_STATS — that prints a histogram of block sizes and some information about memory utilization. Using the Ada command, with, to include this package in your program replaces the default allocator with the DBG_MALLOC at link time automatically. The package specification and some examples are shown in Figure 3-5:

```
package alloc_debug is

    procedure verify_heap;

    procedure print_heap_map;

    procedure print_heap_stats(
            lower_size_cutoff: integer := 1;
            upper_size_cutoff: integer := 512);
end;
```

Figure 3-5 Example of Package Specification for ALLOC_DEBUG

This example program uses VERIFY_HEAP and PRINT_HEAP_MAP:

```
with alloc_debug;
procedure verify_and_print_heap is
begin
    alloc_debug.verify_heap;
    alloc_debug.print_heap_map;
end verify_and_print_heap;
```

The output of the preceding example is:

```
Heap Map:

Address: 16#45120#
    Status: allocated
    Size: 24

Address: 16#45138#
    Status: free
    Size: 127232

Address: 16#64238#
    Status: allocated
    Size: 32

Address: 16#64258#
    Status: allocated
    Size: 1072

Address: 16#64688#
    Status: allocated
    Size: 24
.
.
.
```

Here is an example of using print_heap_stats called from in a large program. The routine is called with the following line in the source code:

```
alloc_debug.print_heap_stats(lower_size_cutoff => 1, upper_size_cutoff => 192);
```

The output is:

```
Heap Stats:

Histogram for blocks in size range 1 .. 192

          Size Range     Count    Freq
-------------------------------------
       1 ..       24:        5 : 0.010 -
      25 ..       48:      184 : 0.362 - ************
      49 ..       72:      137 : 0.270 - **********
      73 ..       96:       12 : 0.024 - *
      97 ..      120:        0 : 0.000 -
     121 ..      144:       47 : 0.093 - ***
     145 ..      168:      120 : 0.236 - *********
     169 ..      192:        3 : 0.006 -

Memory allocated by RTS from kernel: 131072 bytes.
Memory allocated by program from RTS: 104848 bytes.
Memory utilization efficiency: 80.0%
```

Some notes about use:

- The `upper_size_cutoff` rounds up so that each of the eight size intervals are of equal and integral sizes.
- The block size includes the header size; the actual object size is at least two words smaller (depending on the `SMALL_BLOCK_SIZES` and `MIN_SIZE` configuration parameters. To eliminate the effects of small-block sizes on the statistics, set the list to empty and `MIN_SIZE` to 8 in `package V_USR_CONF`).
- Other tasks are blocked from doing allocations while the heap map prints or the heap stats are calculated to avoid creating data structure inconsistencies.
- The use of this package can change the actual statistics somewhat. Although this package does no allocations of its own, it uses `text_io`, which does. In practice, programs that do a lot of allocation and deallocation notice only a slight variation in the statistics. To get exact results, compile, and execute the following program:

```
with alloc_debug;
procedure print_base_heap_stats is
begin
  alloc_debug.print_heap_stats(...);
end print_base_heap_stats;
```

`with` ... being filled in with the same upper and lower size cutoffs used in the real program. Deduct the results from this program from the results of the real program to derive the real program allocation behavior.

We supply the source code for this package in the `usr_conf` library so that it can be tailored. If you modify or recompile this package, you must change the following line in `alloc_dbg_b.a`

Change

```
pragma link_with("$wrong_ada_path/standard/.objects/dbg_malloc.a");
       -- where $wrong_vads_path is the path shipped in the source
```

to

```
pragma link_with("$ada_path/standard/.objects/dbg_malloc.a");
```

We advise that you make copies of the files dbg_heap.a, alloc_dbg.a and alloc_dbg_b.a.

3.5.7 Configuring in a Non-default Allocation Archive

In order to use an archive other than the default, you must include a `WITH`*n* directive in the `ada.lib`. The most convenient way to do this is to use `a.info`. For example:

```
a.info -a WITH /usr2/ada/standard/.objects/dbg_malloc.a
```

Note – As mentioned before, if you use the Ada command, `with`, in `package` `ALLOC_DEBUG`, `DBG_MALLOC` replaces the default allocator automatically. Do not add the `WITH`*n* `INFO` directive to the `ada.lib`.

3.5.8 *pragma* RTS_INTERFACE

Before describing package POOL, it is a useful digression to describe pragma RTS_INTERFACE. This pragma replaces of the default calls made implicitly at runtime to the underlying RTS routines. For example, as described before, the compiler normally generates calls to AA_GLOBAL_NEW to implement the Ada "new" operator. With this pragma, the compiler generates calls to any routine of your choosing, as long as its parameters and return value match the original. As for the allocation routines, they must match the specification in package V_I_ALLOC in standard. Here is a code fragment demonstrating this:

```
package body foo is
    ...
    function my_global_new(size: v_i_types.alloc_t)
            return system.address is
        obj_addr: system.address;
    begin
        obj_addr := v_i_alloc.aa_global_new(size);
        text_io.put("Allocating ")
        my_num_io.put(size, base => 16, width => 1);
        text_io.put(" storage_units from address ")
       my_num_io.put(to_integer(obj_addr), base => 16, width =>
1);
        text_io.newline;
        return obj_addr;
    end my_global_free;

    procedure bar is
        pragma RTS_INTERFACE(AA_GLOBAL_NEW, my_global_new);
        type a_integer is access integer;
        count: a_integer;
    begin
        ...
        count := new integer;  -- my_global_new gets called here
        ...
    end bar;
    ...
end foo;
```

Note – The subprogram name used in the pragma must be a simple name (no package name qualification). If the subprogram is in another package, this can easily be achieved by an Ada `use` clause.

`pragma RTS_INTERFACE` supports replacing the RTS routines whose interfaces are defined in the following packages:

`v_i_alloc.a:`	Memory Allocation routines
`v_i_libop.a:`	Library routines (such as block compares)
`v_i_pass.a:`	Passive tasking routines
`v_i_raise.a:`	Exception routines
`v_i_taskop.a:`	Tasking routines

Because of the powerful nature of this pragma, use it with caution.

3.5.9 Pool-based Allocation: `POOL`

We supply `POOL`, an optional pool-based memory allocation package (pools are sometimes referred to in the literature as “arenas”). `POOL` layers on top of any of `SLIM_MALLOC`, `FAT_MALLOC` or `DBG_MALLOC`. Using this package along with `pragma RTS_INTERFACE`, separate memory into multiple storage pools. Deallocate all objects allocated from a particular pool simultaneously with a single call. The source to this package is provided to show one way to layer upon the underlying RTS memory allocation routines. Figure 3-6 is the package specification:

```
with system;    use system;
with v_i_types;
package pool is
    pragma suppress(ALL_CHECKS);
    subtype alloc_t is v_i_types.alloc_t;
    function aa_global_pool_new(size: in alloc_t) return address;
    procedure aa_global_pool_free(a: in address);
    type a_pool_descr is private;
    function create_pool(
            initial_size, extension_size: in alloc_t;
            base: in address := no_addr) return a_pool_descr;
    procedure deallocate_pool(p: in out a_pool_descr);
    procedure switch_pool(
            old_pool: out a_pool_descr;
            new_pool: in a_pool_descr);
    procedure restore_pool(old_pool: in a_pool_descr);
    function aa_pool_new(pool: in a_pool_descr; size: in alloc_t)
        return address;
    function current_pool return a_pool_descr;
    function heap_pool return a_pool_descr;
private
    type pool_descr;
    type a_pool_descr is access pool_descr;
end pool;
```

Figure 3-6 Example of package POOL

With these pool control facilities, a program creates and deallocates pools of memory and directs its memory requests to specific pools. The interface to these facilities is contained in the usr_conf library package POOL.

The default pool, called the “heap pool,” is just the underlying allocator (SLIM_MALLOC, FAT_MALLOC or DBG_MALLOC). Objects allocated from the heap pool are deallocated with either AA_GLOBAL_FREE or AA_GLOBAL_POOL_FREE. In contrast to the pools created with CREATE_POOL, the heap pool cannot be deallocated.

The only appropriate way to deallocate objects allocated from pools is to deallocate the entire pool. Any use of AA_GLOBAL_POOL_FREE to free an individual object allocated from any pool besides the default is ignored. Any use of AA_GLOBAL_FREE on an object allocated from any pool besides the heap pool is erroneous and results in unpredictable behavior.

Pools other than the heap pool do not support memory coalescing or small block lists, since individual objects are never deallocated.

3.5.10 Pool Control

3.5.10.1 CREATE_POOL

```
function create_pool(initial_size:alloc_t;
                                                    extension_size:
alloc_t := 0;
                     base_address: address := no_addr)
            return a_pool_descr;
```

CREATE_POOL creates an internal data structure for a pool and returns a descriptor or identifier for the pool. Generally, pools use contiguous memory to prevent possible fragmentation. INITIAL_SIZE gives the number of storage units to allocate to the pool initially. Pools grow as necessary, allocating from the heap in lots of EXTENSION_SIZE STORAGE_UNITS. If EXTENSION_SIZE is zero, the pool is not extended and exhaustion raises STORAGE_ERROR. By specifying the base address of a pool, assign a specific region of memory to the pool, perhaps to an area containing faster memory. SC Ada does not check to see if pools created in this manner collide with other objects, for example, other pools; this must be done by you. The default NO_ADDR causes the base to be arbitrary, as the pool storage block is obtained from an arbitrary storage area in the heap. Pools obtained by using NO_ADDR are guaranteed not to collide with other objects. package POOL creates the descriptor for the heap pool at elaboration time.

3.5.10.2 DEALLOCATE_POOL

```
procedure deallocate_pool(p: a_pool_descr);
```

DEALLOCATE_POOL returns all blocks of storage that are obtained for the named pool, including any extensions, to the heap free list. Such memory is no longer reserved for that pool and is used for any heap activity. The heap pool cannot be deallocated.

3.5.10.3 *RESET_POOL*

```
procedure reset_pool(p:  a_pool_descr);
```

RESET_POOL causes the objects in the pool to become deallocated without actually freeing the pool memory back to the underlying allocator. This causes a performance increase if you intend to reuse the pool, rather than calling DEALLOCATE_POOL and then CREATE_POOL again. The heap pool cannot be reset.

3.5.10.4 SWITCH_POOL

```
procedure switch_pool(old_pool: out a_pool_descr; new_pool: in
a_pool_descr);
```

For performance reasons, AA_GLOBAL_POOL_NEW does not use an explicit parameter to specify the pool used for allocation requests. Instead, it uses an implicit parameter defined by the CURRENT_POOL. At system start-up, the heap is the current pool. However, by calling SWITCH_POOL, a program selects an arbitrary pool as the current pool. old_pool is loaded with the previous current pool descriptor. In a multi-task program, each task has its own current pool. All news, performed in the scope of pragma RTS_INTERFACE using AA_GLOBAL_POOL_NEW, are obtained from the current pool. This means that if a procedure using pools calls another procedure, which also uses pools, the called procedure must bracket its allocation from its pool with calls to

SWITCH_POOL and RESTORE_POOL. SWITCH_POOL and RESTORE_POOL are designed to clearly bracket the use of a pool, increasing readability and easing maintenance.

3.5.10.5 RESTORE_POOL

```
procedure restore_pool(old_pool: in a_pool_descr);
```

RESTORE_POOL switches the current pool back to old_pool.

3.5.10.6 CURRENT_POOL

```
function current_pool return a_pool_descr;
```

CURRENT_POOL returns the pool descriptor for the current pool.

3.5.10.7 HEAP_POOL

```
function heap_pool return a_pool_descr;
```

HEAP_POOL returns the pool descriptor for the heap pool. You may want to switch to the HEAP_POOL to allocate objects that must persist.

3.5.10.8 AA_POOL_NEW

```
function aa_pool_new(pool: in a_pool_descr;
                     size: in alloc_t)
   return address;
```

For applications that must switch from one pool to another quickly without incurring the overhead of the SWITCH_POOL and RESTORE_POOL routines, AA_POOL_NEW provides a better alternative. Although it cannot be used with pragma RTS_INTERFACE, call it explicitly to allocate memory from a

particular pool. The caller supplies the pool descriptor and the amount of memory to allocate and receives an address that points to the newly allocated memory. See Figure 3-7.

```
with POOL;
with V_I_ALLOC;
with V_I_TYPES;
with UNCHECKED_DEALLOCATION;

package body window is
  procedure construct_window_descr(window: out a_window_descr) is
      use POOL;
      pragma RTS_INTERFACE(AA_GLOBAL_NEW, aa_global_pool_new);
      save_pool: a_pool_descr;
    begin
      -- allocate the window descriptor itself from the heap pool
      switch_pool(old_pool => save_pool, new_pool =>POOL.heap_pool);
         window := new window_descr;
      restore_pool(save_pool);
    window.pool_descr :=
        create_pool(initial_size => 10_000, extension_size => 5000);
    -- allocate the window's data structures from the pool we just
    -- created
    switch_pool(old_pool => save_pool, new_pool => window.pool_descr);
    window.font_descr := new font_descriptor'(default_font);
    window.color_descr := new color_descriptor'(default_colors);
    window.feature_descr := new feature_descriptor'(default_features);
            ...
    restore_pool(save_pool);
end construct_window_descr;
  procedure destruct_window_descr(window: in a_window_descr) is
      use POOL;
      -- the following pragma is unnecessary, since the window descriptor
      -- was allocated from the heap_pool; it is shown as an example only.
      pragma RTS_INTERFACE(AA_GLOBAL_FREE, aa_global_pool_free);
      procedure free_window_descr is new
         UNCHECKED_DEALLOCATION(a_window_descr);
```

(Continued)

```
   begin
         -- deallocate the window's pool first
         deallocate_pool(window.pool_descr);
         -- deallocate the descriptor itself;
         free_window_descr(window);
   end destruct_window_descr;
   ...
end window;
```

Figure 3-7 Example of Using Pools

3.5.11 Suggestions for Use of SC Ada Memory Allocation

Generally, heap allocation is suited to most applications for which deallocation is straightforward or unimportant. Deallocation requires you can find every object that requires deallocation and call an `UNCHECKED_DEALLOCATION` instantiation to free it.

Worst case fragmentation occurs if something like the following happens:

```
i := 1;
loop until storage error
    small(i) := new small_object;
    large(i) := new large_object;
    i := i + 1;
end loop;

i := 1;
loop until all large_object's are deallocated
    deallocate(large(i));
    i := i + 1;
end loop;

larger := new larger_object;
```

The last allocation fails, even if the `LARGER_OBJECT` is only a little larger than `LARGE_OBJECT`. In this case, we can have megabytes of free memory but no hole large enough to fit one `LARGER_OBJECT`.

The more complicated FAT_MALLOC implementation is somewhat slower than SLIM_MALLOC for programs that do little or no deallocation. It is faster if the process lasts long enough to collect and reuse a lot of deallocated storage. The small object lists prevent fragmentation, but cost time and space if you do not know in advance which object sizes to use.

Pool-based memory deallocation is one of the easiest memory deallocation mechanisms to use. Programmers tend to have a general feel for how long their objects are needed, so they can define a set of pools for each lifetime. They do not need to walk through their data structures to locate garbage and dispose of it explicitly, object by object. Do not use pool-based allocation where object lifetimes are random or unpredictable.

3.5.12 Mutual Exclusion During Allocation

User-space memory allocation, as implemented in the SMPL_MALLOC, SLIM_MALLOC, FAT_MALLOC, DBG_MALLOC archives, and package POOL, is a critical region protected via ABORT_SAFE mutexes. The implementations define a ABORT_SAFE mutex that must be locked before a task enters the allocation/deallocation code. If the mutex is blocked, the task must queue on that mutex's wait list.

Before return is made from allocation, utilities such as AA_GLOBAL_NEW, the allocation mutex must be released, indicating that other tasks can queue up to get their allocation. The mutex must be released if a STORAGE_ERROR occurs during a call to AA_GLOBAL_NEW.

Since an ABORT_SAFE mutex is used, the task doing a memory allocation operation is inhibited from being completed by an Ada abort until it finishes the allocation operation and releases the mutex. In earlier releases of SC Ada, the memory allocations were not ABOUT SAFE.

package V_I_MUTEX in standard provides the interface to the ABORT_SAFE mutex services used by the allocation utilities.

References

Section 3.5.5, "Allocation from Interrupt Handlers," on page 3-23

3.5.13 Memory Management and Underlying Operating Systems

When a program runs on top of an underlying operating system such as UNIX, other libraries can request heap memory, for example, requests for buffers for disk transfers. It is imperative that memory allocations be internally consistent, or these unknown buffers can be allocated in active program memory.

On UNIX-based systems, all programs use a single central allocation service (`sbrk(2)`). The default implementation of `V_GET_HEAP_MEMORY` in `V_USR_CONF` preserves this behavior by making a kernel call that in turn calls `sbrk(2)`. Ada programs are thus consistent: user allocators call `AA_GLOBAL_NEW`, which probably satisfies the request directly and is protected by a mutex. Otherwise, `V_GET_HEAP_MEMORY` calls the Ada Kernel's `alloc` service which is protected by the kernel prohibition against executing multiple single threads and the request is satisfied by a call to `sbrk(2)`.

If that package does not suit your needs, use the mutex mechanism or coding practice of serializing accesses to protect tasks that call programs written in other languages. For example, we suggest that you perform all I/O from a single task. I/O operations are of particular concern because they allocate large blocks of memory either during file `open`s or during the first `read`s and `write`s to the files. To be absolutely safe, one must use the allocation mutex to make critical regions around all calls to foreign language utilities.

We supply an `ABORT_SAFE` mutex protected `malloc` package discussed in the next section, "Protected Malloc".

Without that `malloc` package, SC Ada does not protect its underlying calls to host OS utilities. It is therefore possible that multitasking, time-sliced programs will run into conflicts with unpredictable results if tasks are allowed to suspend while in the host OS (UNIX, ULTRIX, etc.).. We suggest that time-slicing (or other interrupts) be turned off for these tasks or that mutexes be used to protect them or that all such activities be confined to a single task at any time.

3.5.14 Protected Malloc

We supply a package called MALLOC that provides ABORT_SAFE mutex-protected, UNIX-like malloc, calloc, valloc, memalign, realloc, and free routines. This package resides in the usr_conf library. The chosen allocation archive is used as the underlying memory allocation scheme (instead of MALLOC, and so forth).

In order to use it, you must put a WITH*n* directive in the ada.lib file. This supersedes the MALLOC routines normally linked in from the libc.a library. Example:

```
a.info -a WITH /usr2/ada/usr_conf/.objects/malloc02
```

The source to this package is supplied, so if necessary, modify it to suit the needs of your particular application.

Note – This package does not support the older semantics of realloc which stated that any block of memory freed since the last call to MALLOC is valid as a parameter to realloc. The semantics of this in a multi-tasking system are undefined, for example, which thread or threads of execution define "the last call to malloc," and therefore is not supported. SC Ada considers any block already freed to be untouchable, and any program that violates this is erroneous. Check programs using procedure realloc for these semantics and fixed as necessary.

3.5.15 Replacing User-space Memory Allocation

Some users have specialized-performance needs that are not met by any of the supplied memory allocation packages. These users may want to implement their own algorithms. They should compile a new body for the V_I_ALLOC package specifications given earlier, using SMPL_ALLOC as a starting point.

Some considerations:

- If multiple tasks allocate memory simultaneously, protect the critical region of the user algorithms via ABORT_SAFE mutexes. package V_I_MUTEX in standard contains the interface to the ABORT_SAFE mutex services..
- On a host operating system, be aware that standard memory allocators are not protected as critical regions and can be interrupted. Trouble arises if another task enters the allocator before the interrupted task completes its

allocation. Also, calls to other languages can lead to unprotected calls for memory. For example, if TASK1 opens *file1* and TASK2 opens *file2*, both tasks probably call the OS to get memory for buffers and so forth. If TASK1 is suspended during the allocation, unpredictable results can occur. SC Ada does not protect users from this effect.

- Packages in the files v_i_*.a, found in standard, provide access to library services.

3.5.16 Memory Allocation Exerciser

We provide a package called ALLOC_EXERCISER to tune the small block sizes and other memory configuration parameters, to compare the performance of one memory allocation implementation against another or to test the robustness of a user-written memory allocator.

One possible use is in tuning the memory allocation parameters for a specific application, if the memory allocation behavior is characterized previously. In this way, without running the application, you can tune the memory allocation. While it may not reproduce the behavior of a specific application exactly, it is close enough to get some useful information.

It provides the ability to specify:

- Object size
- Object lifetime
- Object alignment and the percentage of objects that need aligned
- Number of objects allocated / deallocated
- Whether or not blocks are filled with a key value and checked at the time of deallocation for a proper key

Object size, alignment, and lifetime are specifiable in terms of either a randomly chosen value in a specified range or in terms of a set of specific values randomly chosen with weighting as specified. For example, size can be specified as in the range of 20 to 1000 bytes or as a set of weighted-specific sizes as in:

size (in bytes)	weight (in percentage)
20	10
40	7
128	50
512	30
4096	3

The weights are not necessarily percentages, but it is convenient to think of them that way. The probability of a specific value coming up is weight/(sum of weights).

Object lifetime is measured in terms of the number of allocations before deallocating a particular object. For example, a lifetime of one means that the object is deallocated immediately after it is allocated. A special value — eternity — is used as a specific lifetime when the object must not be deallocated.

Note – This program does not exercise allocation from pools using `package POOL`.

Figure 3-8 is an example program that uses it:

```
with alloc_exerciser; use alloc_exerciser;
procedure example_exercise is
    s: object_size_descriptor_t(specific_sizes, 5);
    l: object_lifetime_descriptor_t(specific_lifetimes, 4);
    a: object_alignment_descriptor_t(random_alignments, 0);
begin
    s.sizes_and_weights := (
            (value => 16, weight => 40),
            (value => 50, weight => 25),
            (value => 1200, weight => 10),
            (value => 50800, weight => 17),
            (value => 4000, weight => 8));
    l.lifetimes_and_weights := (
            (value => 1, weight => 60),
            (value => 10, weight => 5),
            (value => 100, weight => 25),
            (value => eternity, weight => 10));
    -- Alignment is specified as the power of two to align to
    -- (non power of two alignments are not valid)
    -- e.g. 4 -> 2 ** 4 = 16; 14 -> 2 ** 14 = 16384
    a.low := 4; a.high := 14;
    a.percent_aligned := 1;
    exercise(
        size_desc => s,
        lifetime_desc => l,
        alignment_desc => a,
        use_keys => false,
        num_transactions => 3000);
end example_exercise;
```

Figure 3-8 Example of the Allocation Exerciser

Notice how each of the descriptors is a record with two discriminants. The first discriminant says what sort of distribution to use and if applicable, the second determines how many specific values are used. The `use_keys` flag is useful for testing an allocator to see if it corrupts other blocks as it allocates and deallocates. If it is set to `TRUE`, the program fills the block with a random key

value after the block is allocated. When the block is deallocated, it checks the block to make sure the key is in all locations of the block. In this mode, it takes considerably more time to run.

The source is in the `examples` library as the files named `alloc_exer.a` and `alloc_exer_b.a`. The above example is in file `examples_exer.a`. With some minor modifications, `examples_exer.a` can be a benchmark by using calls to `package CALENDAR`.

References

`package ALLOC_DEBUG`, “Debug Heap Allocation: DBG_MALLOC” on page 3-26

"There is no stronger evidence of a crazy understanding than the making too large of a catalog."

George Seville

Ada Runtime Services 4

The packages in the file `v_vads_exec.a` in the `vads_exec` library provide the user interface to the following VADS EXEC services:

- Signal Handling (`package V_INTERRUPTS`)
- Mailboxes (`package V_MAILBOXES`)
- Memory Management (`package V_MEMORY`)
- Semaphores (`package V_SEMAPHORES`)
- Tasking Extensions (`package V_XTASKING`)
- Stack Operations (`package V_STACK`)

The packages contain subprograms, generics, data types, and exceptions that directly invoke these services. These packages are layered upon the Ada Kernel. The Ada Kernel provides all the threads and synchronization services needed to implement the VADS EXEC services.

The interface to the Ada Kernel services is defined in package `ADA_KRN_I`. Its type definitions are provided in package `ADA_KRN_DEFS`. Both packages can be found in `standard`.

The remainder of this chapter provides an overview of the interface, followed by reference pages for each of the packages and their services

References

Section 2.1, "Ada Kernel," on page 2-1

4

4.1 Overview and Interface Description

The VADS EXEC User Interface provides these packages, functions, and procedures:

`package V_INTERRUPTS` — implements interrupt processing for VADS EXEC through the use of user-defined interrupt service routines (ISRs).

`function ATTACH_ISR` — Attaches an interrupt service routine to a given interrupt vector and returns the previously attached ISR

`procedure ATTACH_ISR` — attaches an interrupt service routine to a given interrupt vector.

`function CURRENT_INTERRUPT_STATUS` — retrieves the current CPU interrupt status mask or priority level.

function `CURRENT_SUPERVISOR_STATE` — Returns the supervisor / user state of the current task.

function `DETACH_ISR` — Detaches an interrupt service routine from a given interrupt vector and returns the previously attached ISR

`procedure DETACH_ISR` — detaches an interrupt routine from a given interrupt vector.

`procedure ENTER_SUPERVISOR_STATE` — enters the supervisor state for the current task, enabling execution of privileged instructions. (This procedure is not supported.)

`generic procedure FAST_ISR` — provides a faster version of the ISR generic. However, restrictions are imposed on the interrupt handler code.

`generic procedure FLOAT_WRAPPER` — saves and restores the state of the floating-point coprocessor. (This generic procedure is not supported; it raises a `TASKING_ERROR` exception.)

`generic procedure ISR` — provides the entry and exit code required of all interrupt service routines and performs the processing required upon entry and exit from an ISR.

`procedure LEAVE_SUPERVISOR_STATE` — exits the supervisor state for the current task, disabling execution of privileged instructions. (This procedure is not supported.)

`function` `SET_INTERRUPT_STATUS` — changes the current interrupt status and returns the previous interrupt status.

function `SET_SUPERVISOR_STATE` — Sets the supervisor / user state of the current `task`

`generic package` `V_MAILBOXES` — provides mailbox operations for asynchronous passing of data between tasks or between an interrupt handler and a task.

`procedure` `CREATE_MAILBOX` — creates and initializes a mailbox.

`procedure` `DELETE_MAILBOX` — deletes a mailbox.

`procedure` `READ_MAILBOX` — retrieves a message from a mailbox.

`procedure` `WRITE_MAILBOX` — writes a message into a mailbox.

`function` `CURRENT_MESSAGE_COUNT` — returns the number of unread messages.

`package` `V_MEMORY` — provides memory management operations for *FixedPools*, *FlexPools*, and *HeapPools.*

`procedure` `CREATE_FIXED_POOL` — create a *FixedPool.*

`procedure` `CREATE_FLEX_POOL` — create a *FlexPool.*

`procedure` `CREATE_HEAP_POOL` — create a *HeapPool.*

`procedure` `DESTROY_FIXED_POOL` — delete a *FixedPool.*

`procedure` `DESTROY_FLEX_POOL` — delete a *FlexPool.*

`procedure` `DESTROY_HEAP_POOL` — delete a *HeapPool.*

`generic function` `FIXED_OBJECT_ALLOCATION` — allocate an object from the given *FixedPool*, initializing it with a specified value.

`generic procedure` `FIXED_OBJECT_DEALLOCATION` — deallocate the memory at the given location.

`generic function` `FLEX_OBJECT_ALLOCATION` — allocate an object from the given *FlexPool*, initializing it with a specified value.

`generic procedure` `FLEX_OBJECT_DEALLOCATION` — deallocate the memory at the given location.

generic function HEAP_OBJECT_ALLOCATION — allocate an object from the given *HeapPool*, initializing it with a specified value.

procedure INITIALIZE_SERVICES — initializes the memory management services.

package V_SEMAPHORES — provides binary and counting semaphores.

procedure CREATE_SEMAPHORE — creates and initializes a semaphore.

procedure DELETE_SEMAPHORE — deletes a semaphore.

procedure SIGNAL_SEMAPHORE — performs a signal operation on a semaphore.

procedure WAIT_SEMAPHORE — performs a wait operation on a semaphore.

package V_STACK — provides operations to control the stack.

procedure CHECK_STACK — determines the current value of the stack pointer and the stack lower boundary.

procedure EXTEND_STACK — extends the current stack.

package V_XTASKING — (extended tasking) provides operations that are performed on Ada tasks and programs.

function ALLOCATE_TASK_STORAGE — allocates storage in the task control block. It returns the storage ID to use in subsequent GET_TASK_STORAGE or GET_TASK_STORAGE2 service calls.

function CALLABLE — returns the P'CALLABLE attribute for the specified task.

function CURRENT_EXIT_DISABLED — returns current value for kernel EXIT_DISABLED_FLAG.

function CURRENT_FAST_RENDEZVOUS_ENABLED return boolean; pragma INLINE_ONLY(CURRENT_FAST_RENDEZVOUS_ENABLED);

function CURRENT_PRIORITY — returns the priority of the specified task.

function CURRENT_PROGRAM — returns the *program_id* of the current task

function CURRENT_TASK — returns the *task_id* of the current task.

`function CURRENT_TIME_SLICE` — returns the current time slice interval of the specified task.

`function CURRENT_TIME_SLICING_ENABLED` — returns the current value of the kernel `TIME_SLICING_ENABLED` configuration parameter.

`function CURRENT_USER_FIELD` — returns the current value for the user-modifiable field of the specified task.

`procedure DISABLE_PREEMPTION` — inhibits the current task from being preempted. It does not disable interrupts.

`procedure ENABLE_TASK_COMPLETE` — Enables the current task to be completed and terminated when aborted. Must be paired with `DISABLE_TASK_COMPLETE`.

`procedure ENABLE_PREEMPTION` — allows the current task to be preempted.

procedure `ENABLE_TASK_COMPLETE` — Enables the current task to be completed and terminated when aborted. Must be paired with `DISABLE_TASK_COMPLETE`.

`function GET_PROGRAM` — returns the *program_id* of the specified task.

`function GET_PROGRAM_KEY` — returns the user-defined key for the specified program.

`function GET_TASK_STORAGE` — returns the starting address of the task storage area for the specified task and storage ID.

function `GET_TASK_STORAGE2` — Returns the starting address of the task storage area using the OS's ID of the task.

`function ID` — returns an identifier for an Ada program or task given the underlying OS's program or task ID.

`procedure INSTALL_CALLOUT` — installs a procedure to be called at a program exit, program switch, task create, task switch, task complete, or idle event.

`procedure RESUME_TASK` — readies the named task for execution.

function `OS_ID` — Returns the underlying OS's program or task ID given the Ada program or task ID

`procedure SET_EXIT_DISABLED` — changes the kernel `EXIT_DISABLE_FLAG` to inhibit or allow the program to exit.

`procedure SET_PRIORITY` — changes the priority of the specified task to a new priority.

procedure `SET_FAST_RENDEZVOUS_ENABLED` — Changes the `FAST_RENDEZVOUS_ENABLED` flag for the current task to a new value.

`procedure SET_TIME_SLICE` — changes the time slice interval of the specified task.

`procedure SET_TIME_SLICING_ENABLED` — sets the kernel `TIME_SLICING_ENABLED` configuration parameter.

`procedure SET_USER_FIELD` — sets the user-modifiable field of the specified task to a new value.

`function START_PROGRAM` — starts another, separately-linked program that is identified by its link block and returns the *program_id* of the just started program.

`procedure SUSPEND_TASK` — suspends a running task.

`function TERMINATED` — returns the `P'TERMINATED` attribute for the specified task.

`procedure TERMINATE_PROGRAM` — terminates the specified program.

`generic function V_ID` — returns an identifier for a task given a task object of the task type used to instantiate the generic.

package V_INTERRUPTS — *provides interrupt processing*

Note – Interrupts are Solaris 2.1 signals, and the interrupt status mask is the signal mask. Throughout, an interrupt or interrupt vector is a Solaris 2.1 signal, and the interrupt status mask is the Solaris 2.1 signal mask.

Description

package V_INTERRUPTS provides interrupt processing support for the User Interface, through the use of user-defined interrupt service routines (ISRs).

VADS EXEC supports only signal handlers installed as an ISR via the ATTACH_ISR service. (Alternatively, install signal handlers as a task interrupt entry.) Avoid the use of the Solaris 2.1 sigvec or signal services. On entry to an ISR, the following actions are performed:

- All asynchronous signals are blocked (they must remain blocked; VADS EXEC does not support nested asynchronous signals).
- The scratch registers are saved.
- If supported by the OS signal handler logic, the floating-point registers are saved.
- The frame pointer is updated, so that the debugger and exception unwinding can deduce that this is the top of the stack for a signal handler.

The ISR performs user-defined signal handling actions. (Floating-point operations cannot execute in an ISR unless your Solaris 2.1 implementation saves and restores floating-point context for signals.) The ISR returns to enable VADS EXEC to complete signal handling and restore the saved context.

A generic procedure ISR provides a wrapper for the signal handler. Instantiate the procedure with a parameterless procedure that performs the user-defined signal handling actions.

Pass the address of the procedure created by the ISR instantiation to ATTACH_ISR to attach the interrupt service routine to the appropriate signal. Detach the ISR by a call to DETACH_ISR.

References

Section 2.1.1.2, “Ada Task,” on page 2-7
step one command, *SPARCompiler Ada User’s Guide*

Data References in ISRs

The user-defined interrupt handler must not reference non-local stack-relative data (including tasks declared in a subprogram). Instead, all references are to objects declared in library-level package specifications or bodies, in the interrupt handler or in subprograms called by the handler.

Exception Propagation in ISRs

Exceptions raised in an interrupt handler must be handled locally. Provide an `others` exception handler to prevent attempting to propagate an exception from an interrupt handler. If you do not provide a handler for a raised exception (such as `NUMERIC_ERROR`), the entire program is abandoned.

ISR/Ada Task Interaction

An ISR executes in the context of the task it interrupted. Since the ISR does not have its own task state, it must not perform any Ada tasking operations that affect the state of the interrupted task. Consequently, these Ada operations cannot be performed from inside an ISR:

- Task creations
- `accept` statements
- `entry` calls
- `delay` statements
- `abort` statements
- Evaluation of an allocator or deallocator

In addition, the ISR cannot invoke any VADS EXEC service that can block the interrupted task.

- `WAIT_SEMAPHORE`
- `READ_MAILBOX`
- Any `V_MEMORY` allocator or deallocator

If the ISR attempts to call a service that would block, the `TASKING_ERROR` exception is raised.

It can invoke any non-blocking VADS EXEC service, including these:

- `RESUME_TASK or SUSPEND_TASK`
- `SIGNAL_SEMAPHORE`
- `WRITE_MAILBOX`

Floating-point registers need not be saved before invoking VADS EXEC services from an ISR.

VADS EXEC tasking and interrupt services support preemptive task scheduling. If a call to a VADS EXEC service from an interrupt handler causes a task with a priority higher than the interrupted task to become ready to run, the higher priority task runs immediately on return from the outermost interrupt service routine.

Package Procedures and Functions

`function ATTACH_ISR`
Attaches an interrupt service routine to a given interrupt vector and returns the previously attached ISR

`procedure ATTACH_ISR`
Attaches an interrupt service routine to a given interrupt vector.

`function CURRENT_INTERRUPT_STATUS`
Retrieves the current CPU interrupt status mask or priority level.

`function CURRENT_SUPERVISOR_STATE`
Returns the supervisor / user state of the current task.

`function DETACH_ISR`
Detaches an interrupt service routine from a given interrupt vector and returns the previously attached ISR

`procedure DETACH_ISR`
Detaches an interrupt routine from a given interrupt vector.

`procedure ENTER_SUPERVISOR_STATE`
Enters the supervisor state for the current task, enabling execution of privileged instructions. (This procedure is not supported.)

`generic procedure FAST_ISR`
Provides a faster version of the ISR. However, restrictions are imposed on the interrupt handler code.

`generic procedure FLOAT_WRAPPER`
Saves and restores the floating point. (This generic procedure is not supported; it raises a `TASKING_ERROR` exception.)

`generic procedure ISR`
Provides the entry and exit code required of all interrupt service routines and performs all processing required upon entering and exiting an ISR.

`procedure LEAVE_SUPERVISOR_STATE`
Exits the supervisor state for the current task, disabling execution of privileged instructions. (This procedure is not supported.)

`function SET_INTERRUPT_STATUS`
Changes the current interrupt status and returns the previous interrupt status.

`function SET_SUPERVISOR_STATE`
Sets the supervisor / user state of the current task.

Types

`type VECTOR_ID`
Specifies the valid range for signal numbers.

`type INTERRUPT_STATUS_T`
Specifies the interrupt status

Constants

`DISABLE_INTERRUPT`
Passed to `SET_INTERRUPT_STATUS` to disable all interrupts

`ENABLE_INTERRUPT`
Passed to `SET_INTERRUPT_STATUS` to enable all interrupts

Exceptions

`INVALID_INTERRUPT_VECTOR`
Raised if the vector number passed to an operation is an invalid vector number.

`UNEXPECTED_V_INTERRUPTS_ERROR`
Can be raised if an unexpected error occurs in an `V_INTERRUPTS` routine.

`VECTOR_IN_USE`
Raised if you attempt to attach an ISR to a vector already attached to an ISR.

Example

Figure 4-1 demonstrates how to utilize services in a handling routine.

```
package ISR_EXAMPLE is
end;

with V_INTERRUPTS;
with SYSTEM;
package body ISR_EXAMPLE is
INTEGER_CNT: integer := 0; FLOAT_CNT: float := 0.0;
procedure INTEGER_HANDLER is begin
         -- No floating point operations
         INTEGER_CNT := INTEGER_CNT + 1; end;
procedure FLOAT_HANDLER is begin
         -- Does floating point operations
         FLOAT_CNT := FLOAT_CNT + 1.0; end;
procedure INTEGER_ISR is new
         V_INTERRUPTS.ISR(INTEGER_HANDLER;
        -- An instantiated isr that doesn't perform any floating
         -- point operations.
procedure WRAPPED_FLOAT_HANDLER is new
         V_INTERRUPTS.FLOAT_WRAPPER(FLOAT_HANDLER);
         -- An instantiated subprogram with floating point state
         -- saved and initialized upon entry and then restored
         -- upon return. This wrapped procedure is passed when
         -- the isr is instantiated.
procedure FLOAT_ISR is new
         V_INTERRUPTS.ISR(WRAPPED_FLOAT_HANDLER);
         -- An instantiated isr that performs floating point
         -- operations.
 begin
         declare
     prev_isr: SYSTEM.address;
         begin
                  -- Attach above instantiated isr's
     prev_isr := V_INTERRUPTS.ATTACH_ISR(16#80#,
                                         INTEGER_ISR'address);
                  prev_isr := V_INTERRUPTS.ATTACH_ISR(16#81#,
                                         FLOAT_ISR'address);
         end;
end ISR_EXAMPLE;
```

Figure 4-1 Example of Utilizing Services in a Handling Routine

Package Specification

```
with ADA_KRN_DEFS;
with SYSTEM;
package V_INTERRUPTS is
pragma SUPPRESS(ALL_CHECKS);
type VECTOR_ID is new ADA_KRN_DEFS.intr_vector_id_t;
type INTERRUPT_STATUS_T is new ADA_KRN_DEFS.intr_status_t;
ENABLE_INTERRUPT  : constant INTERRUPT_STATUS_T :=
         INTERRUPT_STATUS_T(ADA_KRN_DEFS.ENABLE_INTR_STATUS);
DISABLE_INTERRUPT : constant INTERRUPT_STATUS_T :=
         INTERRUPT_STATUS_T(ADA_KRN_DEFS.DISABLE_INTR_STATUS);
INVALID_INTERRUPT_VECTOR         : exception;
VECTOR_IN_USE                    : exception;
UNEXPECTED_V_INTERRUPTS_ERROR : exception;
generic
         with procedure INTERRUPT_HANDLER;
procedure ISR; pragma SHARE_CODE(ISR, FALSE);
generic
         with procedure INTERRUPT_HANDLER;
procedure FAST_ISR;
pragma SHARE_CODE(FAST_ISR, FALSE);
generic
         with procedure FLOAT_HANDLER;
procedure FLOAT_WRAPPER;
pragma SHARE_CODE(FLOAT_WRAPPER, FALSE);
function ATTACH_ISR
           (vector    : in     vector_id;
             isr        : in     system.address) return
system.address;
procedure ATTACH_ISR
           (vector    : in     vector_id;
           isr        : in     system.address);
function DETACH_ISR(vector : in vector_id) return system.address;
procedure DETACH_ISR(vector : in vector_id);
function CURRENT_INTERRUPT_STATUS return interrupt_status_t;
function SET_INTERRUPT_STATUS(new_status : in
interrupt_status_t)
                  return interrupt_status_t;
function CURRENT_SUPERVISOR_STATE return boolean;
procedure ENTER_SUPERVISOR_STATE;
procedure LEAVE_SUPERVISOR_STATE;
function SET_SUPERVISOR_STATE(new_state : in boolean) return
boolean;
end V_INTERRUPTS;
```

procedure /function ATTACH_ISR — *attach ISR to interrupt vector and optionally return the previously attached ISR.*

From Package

V_INTERRUPTS

Syntax

```
procedure ATTACH_ISR
   (vector   : in   VECTOR_ID;
   isr       : in    SYSTEM.ADDRESS);

function ATTACH_ISR
    (vector   :  in   VECTOR_ID;
     isr      : in   SYSTEM.ADDRESS)
          return SYSTEM.ADDRESS
```

Arguments

vector

Specifies the interrupt vector number to which the interrupt service routine is to be attached. The vector number is the number of the interrupt vector, not the vector offset. For Solaris 2.1, the signal number is 1-32.

isr

Specifies the address of the interrupt service routine

Description

procedure ATTACH_ISR is used to attach the ISR at isr to the interrupt vector indicated by vector.

function ATTACH_ISR attaches the ISR and returns the address of the previously attached ISR.

Exceptions

INVALID_INTERRUPT_VECTOR

The vector number is out-of-range.

VECTOR_IN_USE
Indicates that an interrupt handler is assigned already (ATTACH_ISR no longer raises this exception because ATTACH_ISR overrides any previously attached ISRs. For compatibility purposes, this exception is still described.)

Threaded Runtime

ATTACH_ISR is layered upon ADA_KRN_I.ISR_ATTACH.

function CURRENT_INTERRUPT_STATUS — *returns mask/priority setting*

From Package

V_INTERRUPTS

Syntax

```
function CURRENT_INTERRUPT_STATUS
   return interrupt_status_t;
```

Description

CURRENT_INTERRUPT_STATUS returns the current CPU status mask or priority level.

Threaded Runtime

CURRENT_INTERRUPT_STATUS is layered upon ADA_KRN_I.INTERRUPTS_GET_STATUS.

function CURRENT_SUPERVISOR_STATE — *returns supervisor/user state of task*

From Package

V_INTERRUPTS

Syntax

```
function CURRENT_SUPERVISOR_STATE
         return boolean;
```

Description

CURRENT_SUPERVISOR_STATE returns the supervisor/user state of the current task. If the task is in supervisor state, TRUE is returned. If the task is in user state, FALSE is returned.

Threaded Runtime

CURRENT_SUPERVISOR_STATE is layered upon ADA_KRN_I.TASK_GET_SUPERVISOR_STATE.

function/procedure DETACH_ISR — *detach an ISR from an interrupt vector and optionally return the previously attached ISR*

From Package

V_INTERRUPTS

Syntax

```
procedure DETACH_ISR
   (vector  :   in     VECTOR_ID);
function DETACH_ISR
   (vector  :   in     VECTOR_ID)
          return SYSTEM.ADDRESS;
```

Arguments

vector

Specifies the number of the interrupt vector to detach. The vector number is the number of the interrupt vector, not the offset vector. For Solaris 2.1, the signal number if 1-32.

Description

`procedure DETACH_ISR` detaches an interrupt routine from a specified interrupt vector. The attachment is performed during kernel initialization, if the vector is given an initial value in the interrupt vector table.

The default handler is reinstated.

`function DETACH_ISR` detaches the ISR and returns the address of the previously attached ISR.

Exceptions

`INVALID_INTERRUPT_VECTOR`

The vector number is out-of-range.

Threaded Runtime

`DETACH_ISR` is layered upon `ADA_KRN_I.ISR_DETACH`.

procedure ENTER_SUPERVISOR_STATE — *enter a task supervisor state*

From Package

V_INTERRUPTS

Syntax

```
procedure ENTER_SUPERVISOR_STATE
```

Description

ENTER_SUPERVISOR_STATE enables you to enter the supervisor state for the current task. While in supervisor state, execute privileged instructions.

Threaded Runtime

ENTER_SUPERVISOR_STATE is layered upon ADA_KRN_I.TASK_ENTER_SUPERVISOR_STATE.

Caution – ENTER_SUPERVISOR_STATE is not supported.

generic procedure FAST_ISR — *a faster version of the ISR generic*

From Package

V_INTERRUPTS

Syntax

```
generic
   with procedure INTERRUPT_HANDLER;
procedure FAST_ISR;
pragma SHARE_CODE (FAST_ISR, FALSE);
```

Description

Instantiate the generic procedure FAST_ISR with a parameterless procedure that provides the handler for a particular interrupt. Pass the address of the resulting instantiation to ATTACH_ISR to attach the interrupt service routine to a particular vector.

FAST_ISR is identical to the ISR generic.

Restriction

procedure INTERRUPT_HANDLER and the subprograms it calls must be compiled with pragma SUPPRESS(ALL_CHECKS) to suppress stack limit checking.

4

generic procedure FLOAT_WRAPPER — *save/restore floating-point coprocessor state*

From Package

V_INTERRUPTS

Syntax

```
generic
   with procedure FLOAT_HANDLER;
procedure FLOAT_WRAPPER;
pragma SHARE_CODE (FLOAT_WRAPPER, FALSE);
```

Description

FLOAT_WRAPPER saves and restores the floating-point state. Before procedure FLOAT_HANDLER is called, the floating-point state is reset and float exceptions are enabled according to the FLOATING_POINT_CONTROL parameter in the kernel program configuration package, V_KRN_CONF. (This generic procedure is not supported; it raises a TASKING_ERROR exception.

Caution – FLOAT_WRAPPER is not supported.

`generic procedure ISR` — *entry and exit code for ISRs*

From Package

`V_INTERRUPTS`

Syntax

```
generic
    with procedure INTERRUPT_HANDLER;
procedure ISR;
pragma SHARE_CODE(ISR, FALSE);
```

Description

ISR provides the wrapper required for all interrupt service routines. It can be instantiated with a with a parameterless procedure that provides the handler for a particular interrupt. Pass the address of the resulting instantiation to `ATTACH_ISR` to attach the interrupt service routine to a particular vector.

Caution – This wrapper does not save or restore the floating point context. This generic must be instantiated at the library package level

4

procedure LEAVE_SUPERVISOR_STATE — *exit a task supervisor state*

From Package

V_INTERRUPTS

Syntax

```
procedure LEAVE_SUPERVISOR_STATE
```

Description

LEAVE_SUPERVISOR_STATE exits from the supervisor state for the current task. After exiting the supervisor state, you cannot execute privileged instructions. Any attempt to execute a privileged instruction when you are not in supervisor state causes a CPU exception.

If the configuration variable V_KRN_CONF.supervisor_tasks_enabled is TRUE, all tasks are in supervisor state all the time. In this situation, procedure LEAVE_SUPERVISOR_STATE has no effect. (This procedure is not supported.)

Threaded Runtime

LEAVE_SUPERVISOR_STATE is layered upon ADA_KRN_I.TASK_LEAVE_SUPERVISOR_STATE

Caution – LEAVE_SUPREVISOR_STATE is not supported.

function SET_INTERRUPT_STATUS — *change the mask or priority setting*

From Package

V_INTERRUPTS

Syntax

```
function SET_INTERRUPT_STATUS
   (new_status  :     in INTERRUPT_STATUS_T)
   return INTERRUPT_STATUS_T;
```

Arguments

new_status
Specifies the new interrupt status setting

Description

The function SET_INTERRUPT_STATUS changes the setting of the interrupt status mask or priority and returns the previous interrupt status.

Threaded Runtime

SET_INTERRUPT_STATUS is layered upon ADA_KRN_I.INTERRUPTS_SET_STATUS.

function SET_SUPERVISOR_STATE — *change supervisor/user state of task*

From Package

V_INTERRUPTS

Syntax

```
function SET_SUPERVISOR_STATE
         (new_state  :       in      BOOLEAN)
         return boolean;
```

Arguments

new_state

The new supervisor / user state. If TRUE, the task is place in supervisor state. If FALSE, the task is placed in user state.

Description

The function SET_SUPERVISOR_STATE changes the supervisor / user state for the current task. The previous state is returned.

Threaded Runtime

SET_SUPERVISOR_STATE is layered upon the following services in package ADA_KRN_I:

```
TASK_GET_SUPERVISOR_STATE
TASK_ENTER_SUPERVISOR_STATE
TASK_LEAVE_SUPERVISOR_STATE
```

Caution – SET_SUPERVISOR_STATE is not supported.

package V_MAILBOXES — *provides mailbox operations*

Syntax

```
generic
  type MESSAGE_TYPE is private;
package V_MAILBOXES
```

Description

package V_MAILBOXES is a generic package which provides mailbox operations. Mailboxes can be used for the unsynchronized passing of data between tasks or between an interrupt handler and a task. V_MAILBOXES has been layered upon the Ada Kernel's mailbox objects.

procedure CREATE_MAILBOX creates a mailbox for passing objects of the type used to instantiate the generic package.

READ_MAILBOX reads messages from a mailbox on a first-in-first-out (FIFO) basis. Use a parameter to specify how long the task waits for a message, if one is not immediately available. The queuing order for tasks waiting to read a message depends on the attributes passed to CREATE_MAILBOX. The default is FIFO.

WRITE_MAILBOX writes a message to the mailbox and awakens a task waiting on the mailbox, if any. If the awakened task is of sufficient priority, it preempts the current running task.

DELETE_MAILBOX deletes a mailbox. You must specify the action to take if current tasks are waiting on the mailbox.

READ_MAILBOX and WRITE_MAILBOX are declared as overloaded procedures, so you can select the method of error notification. If a result parameter is provided in the call, a result status returns in the parameter; otherwise, an exception is raised if an error occurs.

MESSAGE_TYPE is the type of object which may be passed using the operations provided by an instantiation.

If a task aborts while accessing a mailbox, the resource is permanently locked.

Package Procedures and Functions

`procedure CREATE_MAILBOX`	Creates and initializes a mailbox
`procedure DELETE_MAILBOX`	Deletes a mailbox
`procedure READ_MAILBOX`	Retrieves a message from a mailbox
`procedure WRITE_MAILBOX`	Writes a message into a mailbox
`procedure CURRENT_MESSAGE_COUNT`	Returns the number of unread messages

Types

`MAILBOX_DELETE_OPTION`
Specifies the action to take during a call to `DELETE_MAILBOX` if tasks are waiting on the mailbox that is to be deleted or if the mailbox contains messages. Possible values are:

```
DELETE_OPTION_FORCE
DELETE_OPTION_WARNING
```

`MAILBOX_ID`
A private type that identifies mailboxes. The compiler type checks mailbox parameters to ensure that the buffer type is consistent with the mailbox ID.

`MESSAGE_TYPE`
Can be passed using the operations provided by an instantiation.

`MAILBOX_RESULT`
Returns the completion status of the versions of `READ_MAILBOX` and `WRITE_MAILBOX` that return a status. Possible values are:

```
DELETED
EMPTY
FULL
RECEIVED
SENT
TIMED_OUT
```

References

“procedure DELETE_MAILBOX — remove a mailbox” on page 4-34
“procedure READ_MAILBOX — retrieve a message” on page 4-36
“procedure WRITE_MAILBOX — deposit a message” on page 4-38

Constants

WAIT_FOREVER
Passed to the WAITTIME parameter of READ_MAILBOX to cause the mailbox to wait until a message is received.

DO_NOT_WAIT
Passed to the WAITTIME parameter of READ_MAILBOX to perform a non-waited read of the mailbox.

Exceptions

INVALID_MAILBOX
Raised if the mailbox ID passed to a mailbox operation does not identify an existing mailbox.

MAILBOX_DELETED
Raised by READ_MAILBOX if the mailbox was deleted during the read operation.

MAILBOX_EMPTY
Raised by READ_MAILBOX if an unwaited read was performed and a message was not in the mailbox.

MAILBOX_FULL
Raised by WRITE_MAILBOX if an attempt was made to write to a full mailbox.

MAILBOX_IN_USE
Raised by DELETE_MAILBOX if you attempt to delete a mailbox that a task is waiting for and the delete option is DELETE_OPTION_WARNING.

MAILBOX_NOT_EMPTY
Raised by DELETE_MAILBOX when you attempt to delete a mailbox that is not empty and the delete option is DELETE_OPTION_WARNING.

MAILBOX_TIMED_OUT
Raised by READ_MAILBOX if a timed wait was performed and a message did not arrive in the specified time interval.

NO_MEMORY_FOR_MAILBOX
Raised by CREATE_MAILBOX if insufficient memory was available to create the mailbox.

UNEXPECTED_V_MAILBOX_ERROR
Can be raised if an unexpected error occurs during a V_MAILBOX operation.

Example

This declaration creates a package that provides operations to pass characters via mailboxes.

```
with V_MAILBOXES;
package CHAR_BOX is new V_MAILBOXES
(MESSAGE_TYPE => CHARACTER);
```

The following declaration creates a package providing signal operations via mailboxes (i.e., messages of null length);

```
type signal_t is array(integer 1..0) of integer;
package signal is new V_MAILBOXES(MESSAGE_TYPE => signal_t);
```

Package Specification

```
with ADA_KRN_DEFS;
  generic
type MESSAGE_TYPE is private;
package V_MAILBOXES is

  pragma suppress(ALL_CHECKS);
  type mailbox_id is private;

type mailbox_delete_option is (DELETE_OPTION_FORCE,
DELETE_OPTION_WARNING);

  WAIT_FOREVER : constant duration := -1.0;
  DO_NOT_WAIT  : constant duration := 0.0;
```

(continued)

```
  NO_MEMORY_FOR_MAILBOX     :   exception;
  INVALID_MAILBOX           :   exception;
  MAILBOX_TIMED_OUT         :   exception;
  MAILBOX_EMPTY             :   exception;
  MAILBOX_DELETED           :   exception;
  MAILBOX_FULL              :   exception;
  MAILBOX_NOT_EMPTY         :   exception;
  MAILBOX_IN_USE            :   exception;
  UNEXPECTED_V_MAILBOX_ERROR:   exception;

  type  mailbox_result is (SENT, RECEIVED, TIMED_OUT, FULL, EMPTY,
DELETED);

 procedure CREATE_MAILBOX
       (numberslots         :   in    positive := 1;
       mailbox              :   out   mailbox_id;
      attr              :   in   ADA_KRN_DEFS.a_mailbox_attr_t:=
                                   ADA_KRN_DEFS.DEFAULT_MAILBOX_ATTR;
 function CREATE_MAILBOX
       (numberslots         :   in    positive := 1;
      attr              :   in   ADA_KRN_DEFS.a_mailbox_attr_t:=
                                    ADA_KRN_DEFS.DEFAULT_MAILBOX_ATTR;
                          return mailbox_id;

  procedure READ_MAILBOX
       (mailbox             :   in    mailbox_id;
       waittime             :   in    duration;
       message              :   out   message_type);

  procedure READ_MAILBOX
       (mailbox             :   in    mailbox_id;
       waittime             :   in    duration;
       message              :   out   message_type;
       result               :   out   mailbox_result);

  procedure WRITE_MAILBOX
       (mailbox             :   in    mailbox_id;
       message              :   in    message_type);

  procedure WRITE_MAILBOX
       (mailbox             :   in    mailbox_id;
       message              :   in    message_type;
       result               :   out   mailbox_result);

 function CURRENT_MESSAGE_COUNT
       (mailbox           :   in    mailbox_id) return natural;
```

(continued)

```
  procedure DELETE_MAILBOX
        (mailbox            :   in    mailbox_id;
        delete_option       :   in    mailbox_delete_option);
private
  type mailbox_rec;
  type mailbox_id is access mailbox_rec;
end V_MAILBOXES;
pragma SHARE_BODY(V_MAILBOXES, FALSE);
```

function/procedure CREATE_MAILBOX — *create a mailbox*

From Package

V_MAILBOXES

Syntax

```
function CREATE_MAILBOX
    (numberslots      :   in  positive := 1;
     mailbox          :   out mailbox_id;
    attr              :   in  ADA_KRN_DEFS.a_mailbox_attr_t :=
                                  Ada_KRN_DEFS.DEFAULT_MAILOBX_ATTR);

procedure CREATE_MAILBOX
    (numberslots      :   in  positive := 1;
    attr              :   in  ADA_KRN_DEFS.a_mailbox_attr_t :=
                                  Ada_KRN_DEFS.DEFAULT_MAILOBX_ATTR);
                return mailbox_id;
```

Arguments

attr

Points to an ADA_KRN_DEFS.MAILBOX_ATTR_T record. This record contains the mailbox attributes, which are dependent on the underlying threaded runtime. It can be found in ada_krn_defs.a in standard.

The *attr* parameter has been defaulted to DEFAULT_MAILBOX_ATTR. Unless you want to do something special., the default should suffice. VADS MICRO defaults to FIFO queuing when a task blocks waiting to read a message.

For VADS MICRO, use ADA_KRN_DEFS.DEFAULT_MAILBOX_INTR_ATTR to protect the mailbox's critical region by disabling all interrupts. The subprogram, ADA_KRN_DEFS.MAILBOX_INTR_ATTR_INIT can be used to initialize the attributes so that a subset of the interrupts are disabled.

If the mailbox is accessed from an ISR, it must be protected by disabling interrupts.

mailbox

Identifies the mailbox created.

numberslots
Specifies the number of message slots in the mailbox (maximum number of messages the mailbox holds).

Description

`CREATE_MAILBOX` creates and initializes a mailbox. Two versions of the call are supplied, a procedure that returns the mailbox ID as an out parameter and a function returning the mailbox ID. To notify other tasks of the mailbox ID, place the `MAILBOX_ID` variable at a package level.

Exceptions

`NO_MEMORY_FOR_MAILBOX`
Insufficient memory was available to create the mailbox.

Threaded Runtime

`CREATE_MAILBOX` is layered upon `ADA_KRN_I.MAILBOX_INIT`. See it for more details about mailbox attributes.

function CURRENT_MESSAGE_COUNT — *returns number unread messages*

From Package

V_MAILBOXES

Syntax

```
function CURRENT_MESSAGE_COUNT
     (mailbox           :  in     mailbox_id) return natural;
```

Arguments

mailbox

Identifies the mailbox to get the message count for.

Description

The function CURRENT_MESSAGE_COUNT takes one parameter, the mailbox ID and returns the number of unread messages currently in the that mailbox.

Threaded Runtime

CURRENT_MESSAGE_COUNT is layered upon ADA_KRN_I.MAILBOX_GET_COUNT.

procedure DELETE_MAILBOX — *remove a mailbox*

From Package

V_MAILBOXES

Syntax

```
procedure DELETE_MAILBOX
      (mailbox           :  in     mailbox_id)
      delete_option      :  in     mailbox_delete_option);
```

Arguments

mailbox

Identifier of the mailbox to be deleted.

delete_option

Specifies the action to take if the mailbox is in use or not empty. Possible values are:

DELETE_OPTION_FORCE — Ready all waiting tasks. These task calls to READ_MAILBOX raise the exception MAILBOX_DELETED or return the value DELETED.

The mailbox is deleted.

DELETE_OPTION_WARNING — If messages are in the mailbox, raise the exception MAILBOX_NOT_EMPTY in the calling task.

If tasks are waiting at the mailbox, then raise the exception MAILBOX_IN_USE in the calling task.

The mailbox is not deleted.

Description

procedure DELETE_MAILBOX removes a mailbox from the system. Deleting a mailbox releases all of the buffer space for the mailbox.

Exceptions

INVALID_MAILBOX
mailbox_id does not identify an existing mailbox.

MAILBOX_IN_USE
Mailbox was not empty and *delete_option* is DELETE_OPTION_WARNING.

MAILBOX_NOT_EMPTY
Tasks waiting at mailbox and *delete_option* was DELETE_OPTION_WARNING.

Threaded Runtime

DELETE_MAILBOX is layered upon ADA_KRN_I.MAILBOX_DESTROY.

4

procedure READ_MAILBOX — *retrieve a message*

From Package

V_MAILBOXES

Syntax

```
procedure READ_MAILBOX
      (mailbox          :  in     mailbox_id)
      waittime          :  in     duration;
      message           :  out    message_type);

procedure READ_MAILBOX
      (mailbox          :  in     mailbox_id;
      waittime          :  in     duration;
      message           :  out    message_type;
      result            :  out    mailbox_result)
```

Arguments

mailbox
Specifies the mailbox to read.

waittime
Specifies the time (in duration seconds) to wait for a message.

message
Specifies the message read from the mailbox.

Description

procedure READ_MAILBOX retrieves messages from a specified mailbox. To indicate that the task waits forever or not at all for a message, specify the constants WAIT_FOREVER and DO_NOT_WAIT, respectively.

Do not call READ_MAILBOX from an interrupt service routine unless *waittime* is specified as DO_NOT_WAIT.

Exception/Results

`INVALID_MAILBOX`
mailbox_id specifies a non-existent mailbox.

`MAILBOX_DELETED/DELETED`
Mailbox was deleted during the read operation.

`MAILBOX_EMPTY/EMPTY`
An unwaited read was performed and a message is not in the mailbox.

`MAILBOX_TIMED_OUT/TIMED_OUT`
A timed read is performed and a message was not received in the specified time interval.

`RECEIVED`
Result returned if a message is read.

Threaded Runtime

`READ_MAILBOX` is layered upon `ADA_KRN_I.MAILBOX_READ`.

procedure WRITE_MAILBOX — *deposit a message*

From Package

V_MAILBOXES

Syntax

```
procedure WRITE_MAILBOX
      (mailbox          :  in     mailbox_id)
      message           :  out    message_type);

procedure WRITE_MAILBOX
      (mailbox          :  in     mailbox_id;
      message           :  out    message_type;
      result            :  out    mailbox_result)
```

Arguments

mailbox
Mailbox to write to.

message
Message to write to the mailbox.

Description

If any tasks are waiting at the mailbox, the first-queued waiting task receives the message and becomes ready-to-run. If that task is of higher priority than the current task, it preempts the current task.

Call WRITE_MAILBOX from an interrupt service routine. If the write operation awakens a task with a higher priority than the interrupted task, the interrupted task is preempted upon completion of interrupt processing.

Exception/Results

`INVALID_MAILBOX`
mailbox_id specifies a non-existent mailbox.

`MAILBOX_FULL/FULL`
The mailbox is full.

`SENT`
Result returned if the message is sent.

Threaded Runtime

`WRITE_MAILBOX` is layered upon `ADA_KRN_I.MAILBOX_WRITE`.

References

“package V_INTERRUPTS — provides interrupt processing” on page 4-7

4

package V_MEMORY — *provides memory management operations*

Description

package V_MEMORY provides memory management operations through three distinct methods: *FixedPools*, *FlexPools*, and *HeapPools*.

For each type of pool, operations enable creation, deletion, allocation, and deallocation (with the exception that deallocation is not provided for *HeapPools*). The allocation and deallocation operations are implemented as generics that can be instantiated to create allocators and deallocators for a given type of object for a given type of pool.

FixedPools consist of constant-sized memory blocks, providing fast allocation and deallocation with constant time overheads. Fixed memory pools are best suited for storage of objects of relatively homogeneous size.

FlexPools contain variably-sized memory blocks, providing efficient memory use. The problem of fragmentation, inherent in variably-sized allocation schemes, is diminished by the VADS EXEC concept of granularity, whereby blocks are allocated on boundaries specified. *FlexPools* are organized around a standard boundary tag scheme, providing for compaction of adjacent blocks.

HeapPools provide the fastest memory allocation in VADS EXEC. No deallocation of heap memory. Therefore, no space overhead in managing the pool and minimal processing overhead in allocating from a heap. *HeapPools* are for circumstances where a pool of memory is required for a short period of time. After use, delete the entire pool.

Although, by default, memory for pool usage is allocated from a fixed address, allocate memory from a dynamic address. Simply perform an Ada “new” allocation and use this allocation as the starting address for the pool.

The maximum number of pools that exist at any time is 20. This limit applies only to package V_MEMORY.

Package Procedures and Functions

`procedure CREATE_FIXED_POOL`
Create a *FixedPool*.

`procedure CREATE_FLEX_POOL`
Create a *FlexPool*.

`procedure CREATE_HEAP_POOL`
Create a *HeapPool*.

`procedure DESTROY_FIXED_POOL`
Delete a *FixedPool*.

`procedure DESTROY_FLEX_POOL`
Delete a *FlexPool*.

`procedure DESTROY_HEAP_POOL`
Delete a *HeapPool*.

`generic function FIXED_OBJECT_ALLOCATION`
Allocate an object from the given *FixedPool*, initializing it with a specified value.

`generic procedure FIXED_OBJECT_DEALLOCATION`
Deallocate the memory at the given location.

`generic function FLEX_OBJECT_ALLOCATION`
Allocate an object from the given *FlexPool*, initializing it with a specified value.

`generic procedure FLEX_OBJECT_DEALLOCATION`
Deallocate the memory at the given location.

`generic function HEAP_OBJECT_ALLOCATION`
Allocate an object from the given *HeapPool*, initializing it with a specified value.

`procedure INITIALIZE_SERVICES`
Initialize memory services.

Types

FIXED_POOL_ID	A private type that identifies *FixedPools*
FLEX_POOL_ID	A private type that identifies *FlexPools*
HEAP_POOL_ID	A private type that identifies *HeapPools*

Exceptions

BAD_BLOCK
Raised if a deallocation request is made of memory that is not identifiable as an allocated block from a pool.

BAD_POOL_CREATION_PARAMETER
Raised if a pool cannot be created because a parameter passed to the create operation was unacceptable.

INVALID_POOL_ID
Raised if the pool ID passed to a pool operation does not correspond to an existing pool.

NO_AVAILABLE_POOL
Raised if a pool cannot be created because the maximum number of pools is allocated already.

NO_MEMORY
Raised if a memory request could not be honored because of insufficient memory in the pool.

OBJECT_LARGER_THAN_FIXED_BLOCK_SIZE
Raised if an attempt is made to allocate from a *FixedPool* an object whose size is greater than the size of the blocks in the pool.

UNCONSTRAINED_OBJECT
Raised by the allocation/deallocation subprograms if instantiated with an unconstrained OBJECT type.

UNEXPECTED_V_MEMORY_ERROR
Can be raised if an unexpected error (an internal V_MEMORY bug) occurs during a V_MEMORY operation.

Package Specification

```
with V_I_MEM;
with SYSTEM;
package V_MEMORY is

  pragma SUPPRESS(ALL_CHECKS);

  type fixed_pool_id is private;
  type flex_pool_id is private;
  type heap_pool_id is private;

  BAD_POOL_CREATION_PARAMETER         : exception;
  NO_AVAILABLE_POOL                   : exception;
  INVALID_POOL_ID                     : exception;
  NO_MEMORY                           : exception;
  BAD_BLOCK                           : exception;
  OBJECT_LARGER_THAN_FIXED_BLOCK_SIZE : exception;
  UNCONSTRAINED_OBJECT                : exception;
  UNEXPECTED_V_MEMORY_ERROR           : exception;

  procedure INITIALIZE_SERVICES
      (top_of_memory : in system.address := system.”+”(16#FFFF_FFFF#);
      machine_boundary : in integer := integer’size;
      granularity      : in integer := 16 );
  pragma INLINE_ONLY(INITIALIZE_SERVICES);

  procedure CREATE_FIXED_POOL
              (base_address   : in     system.address;
               pool_size      : in     natural;
               block_size     : in     natural;
               pool           : out    fixed_pool_id);
  pragma INLINE_ONLY(CREATE_FIXED_POOL);

generic
   type OBJECT is private;
   type POINTER is access OBJECT;
 function FIXED_OBJECT_ALLOCATION
             (pool              : in     fixed_pool_id;
              value             : in     object)
              return pointer;
 -- pragma INLINE(FIXED_OBJECT_ALLOCATION);
```

(Continued)

```
  generic
    type OBJECT is private;
    type POINTER is access OBJECT;
  procedure FIXED_OBJECT_DEALLOCATION
              (location          : in     pointer);
  -- pragma INLINE(FIXED_OBJECT_DEALLOCATION);

  procedure DESTROY_FIXED_POOL
               (pool             : in     fixed_pool_id);
  pragma INLINE_ONLY(DESTROY_FIXED_POOL);

  procedure CREATE_FLEX_POOL
              (base_address      : in     system.address;
               pool_size         : in     natural;
               pool              : out    flex_pool_id);
  pragma INLINE_ONLY(CREATE_FLEX_POOL);

  generic
    type OBJECT is private;
    type POINTER is access OBJECT;
  function FLEX_OBJECT_ALLOCATION
              (pool              : in     flex_pool_id;
               value             : in     object)
               return pointer;
  -- pragma INLINE(FLEX_OBJECT_ALLOCATION);

  generic
    type OBJECT is private;
    type POINTER is access OBJECT;

  procedure FLEX_OBJECT_DEALLOCATION
              (location          : in     pointer);
  -- pragma INLINE(FLEX_OBJECT_DEALLOCATION);

  procedure DESTROY_FLEX_POOL
              (pool              : in     flex_pool_id);
  -- pragma INLINE(DESTROY_FLEX_POOL);

  procedure CREATE_HEAP_POOL
              (base_address      : in     system.address;
               pool_size         : in     natural;
               pool              : out    heap_pool_id);
pragma INLINE_ONLY(CREATE_HEAP_POOL);
```

(Continued)

```
 generic
   type OBJECT is private;
   type POINTER is access OBJECT;
 function HEAP_OBJECT_ALLOCATION
             (pool              : in     heap_pool_id;
              value             : in     object)
              return pointer;
 -- pragma INLINE(HEAP_OBJECT_ALLOCATION);

 procedure DESTROY_HEAP_POOL
             (pool              : in     heap_pool_id);
  pragma INLINE_ONLY(DESTROY_HEAP_POOL);

private
  type fixed_pool_id is new V_I_MEM.pool_id;
  type flex_pool_id is new V_I_MEM.pool_id;
  type heap_pool_id is new V_I_MEM.pool_id;
end V_MEMORY;
```

4

procedure CREATE_FIXED_POOL — *create a FixedPool*

From Package

V_MEMORY

Syntax

```
procedure CREATE_FIXED_POOL
              (base_address   : in     system.address;
               pool_size      : in     natural;
               block_size     : in     natural;
               pool           : out    fixed_pool_id);
pragma INLINE_ONLY (CREATE_FIXED_POOL);
```

Arguments

base_address
Address at which the pool starts.

pool_size
Amount of memory, in bytes, to allocate to the pool.

block_size
Size of each block, in bytes, in the pool.

pool
Identifier associated with the created pool.

Description

Upon creation, the pool is subdivided into blocks. Each block is of the size specified by the *block_size* parameter. A 20-byte header that contains information used to manage the pool precedes each block.

Thus, a 16#10_000# byte pool of 16#400# byte blocks provides 62 blocks, with 1240 bytes used for headers.

Exceptions

BAD_POOL_CREATION_PARAMETER
Raised if a pool creation parameter was invalid.

NO_AVAILABLE_POOL
Raised if the maximum number of pools that can exist simultaneously in the system are allocated already.

procedure CREATE_FLEX_POOL — *create a FlexPool*

From Package

V_MEMORY

Syntax

```
procedure CREATE_FLEX_POOL
              (base_address       : in     system.address;
               pool_size          : in     natural;
               pool               : out    flex_pool_id);
pragma INLINE_ONLY (CREATE_FLEX_POOL);
```

Arguments

base_address
Address at which the pool starts.

pool_size
Amount of memory, in bytes, to allocate to the pool.

pool
Identifier associated with the created pool.

Description

Each block in a *FlexPool* requires 28 bytes of overhead for pool management. On creation, blocks are created at the front and back of the pool to simplify the pool management operations. Because these are null blocks, they consume a total of 56 bytes.

After creation, a 1000-byte pool contains a 916-byte block. Subsequent allocations split this block into smaller blocks.

Exceptions

BAD_POOL_CREATION_PARAMETER
Raised if a pool creation parameter was invalid.

NO_AVAILABLE_POOL
Raised if the maximum number of pools that can exist simultaneously in the system is allocated already.

4

procedure CREATE_HEAP_POOL — *create a HeapPool*

From Package

V_MEMORY

Syntax

```
procedure CREATE_HEAP_POOL
              (base_address       : in     system.address;
               pool_size          : in     natural;
               pool               : out    heap_pool_id);
pragma INLINE_ONLY (CREATE_HEAP_POOL);
```

Arguments

base_address
Address at which the pool starts.

pool_size
Amount of memory to allocate to the pool.

pool
Identifier associated with the created pool.

Description

No internal management is performed on *HeapPools* and thus, no memory in the pool is reserved for pool management. A 1000-byte pool provides 1000 bytes of available memory.

Exceptions

BAD_POOL_CREATION_PARAMETER
A pool creation parameter was invalid.

NO_AVAILABLE_POOL
The maximum number of pools that can exist simultaneously in the system is allocated already.

procedure DESTROY_FIXED_POOL — *delete a FixedPool*

From Package

V_MEMORY

Syntax

```
procedure DESTROY_FIXED_POOL  (pool   : in   fixed_pool_id);
pragma INLINE_ONLY (DESTROY_FIXED_POOL);
```

Arguments

pool

Identifier of the pool to delete.

Exceptions

INVALID_POOL_ID

pool does not identify a *FixedPool.*

procedure DESTROY_FLEX_POOL — *delete a FlexPool*

From Package

V_MEMORY

Syntax

```
procedure DESTROY_FLEX_POOL   (pool   : in   flex_pool_id);
pragma INLINE_ONLY (DESTROY_FLEX_POOL);
```

Arguments

pool
Identifier of the pool to delete.

Exceptions

INVALID_POOL_ID
pool does not identify a *FlexPool.*

procedure DESTROY_HEAP_POOL — *delete a HeapPool*

From Package

V_MEMORY

Syntax

```
procedure DESTROY_HEAP_POOL   (pool   : in   heap_pool_id);
pragma INLINE_ONLY (DESTROY_HEAP_POOL);
```

Arguments

pool

Identity of the pool to delete.

Exceptions

INVALID_POOL_ID

pool does not identify a *HeapPool*.

generic function FIXED_OBJECT_ALLOCATION — *allocate FixedPool object*

From Package

V_MEMORY

Syntax

```
generic
  type OBJECT is private;
  type POINTER is access OBJECT;

function FIXED_OBJECT_ALLOCATION
            (pool           : in     fixed_pool_id;
             value          : in     object)
             return pointer;
```

Arguments

pool
Specifies the pool from which to allocate the object.

value
Specifies the initial value for the object.

Description

FIXED_OBJECT_ALLOCATION allocates an object of type OBJECT from a specified *FixedPool*, initializing it with the specified *value*. Multiple instantiations of FIXED_OBJECT_ALLOCATION can use the same *FixedPool*.

Exceptions

INVALID_POOL_ID
Raised if *pool* does not identify a *FixedPool*.

NO_MEMORY
Raised if the object could not be allocated from the pool due to insufficient memory.

OBJECT_LARGER_THAN_FIXED_BLOCK_SIZE
Raised if the size of the object exceeded the size of the pool blocks.

UNCONSTRAINED_OBJECT
Raised if the generic was instantiated with an unconstrained OBJECT type.

generic procedure FIXED_OBJECT_DEALLOCATION — *deallocate FixedPool memory*

From Package

V_MEMORY

Syntax

```
generic
  type OBJECT is private;
  type POINTER is access OBJECT;

procedure FLEX_OBJECT_DEALLOCATION
             (location          : in     pointer);
```

Arguments

location
Pointer to the object whose space is to be deallocated.

Description

FIXED_OBJECT_DEALLOCATION deallocates memory at the given location.

Exceptions

BAD_BLOCK
Raised if the pointer does not point to a block in a *FixedPool*.

generic function FLEX_OBJECT_ALLOCATION — *allocate a FlexPool object*

From Package

V_MEMORY

Syntax

```
generic
  type OBJECT is private;
  type POINTER is access OBJECT;

function FLEX_OBJECT_ALLOCATION
              (pool             : in     flex_pool_id;
               value            : in     object)
               return pointer;
```

Arguments

pool
Pool from which to allocate the object.

value
Initial value for the object.

Description

FLEX_OBJECT_ALLOCATION allocates an object of type OBJECT from a specified *FlexPool*, initializing it with the specified *value*.

The object is allocated from the pool using a first-fit algorithm. If, after taking into account the pool granularity, enough unused memory is in the selected block to create a new block, the block is split into two blocks.

Exceptions

INVALID_POOL_ID
pool does not identify a *FlexPool*.

NO_MEMORY
The object could not be allocated from the pool because of insufficient memory.

UNCONSTRAINED_OBJECT
Raised if the generic was instantiated with an unconstrained OBJECT type.

generic procedure FLEX_OBJECT_DEALLOCATION — *deallocate FlexPool memory*

From Package

V_MEMORY

Syntax

```
generic
  type OBJECT is private;
  type POINTER is access OBJECT;

procedure FLEX_OBJECT_DEALLOCATION
            (location          : in     pointer);
```

Arguments

location

Pointer to the object whose space is to be deallocated.

Description

This procedure combines the deallocated block with any adjoining free blocks to form a single, larger free block.

Exceptions

BAD_BLOCK

The pointer does not point to a block in a *FlexPool*.

4

generic function HEAP_OBJECT_ALLOCATION — *allocate HeapPool object*

From Package

V_MEMORY

Syntax

```
generic
  type OBJECT is private;
  type POINTER is access OBJECT;

function HEAP_OBJECT_ALLOCATION
            (pool           : in     heap_pool_id;
             value          : in     object)
             return pointer;
```

Arguments

pool
Pool from which to allocate the object.

value
Initial value for the object.

Description

HEAP_OBJECT_ALLOCATION allocates an object of type OBJECT from a specified *HeapPool*, initializing it with the specified *value*. Heap objects are allocated through a pointer, which indicates the next available block and the number of bytes available.

Exceptions

INVALID_POOL_ID
pool does not identify a *HeapPool*.

NO_MEMORY
The object could not be allocated from the pool because of insufficient memory.

UNCONSTRAINED_OBJECT
Raised if the generic was instantiated with an unconstrained OBJECT type.

procedure INITIALIZE_SERVICES — *initialize memory services*

From Package

V_MEMORY

Syntax

```
procedure INITIALIZE_SERVICES
      (top_of_memory      :  in    system.address :=
                                     system.”+”(16#FFFF_FFFF#);
      machine_boundary    :  in    integer := integer’size;
      granularity         :  in    integer := 16);
pragma INLINE_ONLY(INITIALIZE_SERVICES);
```

Arguments

top_of_memory
Specifies the highest memory location addressable by the target/host (default value = 16#FFFF-FFFF#).

machine_boundary
Specifies the CPU natural boundary, in BITS.

granularity
Controls memory fragmentation within the flex memory pools.

Description

procedure INITIALIZE_SERVICES initializes memory services by supplying them with top-of-memory, machine boundary and granularity information. The machine boundary parameter is particularly important on machines that impose specific bit alignment for certain data types. For INITIALIZE_SERVICES, the *machine_boundary* parameter defaults to INTEGER’SIZE.

In procedure INITIALIZE_SERVICES, the granularity parameter controls *FlexPool* memory fragmentation. *Flexpools* provide storage in blocks of various sizes, differing in BYTES, which causes all allocation requests to round to the nearest multiple of 16. Unless specified otherwise, INITIALIZE_SERVICES defaults the granularity to 16.

INITIALIZE_SERVICES must be called before any of the memory services. The V_MEMORY package body calls INITIALIZE_SERVICES, using the default parameter values. Consequently, call INITIALIZE_SERVICES only when you want to override the default parameters.

The *top_of_memory* parameter validates the BASE_ADDRESS parameter for the CREATE_FIXED_POOL, CREATE_FLEX_POOL, and CREATE_HEAP_POOL services. The default value of 16#FFFF_FFFF# ensures that any BASE_ADDRESS parameter is valid.

package V_SEMAPHORES — *provides binary and counting semaphores*

Description

package V_SEMAPHORES provides operations for binary and counting semaphores. The semaphore data structure is allocated by using the Ada "new" allocator.

V_SEMAPHORES has been layered on the Ada Kernel's binary and counting semaphore objects.

The following operations are overloaded and apply to both binary and counting semaphores.

The operation CREATE_SEMAPHORE creates a semaphore with an initial semaphore count. The semaphore count indicates the number of available resources; for example, an initial value of one allows only one task at a time to access the semaphore.

WAIT_SEMAPHORE decrements the semaphore count, causing the task to block on the semaphore if the semaphore is not available (the count becomes negative). The queuing order for blocked tasks depends on the attributes passed to CREATE_SEMAPHORE. VADS MICRO only supports first-in-first-out (FIFO) queuing for binary semaphores. For counting semaphores, FIFO or priority ordered queues are supported with FIFO as the default. The task must specify how long it can wait for the semaphore.

WAIT_SEMAPHORE enables you to select the error notification method. If a result parameter is provided in the call, a result status returns in the parameter; otherwise, an exception is raised if an error occurs.

SIGNAL_SEMAPHORE increments the semaphore count and awakens a task that is waiting on the semaphore, if any. If the awakened task is of sufficient priority, it preempts the current task.

DELETE_SEMAPHORE removes a semaphore. You must specify the action to take if tasks are currently waiting on the semaphore.

Package Procedures and Functions

procedure CREATE_SEMAPHORE
Creates and initializes a semaphore.

procedure DELETE_SEMAPHORE
Deletes a semaphore.

`procedure SIGNAL_SEMAPHORE`
Performs a signal operation on a semaphore.

`procedure WAIT_SEMAPHORE`
Performs a wait operation on a semaphore.

Types

`COUNT_SEMAPHORE_ID`
A private type that identifies a counting semaphore.

`BINARY_SEMAPHORE_ID`
A private type that identifies a binary semaphore.

`SEMAPHORE_DELETE_OPTION`
Specifies the action to take during a call to `DELETE_SEMAPHORE` if tasks are waiting on the semaphore to delete. Possible values are:

```
DELETE_OPTION_FORCE
DELETE_OPTION_WARNING
```

`SEMAPHORE_RESULT`
Returns the completion status of the version of `WAIT_SEMAPHORE` that returns a status. Possible values are:

```
OBTAINED
TIMED_OUT
NOT_AVAILABLE
DELETED
```

Use `pragma NO_IMAGE` to eliminate the excess space overhead for enumeration types. The image array associated with an enumeration type is allocated in its own `CONST` subsection and is deleted by selective linking, if no uses of `ENUM_TYPE'image` exist.

References

“procedure DELETE_SEMAPHORE — delete a semaphore” on page 4-67
“procedure WAIT_SEMAPHORE — perform a wait operation” on page 4-70

Subtypes

`BINARY_COUNT_T`
Restricts the range for the initial count of a binary semaphore.

Constants

WAIT_FOREVER
: Can be passed to the WAIT_TIME parameter of WAIT_SEMAPHORE to wait on the semaphore until it is signaled.

DO_NOT_WAIT
: Can be passed to the WAIT_TIME parameter of WAIT_SEMAPHORE to specify that the call must not block on the semaphore. If the semaphore is not available, an appropriate status is returned, or an exception is raised.

Exceptions

NO_MEMORY_FOR_SEMAPHORE
: Raised by CREATE_SEMAPHORE if an attempt is made to create a semaphore and insufficient memory exists for the semaphore object.

SEMAPHORE_DELETED
: Raised by WAIT_SEMAPHORE if the semaphore is deleted while the task was waiting.

SEMAPHORE_IN_USE
: Raised by DELETE_SEMAPHORE if an attempt is made to delete a semaphore when tasks are waiting on the semaphore and DELETE_OPTION_WARNING is specified.

SEMAPHORE_NOT_AVAILABLE
: Raised by WAIT_SEMAPHORE if a non-waited attempt is made to obtain the semaphore and the semaphore was not available.

SEMAPHORE_TIMED_OUT
: Raised by WAIT_SEMAPHORE if a timed wait is attempted and the semaphore did not become available in the given time interval.

UNEXPECTED_V_SEMAPHORE_ERROR
: Can be raised if a semaphore routine is called with an invalid pointer to a semaphore or called using a deleted semaphore.

Package Specification

```
with ADA_KRN_DEFS;
 package V_SEMAPHORES is

 pragma SUPPRESS(ALL_CHECKS);

 type binary_semaphore_id is private;

 type count_semaphore_id is private;

 subtype binary_count_t is integer range 0 .. 1;

 type semaphore_delete_option is
 (DELETE_OPTION_FORCE,DELETE_OPTION_WARNING);

WAIT_FOREVER : constant duration := -1.0;
DO_NOT_WAIT  : constant duration := 0.0;

NO_MEMORY_FOR_SEMAPHORE         : exception;
SEMAPHORE_IN_USE                : exception;
SEMAPHORE_DELETED               : exception;
SEMAPHORE_NOT_AVAILABLE         : exception;
SEMAPHORE_TIMED_OUT             : exception;
UNEXPECTED_V_SEMAPHORE_ERROR    : exception;

type semaphore_result is (OBTAINED, TIMED_OUT,
                          NOT_AVAILABLE,  DELETED);

 procedure CREATE_SEMAPHORE
        (initial_count       : in  binary_count_t := 1;
        semaphore            : out binary_semaphore_id;
         attr                : in  ADA_KRN_DEFS.a_semaphore_attr_t :=
                                      ADA_KRN_DEFS.DEFAULT_SEMAPHORE_ATTR);
function CREATE_SEMAPHORE
        (initial_count      : in  binary_count_t := 1;
         attr               : in  ADA_KRN_DEFS.a_semaphore_attr_t :=
                                       ADA_KRN_DEFS.DEFAULT_SEMAPHORE_ATTR)
         return binary_semaphore_id;
procedure CREATE_SEMAPHORE
         (initial_count         : in  integer := 1;
         semaphore              : out count_semaphore_id;
       attr                : in  ADA_KRN_DEFS.a_count_semaphore_attr_t
:=
                             ADA_KRN_DEFS.DEFAULT_COUNT_SEMAPHORE_ATTR);
function CREATE_SEMAPHORE
         (initial_count         : in integer := 1;
       attr               : in ADA_KRN_DEFS.a_count_semaphore_attr_t :=
                              ADA_KRN_DEFS.DEFAULT_COUNT_SEMAPHORE_ATTR)
         return count_semaphore_id;
```

```
(continued)

procedure DELETE_SEMAPHORE
         (semaphore        : in   binary_semaphore_id;
         delete_option     : in   semaphore_delete_option);

procedure DELETE_SEMAPHORE
         (semaphore        : in   count_semaphore_id;
         delete_option     : in   semaphore_delete_option);

procedure SIGNAL_SEMAPHORE
         (semaphore        : in   binary_semaphore_id);

procedure SIGNAL_SEMAPHORE
         (semaphore        : in   count_semaphore_id);

procedure WAIT_SEMAPHORE
         (semaphore       : in   binary_semaphore_id;
         wait_time        : in   duration);

procedure WAIT_SEMAPHORE
         (semaphore       : in   binary_semaphore_id;
         wait_time        : in   duration;
         result           : out  semaphore_result);

procedure WAIT_SEMAPHORE
         (semaphore       : in   count_semaphore_id;
         wait_time        : in   duration);

procedure WAIT_SEMAPHORE
         (semaphore       : in   count_semaphore_id;
         wait_time        : in   duration;
         result           : out  semaphore_result);

private
         type binary_semaphore_rec;
         type binary_semaphore_id is access binary_semaphore_rec;
         type count_semaphore_rec;
         type count_semaphore_id is access count_semaphore_rec;
end V_SEMAPHORES;
```

procedure CREATE_SEMAPHORE — *create a semaphore*

From Package

V_SEMAPHORES

Syntax

```
procedure CREATE_SEMAPHORE
         (initial_count          : in  binary_count_t := 1;
          semaphore              : out binary_semaphore_id;
         attr                  : in  ADA_KRN_DEFS.a_semaphore_attr_t :=
                             ADA_KRN_DEFS.DEFAULT_SEMAPHORE_ATTR);

function CREATE_SEMAPHORE
         (initial_count          : in  binary_count_t := 1;
         attr                  : in  ADA_KRN_DEFS.a_semaphore_attr_t :=
                              ADA_KRN_DEFS.DEFAULT_SEMAPHORE_ATTR)
          return binary_semaphore_id;

procedure CREATE_SEMAPHORE
         (initial_count          : in  integer := 1;
          semaphore                : out count_semaphore_id;
          attr       : in  ADA_KRN_DEFS.a_count_semaphore_attr_t  :=
                             ADA_KRN_DEFS.DEFAULT_COUNT_SEMAPHORE_ATTR);

function CREATE_SEMAPHORE
         (initial_count          : in integer := 1;
        attr            : in ADA_KRN_DEFS.a_count_semaphore_attr_t :=
                              ADA_KRN_DEFS.DEFAULT_COUNT_SEMAPHORE_ATTR)
          return count_semaphore_id;
```

Arguments

attr

For the binary CREATE_SEMAPHORE, attr points to an ADA_KRN_DEFS.SEMAPHORE_ATTR_T record. For the counting CREATE_SEMAPHORE, attr points to an ADA_KRN_DEFS.COUNT_SEMAPHORE_ATTR_T record. These records contain the binary/counting attributes. These are dependent on the underlying threaded runtime. The type definitions of SEMAPHORE_ATTR_T and COUNT_SEMAPHORE_ATTR_T and the different options supported are found in ada_krn_defs.a in standard.

The attr parameter has been defaulted to DEFAULT_SEMAPHORE_ATTR or DEFAULT_COUNT_SEMAPHORE_ATTR. Unless you want to do something special, the default should suffice. VADS MICRO defaults to FIFO queuing when a task blocks waiting for a semaphore.

For the VADS MICRO counting CREATE_SEMAPHORE, use ADA_KRN_DEFS.DEFAULT_COUNT_INTR_ATTR to protect the critical region for updating the semaphore's count by disabling all interrupts.

The subprogram, ADA_KRN_DEFS.COUNT_INTR_ATTR_INIT can be used to initialize the attributes so that a subset of the interrupts are disabled.

If the counting semaphore is to be signaled from an ISR, it must be protected by disabling interrupts.

initial_count

Specifies the initial number of resources allocated to the semaphore. (Binary semaphores are restricted to an initial count of 0 or 1. Use binary semaphores with an initial value of 0 for event posting.)

semaphore

Specifies the identifier for the created semaphore.

Description

CREATE_SEMAPHORE creates and initializes a binary or counting semaphore. Two versions are supplied for each semaphore type, a procedure that returns the semaphore ID as an out parameter or a function that returns the semaphore ID.

Exceptions

NO_MEMORY_FOR_SEMAPHORE
Semaphore could not be created because of insufficient memory.

Threaded Runtime

CREATE_SEMAPHORE is layered upon ADA_KRN_I.SEMAPHORE_INIT or ADA_KRN_I.COUNT_SEMAPHORE_INIT. See them for more details about semaphore and counting semaphore attributes.

procedure DELETE_SEMAPHORE — *delete a semaphore*

From Package

V_SEMAPHORES

Syntax

```
procedure DELETE_SEMAPHORE
            (semaphore       : in     binary_semaphore_id;
             delete_option   : in     semaphore_delete_option);

procedure DELETE_SEMAPHORE
            (semaphore       : in     count_semaphore_id;
             delete_option   : in     semaphore_delete_option);
```

Arguments

semaphore

Specifies the identifier of the semaphore to delete.

delete_option

Specifies the action to take *if* the semaphore is in use. Possible values are:

DELETE_OPTION_FORCE — Ready all waiting tasks. These task calls to WAIT_SEMAPHORE raise the exception SEMAPHORE_DELETED or return the result value DELETED. The semaphore is deleted.

DELETE_OPTION_WARNING — Raise the exception SEMAPHORE_IN_USE in the calling task. The semaphore is not deleted.

Description

DELETE_SEMAPHORE is used to delete either a binary or counting semaphore. Note that the memory allocated for the semaphore is always freed after the semaphore is deleted.

Exceptions

SEMAPHORE_IN_USE

Raised if an attempt is made to delete a semaphore when tasks are waiting on the semaphore and DELETE_OPTION_WARNING ia specified.

Threaded Runtime

DELETE_SEMAPHORE is layered upon ADA_KRN_I.SEMAPHORE_DESTROY or ADA_KRN_I.COUNT_SEMAPHORE_DESTROY.

procedure SIGNAL_SEMAPHORE — *perform a signal operation*

From Package

V_SEMAPHORES

Syntax

```
procedure SIGNAL_SEMAPHORE
            (semaphore     : in     binary_semaphore_id);

procedure SIGNAL_SEMAPHORE
            (semaphore     : in     count_semaphore_id);
```

Arguments

semaphore

Specifies the identifier of the semaphore to signal.

Description

SIGNAL_SEMAPHORE performs a signal operation on a semaphore. If tasks are waiting on the semaphore, the signal operation readies a waiting task. If the readied task has a priority higher than the current task, the waiting task preempts the current task.

Call this service from an interrupt service routine.

Threaded Runtime

SIGNAL_SEMAPHORE is layered upon ADA_KRN_I.SEMAPHORE_SIGNAL or ADA_KRN_I.COUNT_SEMAPHORE_SIGNAL.

procedure WAIT_SEMAPHORE — *perform a wait operation*

From Package

V_SEMAPHORES

Syntax

```
procedure WAIT_SEMAPHORE
            (semaphore      : in     binary_semaphore_id;
             wait_time      : in     duration);

procedure WAIT_SEMAPHORE
            (semaphore      : in     binary_semaphore_id;
             wait_time      : in     duration;
             result         : out    semaphore_result);

procedure WAIT_SEMAPHORE
            (semaphore      : in     count_semaphore_id;
             wait_time      : in     duration);

procedure WAIT_SEMAPHORE
            (semaphore      : in     count_semaphore_id;
             wait_time      : in     duration;
             result         : out    semaphore_result);
```

Arguments

semaphore

Specifies the identifier of the semaphore to wait on.

wait_time

Specifies the amount of tim to wait for the resource governed by the semaphore. Two predefined values that are allowable are:

WAIT_FOREVER — Wait forever for the semaphore.

DO_NOT_WAIT — Do not wait if semaphore is not available.

Other values are allowable.

Description

Do not call WAIT_SEMAPHORE from an interrupt service routine, unless the *wait_time* is specified as DO_NOT_WAIT.

Exceptions/Results

SEMAPHORE_DELETED/DELETED
Semaphore was deleted while the task was waiting.

SEMAPHORE_NOT_AVAILABLE/NOT_AVAILABLE
A non-waited attempt was made to obtain the semaphore and the semaphore is not available.

SEMAPHORE_TIMED_OUT/TIMED_OUT
A timed wait was attempted and the semaphore did not become available in the given time interval.

OBTAINED
Result returned if the semaphore is obtained.

Threaded Runtime

WAIT_SEMAPHORE is layered upon ADA_KRN_I.SEMAPHORE_WAIT or ADA_KRN_I.COUNT_SEMAPHORE_WAIT.

4

package V_STACK — *provides stack operations*

Description

package V_STACK provides stack operations. procedure CHECK_STACK returns the current value of the stack pointer and the lower limit of the stack. Another procedure is provided to extend the current sack.

Package Procedures and Functions

procedure CHECK_STACK
: Returns the current value of the stack pointer and the lower limit of the stack.

procedure EXTEND_STACK
: Extends the current stack.

Package Specification

```
with SYSTEM;
package V_STACK is

  pragma SUPPRESS(ALL_CHECKS);

  procedure CHECK_STACK
              (current :  out system.address;
               limit   :  out system.address);
 pragma INLINE_ONLY(CHECK_STACK);

 procedure EXTEND_STACK;
 pragma INLINE_ONLY(EXTEND_STACK);

end V_STACK;
```

procedure CHECK_STACK — *returns stack pointer value and lower limit*

From Package

V_STACK

Syntax

```
procedure CHECK_STACK
           (current :  out system.address;
            limit   :  out system.address);
pragma INLINE_ONLY(CHECK_STACK);
```

Arguments

current
Current value of the stack pointer

limit
Value of the stack's lower boundary

Description

CHECK_STACK returns the current value of the stack pointer and the stack lower boundary. Use this information to determine the amount of space remaining on the stack. The CURRENT out parameter returned by CHECK_STACK is a close approximation of the current SP. Because of compiler code, CHECK_STACK can return a value that is a few bytes lower than the actual SP.

Under certain conditions, code generated by this procedure may not use the stack. However, the compiler can implicitly generate code that uses the stack to generate a reference to the parameters. Use disassembly of the inline expansion to determine if a given call performs stack allocation.

procedure EXTEND_STACK — *extends the current stack*

From Package

V_STACK

Syntax

```
procedure EXTEND_STACK;
pragma INLINE_ONLY(EXTAND_STACK);
```

Description

This service is no longer supported. It always raises STORAGE_EXCEPTION exception.

package V_XTASKING — *provides Ada task operations*

Description

XTASKING (extended tasking) provides operations that can be performed on Ada tasks. XTASKING services augment the services defined by the language.

SUSPEND_TASK immediately inhibits the task from running regardless of its current state. RESUME_TASK allows a suspended task to run when it is in a ready-to-run state. Neither SUSPEND_TASK or RESUME_TASK affects the task's state.

In addition to SUSPEND_TASK and RESUME_TASK, V_TASKING provides operations to determine the current task, and to get and set these task parameters: priority, time slice interval, user field, fast rendezvous enabled, callable attribute, and terminated attribute. (The attribute parameters cannot be set.) V_XTASKING provides operations to get and set the global time slicing enabled configuration parameter.

Services to disable and enable task preemption are provided. In addition, services to disable and enable the current task from being completed / terminated by an ABORT are available.

Ada tasks and programs are layered upon the underlying OS tasks and programs. Services are provided for mapping an Ada task ID to an OS task ID and vice versa. Services are also provided for mapping program IDs.

For cross versions, V_XTASKING provides a service to start and terminate another separately-linked program. It has services to get the program ID of the current program or for any task.

Services are provided to install subprogram callouts resident in the user program for program, task and idle events. Install a callout for the following program events: an exit, unexpected exit (main program abandoned because of an unhandled exception), or switch. Install a callout for the following task events: creation, switch, and completion. A callout can be called whenever the kernel is in its idle state. Additionally, allocate user-defined storage in the control block for a task.

Ada Tasking has the global flag, EXIT_DISABLED_FLAG, which can be set to TRUE to inhibit the program from exiting. Services are provided to get and set this flag.

Package Procedures and Functions

`function ALLOCATE_TASK_STORAGE`
Allocates storage in the task control block. It returns the storage ID used in subsequent `GET_TASK_STORAGE` or `GET_TASK_STORAGE2` service calls.

`function CALLABLE`
Returns the `P'CALLABLE` attribute for the specified task.

`function CURRENT_EXIT_DISABLED`
Returns current value for the kernel `EXIT_DISABLED_FLAG`.

`function CURRENT_FAST_RENDEZVOUS_ENABLED`
Returns the value of the `FAST_RENDEZVOUS_ENABLED` flag of the current task. See Section 2.6, “Fast Rendezvous Optimization,” on page 2-70.

`function CURRENT_PRIORITY`
Returns the priority of the specified task.

`function CURRENT_PROGRAM`
Returns the *program_id* of the current task.

`function CURRENT_TASK`
Returns the *task_id* of the current task.

`function CURRENT_TIME_SLICE`
Returns the current time slice interval of the specified task.

`function CURRENT_TIME_SLICING_ENABLED`
Returns the current value of the kernel `TIME_SLICING_ENABLED` configuration parameter.

`function CURRENT_USER_FIELD`
Returns the current value of the specified task user-modifiable field.

`procedure DISABLE_PREEMPTION`
Inhibits the current task from being preempted. It does not disable interrupts.

`procedure DISABLE_TASK_COMPLETE`
Disables the current task from being completed and terminated when aborted. Must be paired with `ENABLE_TASK_COMPLETE`.

`procedure ENABLE_PREEMPTION`
Allows the current task to be preempted.

`procedure ENABLE_TASK_COMPLETE`
Enables the current task to be completed and terminated when aborted. Must be paired with `DISABLE_TASK_COMPLETE`.

`function GET_PROGRAM`
Returns the *program_id* of the specified task.

`function GET_PROGRAM_KEY`
Returns the user-defined key for the specified program.

`function GET_TASK_STORAGE`
Returns the starting address of the task storage area of the specified task and storage ID.

`function GET_TASK_STORAGE2`
Returns the starting address of the task storage area using the OS's ID of the task.

`function ID`
Returns an identifier for an Ada program or task given the underlying OS's program or task ID.

`procedure INSTALL_CALLOUT`
Installs a procedure to be called at a program exit, program switch, task create, task switch or task complete event.

`function OS_ID`
Returns the underlying OS's program or task ID given the Ada program or task ID.

procedure `RESUME_TASK`
Causes the named task to ready for execution.

`procedure SET_EXIT_DISABLED`
Changes the kernel `EXIT_DISABLE_FLAG` to inhibit or allow the program to exit.

`procedure SET_FAST_RENDEZVOUS_ENABLED`
Changes the `FAST_RENDEZVOUS_ENABLED` flag for the current task to a new value.

`procedure SET_PRIORITY`
Changes the priority of the specified task.

`procedure SET_TIME_SLICE`
Changes time slice interval of specified task.

`procedure SET_TIME_SLICING_ENABLED`
Sets kernel configuration parameter `TIME_SLICING_ENABLED`.

`procedure SET_USER_FIELD`
Changes the value of the specified task user-modifiable field.

`function START_PROGRAM`
Starts another, separately-linked program that is identified by its link block and returns the `PROGRAM_ID` of the just started program.

`procedure SUSPEND_TASK`
Causes a running task to become suspended.

`function TERMINATED`
Returns the `P'TERMINATED` attribute for the specified task.

`procedure TERMINATE_PROGRAM`
Terminates the specified program.

`generic function V_ID`
Returns an identifier for a task, given a task object of the task type used to instantiate the generic.

Types

`CALLOUT_EVENT_T`
Type of program or tasking event that can have a callout procedure installed via `INSTALL_TASK_CALLOUT` service. Possible values are:

```
EXIT_EVENT
IDLE_EVENT
PROGRAM_SWITCH_EVENT
TASK_COMPLETION_EVENT
TASK_CREATE_EVENT
TASK_SWITCH_EVENT
UNEXPECTED_EXIT_EVENT
```

`OS_PROGRAM_ID`
Type of the underlying OS's program control block.

OS_TASK_ID
Type of the underlying OS's task control block.

PROGRAM_ID
Type of the Ada program control block. This type is defined in package SYSTEM.

TASK_ID
Type of the Ada task control block. This type is defined in package SYSTEM.

TASK_STORAGE_ID
Provides an identifier for user-defined storage in a task control block created and returned by the ALLOCATE_TASK_STORAGE service and passed to the GET_TASK_STORAGE extended tasking service.

XTASKING_RESULT
Type of the result codes returned by the non-exception-raising versions of the SUSPEND_TASK and RESUME_TASK routines. Possible values are:

```
NOT_RESUMED
NOT_SUSPENDED
RESUMED  SUSPENDED
```

Subtypes

USER_FIELD_T
Type of user-modifiable field stored in task control block.

Constants

NULL_TASK_NAME
Null task constant.

NO_TASK_STORAGE_ID
Returned by ALLOCATE_TASK_STORAGE when no more space is available in the task control block.

NULL_OS_TASK_NAME
Null os task constant.

NULL_OS_PROGRAM_NAME
Null os program constant.

Exceptions

`INVALID_RESUME`
Raised by `RESUME_TASK` if the task could not be resumed. This occurs if the task is not currently suspended.

`INVALID_SUSPEND`
Raised by `SUSPEND_TASK` if the task could not be suspended. This occurs if the task cannot run currently.

`UNEXPECTED_V_XTASKING_ERROR`
Can be raised if an unexpected error occurs in an `V_XTASKING` routine

Package Specification

```
with ADA_KRN_DEFS;
with SYSTEM;
package V_XTASKING is
pragma suppress(ALL_CHECKS);
NULL_TASK_NAME: constant system.task_id := system.NO_TASK_ID;
                type os_task_id is new ADA_KRN_DEFS.krn_task_id;
 NULL_OS_TASK_NAME: constant os_task_id :=
                os_task_id(ADA_KRN_DEFS.NO_KRN_TASK_ID);
type os_program_id is new ADA_KRN_DEFS.krn_program_id;
NULL_OS_PROGRAM_NAME: constant os_program_id :=
                os_program_id(ADA_KRN_DEFS.NO_KRN_PROGRAM_ID);
type task_storage_id is private;
NO_TASK_STORAGE_ID: constant task_storage_id;
type callout_event_t is  new ADA_KRN_DEFS.callout_event_t;
subtype user_field_t is integer;
INVALID_SUSPEND             : exception;
INVALID_RESUME              : exception;
UNEXPECTED_V_XTASKING_ERROR : exception;
type xtasking_result is (SUSPENDED, RESUMED, NOT_SUSPENDED,
NOT_RESUMED);
function ID(os_task_name    : in os_task_id) return system.task_id;
function ID(os_program_name : in os_program_id) return
system.program_id;
function ID(task_address    : in system.task_id) return system.task_id;
pragma INLINE_ONLY(ID);
generic
   type task_type is limited private;
function V_ID(task_object   : in task_type) return system.task_id;
pragma INLINE_ONLY(V_ID);
function OS_ID(task_name    : in system.task_id) return os_task_id;
function OS_ID(program_name : in system.program_id) return
os_program_id;
pragma INLINE_ONLY(OS_ID);
function CURRENT_TASK return system.task_id;
pragma INLINE_ONLY(CURRENT_TASK);
procedure RESUME_TASK (task_name     : in     system.task_id);
procedure RESUME_TASK (task_name     : in     system.task_id;
                       result        : out    xtasking_result);
pragma INLINE_ONLY(RESUME_TASK);
procedure SUSPEND_TASK (task_name    : in     system.task_id);
procedure SUSPEND_TASK (task_name    : in     system.task_id;
                        result       : out    xtasking_result);
pragma INLINE_ONLY(SUSPEND_TASK);
function CURRENT_PRIORITY (task_name : in system.task_id :=
CURRENT_TASK)
                  return system.priority;
```

(Continued)

```
   pragma INLINE_ONLY(CURRENT_PRIORITY);
   procedure SET_PRIORITY
              (new_priority : in system.priority;
               task_name    : in system.task_id := CURRENT_TASK);
   pragma INLINE_ONLY(SET_PRIORITY);
   function CURRENT_TIME_SLICE
              (task_name    : in system.task_id := CURRENT_TASK)
               return duration;
   pragma INLINE_ONLY(CURRENT_TIME_SLICE);
   procedure SET_TIME_SLICE
              (new_interval : in duration;
              task_name    : in system.task_id := CURRENT_TASK);
   pragma INLINE_ONLY(SET_TIME_SLICE);
  function CURRENT_USER_FIELD
              (task_name    : in system.task_id := CURRENT_TASK)
                           return user_field_t;
   pragma INLINE_ONLY(CURRENT_USER_FIELD);
  procedure SET_USER_FIELD
             (new_value    : in user_field_t;
               task_name    : in system.task_id := CURRENT_TASK);
   pragma INLINE_ONLY(SET_USER_FIELD);
   function CALLABLE
              (task_name    : in system.task_id) return boolean;
   pragma INLINE_ONLY(CALLABLE);
   function TERMINATED
              (task_name    : in system.task_id) return boolean;
   pragma INLINE_ONLY(TERMINATED);
   function CURRENT_TIME_SLICING_ENABLED return boolean;
   pragma INLINE_ONLY(CURRENT_TIME_SLICING_ENABLED);
   procedure SET_TIME_SLICING_ENABLED
              (new_value    : in  boolean := TRUE);
   pragma INLINE_ONLY(SET_TIME_SLICING_ENABLED);
   function CURRENT_EXIT_DISABLED return boolean;
   pragma INLINE_ONLY(CURRENT_EXIT_DISABLED);
   procedure SET_EXIT_DISABLED
              (new_value    : in  boolean := TRUE);
   pragma INLINE_ONLY(SET_EXIT_DISABLED);
   function START_PROGRAM
                 (link_block_address : in system.address;
                 key                          : in system.address :=
system.memory_address(2);
              terminate_callout   : in system.address := system.NO_ADDR)
                                          return system.program_id;
   pragma INLINE_ONLY(START_PROGRAM);
   function CURRENT_PROGRAM return system.program_id;
   pragma INLINE_ONLY(CURRENT_PROGRAM);
   function GET_PROGRAM(task_name : in system.task_id)
                                             return system.program_id;
```

(Continued)

```
   pragma INLINE_ONLY(GET_PROGRAM);
  procedure TERMINATE_PROGRAM
                          (status       : in integer;
                          program_name    : in system.program_id :=
current_program);
   pragma INLINE_ONLY(TERMINATE_PROGRAM);
  function GET_PROGRAM_KEY
                          (program_name  : in system.program_id :=
CURRENT_PROGRAM)
                                                  return system.address;

   pragma INLINE_ONLY(GET_PROGRAM_KEY);
  procedure INSTALL_CALLOUT
            (event         : in callout_event_t;
             proc          : in system.address);
   pragma INLINE_ONLY(INSTALL_CALLOUT);
  function ALLOCATE_TASK_STORAGE
             (size         : in natural) return task_storage_id;
   pragma INLINE_ONLY(ALLOCATE_TASK_STORAGE);
  function GET_TASK_STORAGE
             (task_name    : in system.task_id;
              storage_id   : in task_storage_id) return system.address;

   pragma INLINE_ONLY(GET_TASK_STORAGE);
  function GET_TASK_STORAGE2
              (os_task_name  : in os_task_id;
            storage_id   : in task_storage_id) return system.address;
pragma INLINE_ONLY(GET_TASK_STORAGE2);
  procedure DISABLE_PREEMPTION;
   pragma INLINE_ONLY(DISABLE_PREEMPTION);
     procedure ENABLE_PREEMPTION;
   pragma INLINE_ONLY(ENABLE_PREEMPTION);
     procedure DISABLE_TASK_COMPLETE;
   procedure ENABLE_TASK_COMPLETE;
   pragma INLINE_ONLY(DISABLE_TASK_COMPLETE);
   pragma INLINE_ONLY(ENABLE_TASK_COMPLETE);
     function CURRENT_FAST_RENDEZVOUS_ENABLED return boolean;
   pragma INLINE_ONLY(CURRENT_FAST_RENDEZVOUS_ENABLED);
  procedure SET_FAST_RENDEZVOUS_ENABLED
              (new_value      : in boolean);
   pragma INLINE_ONLY(SET_FAST_RENDEZVOUS_ENABLED);
private
   type task_storage_id is new ADA_KRN_DEFS.task_storage_id;
   NO_TASK_STORAGE_ID: constant task_storage_id :=
                    task_storage_id(ADA_KRN_DEFS.NO_TASK_STORAGE_ID);
end V_XTASKING;
```

function ALLOCATE_TASK_STORAGE — *allocates storage in the task control block*

From Package

V_XTASKING

Syntax

```
function ALLOCATE_TASK_STORAGE
              (size     : in natural) return task_storage_id;
 pragma INLINE_ONLY(ALLOCATE_TASK_STORAGE);
```

Arguments

size

Indicates the number of bytes to allocate in the task control block.

Description

This service allocates storage in the task control block. It returns the ID used in subsequent GET_TASK_STORAGE or GET_TASK_STORAGE2 service calls.

The task storage allocation is only applicable to tasks in the current program.

Exceptions

STORAGE_ERROR

Raised if enough memory is not in the task control block for the task storage. The configuration parameter, TASK_STORAGE_SIZE, defines the size of the storage area set aside in the control block for each task. Each allocation from this area aligns on a 4- or 8-byte boundary (the alignment is CPU-dependent).

Threaded Runtime

ALLOCATE_TASK_STORAGE is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function CALLABLE — *returns the value of a task* P'CALLABLE *attribute*

From Package

V_XTASKING

Syntax

```
function CALLABLE
              (task_name      : in system.task_id)
              return boolean;
pragma INLINE_ONLY(CALLABLE);
```

Arguments

task_name

Specifies the ID of the task for which the function must get the value of the P'CALLABLE attribute.

Description

The function CALLABLE returns the value of P'CALLABLE attribute for a specified task. When the specified task completes, terminates or executes abnormally, CALLABLE returns the Boolean value FALSE. Under all other conditions, CALLABLE returns the Boolean value TRUE. Referencing a nonexistent task or a task that is not created yields indeterminate values.

function CURRENT_EXIT_DISABLED — *returns current value for kernel* EXIT_DISABLED_FLAG

From Package

V_XTASKING

Syntax

```
function CURRENT_EXIT_DISABLED return boolean;
pragma INLINE_ONLY(CURRENT_EXIT_DISABLED);
```

Description

This function returns the current value for the Ada tasking global variable, EXIT_DISABLED_FLAG. When TRUE, the application program is inhibited from exiting.

function CURRENT_FAST_RENDEZVOUS_ENABLED — *return value of* FAST_RENDEZVOUS_ENABLED *flag*

From Package

V_XTASKING

Syntax

```
function CURRENT_FAST_RENDEZVOUS_ENABLED return boolean;
pragma INLINE_ONLY(CURRENT_FAST_RENDEZVOUS_ENABLED);Description
```

This function returns the value for the current Ada task's FAST_RENDEZVOUS_ENABLED flag. See FAST_RENDEZVOUS_ENABLED in the v_usr_conf.a for details about the fast rendezvous optimization.

References

Section 2.6, “Fast Rendezvous Optimization,” on page 2-70

function CURRENT_PRIORITY — *returns the priority of a task*

From Package

V_XTASKING

Syntax

```
function CURRENT_PRIORITY
              (task_name          : in system.task_id := CURRENT_TASK)
              return system.priority;
pragma INLINE_ONLY(CURRENT_PRIORITY);
```

Arguments

task_name

Specifies the identifier of the task whose priority is returned to the caller. If no task name is specified, *task_name* defaults to the current task.

Description

CURRENT_PRIORITY returns the current priority of the specified task. This can be the task priority as specified by a pragma PRIORITY, the default task priority or the priority of a task it is in rendezvous with, if the task it is in rendezvous with has a higher priority task or the task's priority changed with SET_PRIORITY.

function CURRENT_PROGRAM — *returns the current program identifier*

From Package

V_XTASKING

Syntax

```
function CURRENT_PROGRAM
             return system.program_id;
pragma INLINE_ONLY(CURRENT_PROGRAM);
```

Description

This function returns the program ID of the current program

Threaded Runtime

CURRENT_PROGRAM is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

`function` CURRENT_TASK — *returns the current task identifier*

From Package

V_XTASKING

Syntax

```
function CURRENT_TASK
              return system.task_id;
pragma INLINE_ONLY(CURRENT_TASK);
```

Example

The following call suspends the currently running task:

```
V_XTASKING.SUSPEND_TASK(V_XTASKING.CURRENT_TASK);
```

function CURRENT_TIME_SLICE — *returns current time slice interval*

From Package

V_XTASKING

Syntax

```
function CURRENT_TIME_SLICE
               (task_name       : in system.task_id := CURRENT_TASK)
                 return duration;
pragma INLINE_ONLY(CURRENT_TIME_SLICE);
```

Arguments

task_name

Indicates the ID of the task whose time slice interval is returned to the caller. If no *task_name* is specified, the routine defaults to the current task.

Description

The function CURRENT_TIME_SLICE returns the value of the specified task current time slice interval. CURRENT_TIME_SLICE requires a task ID for a parameter. If you do not supply a task ID, the routine defaults to the current task.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function CURRENT_TIME_SLICING_ENABLED — *checks if time slicing is enabled*

From Package

V_XTASKING

Syntax

```
function CURRENT_TIME_SLICING_ENABLED
                return boolean;
pragma INLINE_ONLY(CURRENT_TIME_SLICING_ENABLED);
```

Description

The function CURRENT_TIME_SLICING_ENABLED returns a Boolean value that indicates the current value of the kernel TIME_SLICING_ENABLED configuration parameter.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function CURRENT_USER_FIELD — *returns value of user-modifiable field*

From Package

V_XTASKING

Syntax

```
function CURRENT_USER_FIELD
                (task_name      : in system.task_id := CURRENT_TASK)
                 return user_field_t;
pragma INLINE_ONLY(CURRENT_USER_FIELD);
```

Arguments

task_name

Indicates the ID of the task that is to have the value of the user-modifiable field returned. The default is the current task.

Description

The function CURRENT_USER_FIELD returns the value of the user-modifiable field of a specified task. If no task ID is specified for the parameter *task_name*, the routine defaults to the current task. The USER_FIELD is a field of INTEGER'SIZE is stored in the TCB. The runtime system does not use the USER_FIELD.

procedure DISABLE_PREEMPTION — *inhibits the current task from being preempted*

From Package

V_XTASKING

Syntax

```
procedure DISABLE_PREEMPTION;
pragma INLINE_ONLY(DISABLE_PREEMPTION);
```

Description

procedure DISABLE_PREEMPTION, inhibits the current task from being preempted. This service does not disable signals. Task switching may still occur through the direct action of the currently running task making another higher priority task available to run. Signals still occur and ISR code is executed, but no other tasks will run as a result of a signal.

Threaded Runtime

VADS MICRO maintains a preemption depth count for each task. This preemption depth is saved/restored at a task switch. Each call to DISABLE_PREEMPTION increments the depth. A nonzero depth count inhibits preemption. However, another task may run if the task calls a kernel service that causes it to block. Each call to ENABLE_PREEMPTION decrements the depth. When the depth is zero, the task can be preempted.

Other threaded runtimes may not support the disabling of preemption.

procedure DISABLE_TASK_COMPLETE - *disables completion and termination of task*

From Package

V_XTASKING

Syntax

```
procedure DISABLE_TASK_COMPLETE;
pragma INLINE_ONLY(DISABLE_TASK_COMPLETE);
```

Description

DISABLE_TASK_COMPLETE disables the current task from being completed and terminated when aborted. If the task is aborted after DISABLE_TASK_COMPLETE is called, its completion is deferred until its mate, ENABLE_TASK_COMPLETE, is called. Calls to DISABLE_TASK_COMPLETE and ENABLE_TASK_COMPLETE can be nested.

These services can be used as follows to inhibit a task from being completed after it has acquired a sharable resource such as a semaphore.

```
DISABLE_TASK_COMPLETE;
   acquire_resource;
   use_resource;
   release_resource;
ENABLE_TASK_COMPLETE;
```

Caution – This procedure must always be paired with procedure ENABLE_TASK_COMPLETE.

procedure ENABLE_PREEMPTION — *allows the current task to be preempted*

From Package

V_XTASKING

Syntax

```
procedure ENABLE_PREEMPTION;
pragma INLINE_ONLY(ENABLE_PREEMPTION);
```

Description

procedure ENABLE_PREEMPTION allows the current task to be preempted.

Threaded Runtime

VADS MICRO maintains a preemption depth count for each task. This preemption depth is saved/restored at a task switch. Each call to DISABLE_PREEMPTION increments the depth. A nonzero depth count inhibits preemption. However, another task may run if the task calls a kernel service that causes it to block. Each call to ENABLE_PREEMPTION decrements the depth. When the depth is zero, the task can be preempted.

Other threaded runtimes may not support the disabling of preemption.

procedure ENABLE_TASK_COMPLETE —
enables completion and termination of task

From Package

V_XTASKING

Syntax

```
procedure ENABLE_TASK_COMPLETE;
pragma INLINE_ONLY(ENABLE_TASK_COMPLETE);
```

Description

ENABLE_TASK_COMPLETE enables the current task to be completed and terminated when aborted. This procedure must be paired with DISABLE_TASK_COMPLETE. They can be nested. There is no return if they are not nested and the current task has been marked abnormal by a previous abort.

These services can be used as follows to inhibit a task from being completed after it has acquired a sharable resource such as a semaphore.

```
DISABLE_TASK_COMPLETE;
         acquire_resource;
         use_resource;
         release_resource;
ENABLE_TASK_COMPLETE;
```

Caution – This procedure must always be paired with procedure DISABLE_TASK_COMPLETE

`function` GET_PROGRAM — *returns a task program identifier*

From Package

V_XTASKING

Syntax

```
function GET_PROGRAM
              (task_name      :     in    system.task_id)
              return system.program_id;
pragma INLINE_ONLY(GET_PROGRAM);
```

Arguments

task_name

Indicates the ID of the task that is to have the value of the program ID returned.

Description

This function returns the program ID for the specified task.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function GET_PROGRAM_KEY — *returns the user-defined key for the program*

From Package

V_XTASKING

Syntax

```
function GET_PROGRAM_KEY
          (program_name:  in system.program_id := CURRENT_PROGRAM)
          return system.address;
pragma INLINE_ONLY(GET_PROGRAM_KEY);
```

Arguments

program_name

Indicates the ID of the program to get the key for.

Description

This function returns the user-defined key for the specified program. The key is stored when the program is started via the START_PROGRAM service. The main program has a predefined key of system.NO_ADDR(0).

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function GET_TASK_STORAGE — *returns starting address of task storage area*

From Package

V_XTASKING

Syntax

```
function GET_TASK_STORAGE
              (task_name          :     in    system.task_id)
              storage_id          :     in    task_storage_id)
              return system.address;
pragma INLINE_ONLY(GET_TASK_STORAGE);
```

Arguments

storage_id

Contains the value returned by a previous call to ALLOCATE_TASK_STORAGE. It is only applicable to tasks in the program where the ALLOCATE_TASK_STORAGE service is called from.

task_name

Indicates the ID of the task for which the address of the callout storage area is obtained.

Description

The service returns the starting address of the task storage area associated with the *storage_id*.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

function GET_TASK_STORAGE2 — *get task storage using OS's ID of task*

From Package

V_XTASKING

Syntax

```
function GET_TASK_STORAGE2
                (os_task_name     :   in     os_task_id)
                storage_id        :   in     task_storage_id)
                return system.address;
 pragma INLINE_ONLY(GET_TASK_STORAGE2);
```

Arguments

os_task_name

OS identifier of the task for which the address of the callout storage area is returned.

storage_id

Value returned by a previous call to ALLOCATE_TASK_STORAGE. It is only applicable to tasks in the program where the ALLOCATE_TASK_STORAGE service is called from.

Description

The service returns the starting address of the task storage area associated with the storage_id using the OS's ID of the task (instead of the Ada task identifier).

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

`function ID` — *returns a task identifier*

From Package

`V_XTASKING`

Syntax

```
function ID
              (task_address  : in system.task_id)
              return task_id;
pragma INLINE_ONLY(ID);
function ID
               (os_task_name  : in os_task_id)
               return system.task_id; pragma INLINE_ONLY(ID);
function ID
               (os_program_name  : in os_program_id)
               return system.program_id;
pragma INLINE_ONLY(ID);
```

Arguments

os_program_name
OS identifier of the program.

os_task_name
OS identifier of the task.

task_address
Address of a task obtained by applying 'TASK_ID attribute to a task name.

The T'ADDRESS attribute changed in SPARCompiler Ada 1.1 and later releases to be the starting address of the task body machine code. Therefore, the type of the TASK_ADDRESS parameter is changed from SYSTEM.ADDRESS to SYSTEM.TASK_ID.

Description

If a task is given, ID returns a task identifier for any task. Determine the ID of a task object of a task type using either this function or a function created by an instantiation of the `generic function V_ID`. However, the ID of a task that is not a task object of a task type is determined only by the ID function. Use this function for all tasks.

Note – This function no longer needs to be called. The `T'TASK_ID` attribute returns the ID for a task that can be used by the `V_XTASKING` services.

ID also converts from an underlying thread or operating system identifier to an Ada task ID or Ada program ID.

Example

The following code fragment uses the ID function with the `RESUME_TASK` operation to resume the task `OTHER_TASK`:

```
V_XTASKING.RESUME_TASK(V_XTASKING.ID(OTHER_TASK'task_id));
```

Exceptions

`NULL_TASK_NAME`
Returned if the OS task isn't also an Ada task.

`NO_PROGRAM_ID`
Returned is the OS program isn't also an Ada program.

procedure INSTALL_CALLOUT —

installs a procedure to call at a program, task, or idle event

From Package

V_XTASKING

Syntax

```
procedure INSTALL_CALLOUT
             (event    :  in   callout_event_t;
              proc     :  in   system.address);
pragma INLINE_ONLY(INSTALL_CALLOUT)
```

Arguments

event

The program, task, or idle event at which time the installed procedure is to be called.

proc

The address of the procedure to be called. The EXIT_EVENT or UNEXPECTED_EXIT_EVENT callout procedures are called as follows:

```
procedure exit_callout_proc
    (status : in integer);  -- main subprogram
                           -- return status
```

The PROGRAM_SWITCH_EVENT callout procedure is called as follows:

```
procedure program_switch_callout_proc
        (new_os_program_name  : in os_program_id;
         key                  : in address);
```

Note – This procedure is called with the OS's PROGRAM_NAME and not the Ada PROGRAM_NAME. Use V_XTASKING.ID(*os_program_name*) to get the Ada PROGRAM_ID.

The TASK_CREATE_EVENT, TASK_SWITCH_EVENT, and TASK_COMPLETE_EVENT callout procedures are called as follows:

```
procedure task_callout_proc
       (task_name     : in task_id);
```

Note – This procedure is called with the OS's TASK_NAME and not the Ada TASK_NAME. Use V_XTASKING.ID(*os_task_name*) to get the Ada TASK_ID.

The IDLE_EVENT callout procedure is called as follows:

```
procedure idle_callout_proc;
```

Description

This service installs a procedure to be called at a program or task event. Install callouts for EXIT_EVENT, UNEXPECTED_EXIT_EVENT, TASK_SWITCH_EVENT, PROGRAM_SWITCH_EVENT, TASK_CREATE_EVENT, TASK_COMPLETE_EVENT, or IDLE_EVENT.

The EXIT_EVENT, UNEXPECTED_EXIT_EVENT and IDLE_EVENT callout procedures are called in LIFO (last-in-first-out) order. The remaining callout procedures are called in the order in which they are installed.

The callouts reside in the user program space. The EXIT_EVENT and UNEXPECTED_EXIT_EVENT callouts are called in the context of the program main task. The remaining callouts are called directly from kernel logic (that is, they use the kernel stack) and only call kernel services that are reentrant, the same services callable from ISRs. The service of most interest is CALENDAR.CLOCK, which is called for time stamping.

Before any non-PROGRAM_SWITCH_EVENT callout procedure is invoked, the STACK_LIMIT in the user program is set to 0 to negate any stack limit checking. Therefore, the callout procedures don't need to be compiled with stack limit checking suppressed. However, the STACK_LIMIT isn't zeroed before calling the PROGRAM_SWITCH_EVENT callout. It needs to be compiled with stack checking suppressed.

Except for the PROGRAM_SWITCH_EVENT, the callouts are only installed and called for the program in which they reside.

An overview of the different callout events follows:

EXIT_EVENT
: Called when the program exits or terminates. Not called when the program is terminated from another program. Still called when the UNEXPECTED_EXIT_EVENT callout is called.

IDLE_EVENT
: Called whenever there aren't any ready-to-run tasks.

PROGRAM_SWITCH_EVENT
Called before switching to a task that resides in a program different from the current program. Called for all program switches, not just switches to and from the program containing the callout.

TASK_COMPLETE_EVENT
Called whenever any task in the callout's program completes or is aborted.

TASK_CREATE_EVENT
Called when a task is created in the program containing the callout. Since the TASK_CREATE_EVENT callout can be called after numerous tasks are created, the INSTALL_CALLOUT service loops through all existing tasks invoking the just installed TASK_CREATE_EVENT callout.

TASK_SWITCH_EVENT
Called before switching to a different task in the same program. For a program switch, the TASK_SWITCH_EVENT callout is called with the *os_task_name* parameter set to NULL_OS_TASK_NAME.

UNEXPECTED_EXIT_EVENT
Called when the program is abandoned because of an unhandled Ada exception.

Exceptions

STORAGE_ERROR
Raised if not enough memory is available for the callout data structures.

Threaded Runtime

This service is provided as described for VADS MICRO. Other underlying threaded runtimes may support different callout events. However, all implementations are expected to support EXIT_EVENT and UNEXPECTED_EXIT_EVENT.

function OS_ID — *return the underlying OS task or program identifier*

From Package

V_XTASKING

Syntax

```
function OS_ID
         (task_name  : in system.task_id)
         return os_task_id;
pragma INLINE_ONLY(OS_ID);
function OS_ID
                 (program_name     : in system.program_id)
                 return os_program_id; pragma INLINE_ONLY(OS_ID);
```

Arguments

program_name
Name of Ada program to be converted

task_name
Name of Ada task to be converted

Description

OS_ID returns the underlying OS's task or program identifier given either the Ada task ID or the Ada program ID.

procedure RESUME_TASK — *resume execution of a task*

From Package

V_XTASKING

Syntax

```
procedure RESUME_TASK
              (task_name      : in     system.task_id);
pragma INLINE_ONLY(RESUME_TASK);

procedure RESUME_TASK
              (task_name      : in     system.task_id;
              result           :    out xtasking_result);
pragma INLINE_ONLY(RESUME_TASK);
```

Arguments

task_name
Task to ready for execution.

Description

RESUME_TASK only readies a task suspended by SUSPEND_TASK. The task does not execute unless it is the highest priority ready task.

This service can only be used to activate a task suspended by a call to SUSPEND_TASK.

Exceptions/Results

INVALID_RESUME/NOT_RESUMED
Task was not suspended.

RESUMED
The result value RESUMED returns if the task is resumed.

Threaded Runtime

Note that exceptions and results are OS dependent. For the VADS MICRO kernel, `RESUME_TASK` always returns `RESUMED` (or no exception is raised). Each task has a suspend flag. `RESUME_TASK` sets the task's suspend flag to `FALSE`. If the task is ready to run, it is put on the run queue.

The semantics of the `RESUME_TASK` service are dependent on the underlying operating system. `RESUME_TASK` is layered on `ADA_KRN_I.TASK_RESUME`.

procedure SET_EXIT_DISABLED — *change the kernel* EXIT_DISABLED_FLAG

From Package

V_XTASKING

Syntax

```
procedure SET_EXIT_DISABLED
              (new_value    : in   boolean := TRUE);
pragma INLINE_ONLY(SET_EXIT_DISABLED);
```

Arguments

new_value

Boolean value to which the SET_EXIT_DISABLED is set.

Description

procedure SET_EXIT_DISABLED sets the Ada tasking global variable, EXIT_DISABLED_FLAG. This flag initializes to FALSE, which allows the application program to exit when no tasks are on either the run or delay queue. This service is called with *new_value* := TRUE to inhibit the program from exiting. Normally, the service is called after the application program attaches an ISR. The program can exit with a subsequent call, where *new_value* := FALSE.

procedure SET_FAST_RENDEZVOUS_ENABLED — *set* FAST_RENDEZVOUS_ENABLED *flag*

From Package

V_XTASKING

Syntax

```
procedure SET_FAST_RENDEZVOUS_ENABLED
             (new_value   :  boolean);
pragma INLINE_ONLY(SET_FAST_RENDEZVOUS_ENABLED);
```

Arguments

new_value
New flag setting

Description

SET_FAST_RENDEZVOUS_ENABLED sets the FAST_RENDEZVOUS_ENABLED flag for the current Ada task. See FAST_RENDEZVOUS_ENABLED in v_usr_conf.a for details about the fast rendezvous optimization.

If FAST_RENDEZVOUS_ENABLED is disabled in the configuration table, it can never be enabled.

Normally, fast rendezvous would only need to be disabled for multiprocessor Ada where the accept body must execute in the acceptor task bound to a processor.

References

Section 2.6, “Fast Rendezvous Optimization,” on page 2-70

procedure SET_PRIORITY — *change a task priority*

From Package

V_XTASKING

Syntax

```
procedure SET_PRIORITY
              (new_priority   : in   system.priority;
              task_name       : in   system.task_id := CURRENT_TASK);
pragma INLINE_ONLY(SET_PRIORITY);
```

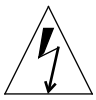
Arguments

new_priority
Specifies the new priority setting.

task_name
Specifies the task to change.

Description

procedure SET_PRIORITY enables you to change the priority of a specified task. Task scheduling is then reevaluated



Warning – Use this service with extreme caution because it can interfere with the kernel scheduling.

procedure SET_TIME_SLICE — *change a task time slice interval*

From Package

V_XTASKING

Syntax

```
procedure SET_TIME_SLICE
            (new_interval     : in   duration;
             task_name        : in   system.task_id := CURRENT_TASK);
pragma INLINE_ONLY(SET_TIME_SLICE);
```

Arguments

new_interval

Specifies the new time slice duration. An interval of 0.0 seconds disables time slicing for the task.

task_name

Specifies the ID of the task that is to have the time slice interval changed. The default is the current task.

Description

procedure SET_TIME_SLICE enables you to change the time slice interval of a specified task. SET_TIME_SLICE requires two parameters: the duration of the new time slice interval (*new_interval*) and the ID of the task that is to have the time slice interval changed (*task_name*).

If a task that is time slicing receives a higher priority that does not require time slicing, for example, SET_PRIORITY is called to change the mode, the task cannot be blocked prematurely by an in-progress time slice period.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

procedure SET_TIME_SLICING_ENABLED — *enable or disable time slicing*

From Package

V_XTASKING

Syntax

```
procedure SET_TIME_SLICING_ENABLED
              (new_value      : in    boolean := TRUE);
pragma INLINE_ONLY(SET_TIME_SLICING_ENABLED);
```

Arguments

new_value

Specifies the new value of the TIME_SLICING_ENABLED parameter.

Description

procedure SET_TIME_SLICING_ENABLED enables you to change the value of the kernel TIME_SLICING_ENABLED configuration parameter. If no new value is specified for this function, the function defaults to a Boolean value of TRUE.

Threaded Runtime

This service may not be supported by other underlying threaded runtimes.

procedure SET_USER_FIELD — *change a task user-modifiable field*

From Package

V_XTASKING

Syntax

```
procedure SET_USER_FIELD
              (new_value     : in    user_field_t;
              task_name      : in    system.task_id := CURRENT_TASK);
pragma INLINE_ONLY(SET_USER_FIELD);
```

Arguments

new_value

Specifies the new value to write to the user-modifiable field.

task_name

Specifies the ID of the task that is to have the user-modifiable field changed. The default is the current task.

Description

procedure SET_USER_FIELD changes the value of the user-modifiable field for a specified task. If the task ID is not specified, the routine defaults to the current task. The USER_FIELD is a field of INTEGER'SIZE that is stored in the TCB. The runtime system does not use the USER_FIELD.

function START_PROGRAM — *start a separately-linked program*

From Package

V_XTASKING

Syntax

```
function START_PROGRAM
 (link_block_address     : in system.address;
  key                    : in system.address := system.memory_address(1);
terminate_callout        : in system.address := system.NO_ADDR);
 return system.program_id;
pragma INLINE_ONLY(START_PROGRAM);
```

Arguments

key

User-defined value stored in the new program control block. This key is passed to the PROGRAM_SWITCH_EVENT callouts. Obtain the key from routines in the new program via the GET_PROGRAM_KEY service. One use for the key is to have it point to a list of program arguments. The value for the main program key is 0 (system.NO_ADDR).

link_block_address

Specifies the LINK_BLOCK address of the program to be started.

terminate_callout

Address of the procedure to be called when the program exits or is terminated. A value of NO_ADDR indicates no callout. The callout procedure is called as follows:

```
procedure terminate_callout_proc
        (os_program_name   : in os_program_id;
         key            : in address);
```

Note – This procedure is called with the OS PROGRAM_NAME, not the Ada PROGRAM_NAME Use V_XTASKING.ID(*os_program_name*) to get the Ada PROGRAM_ID.

---

terminate_callout_proc must be compiled with stack limit checking suppressed. The PROGRAM_SWITCH_EVENT callout is not called before the *terminate_callout_proc* is called.

Description

The function START_PROGRAM starts separately-linked programs, which are identified by their link block and enables concurrent execution of those programs. START_PROGRAM takes the parameter *link_block_address*, which specifies the address of the LINK_BLOCK for the program to start. It returns the ID of the just started program. Note that the Ada PROGRAM_ID and not the OS program or process ID is returned. This function assumes that the program to start is loaded.

Each program has a main task and a set of tasks that it creates. Tasks from all programs execute from the same run queue.

The kernel has a linked list of programs, with each program pointing to a linked list of the program tasks. Tasks from all programs compete for CPU time, according to their priority.

Threaded Runtime

This service is not supported by the VADS MICRO kernel.

procedure SUSPEND_TASK — *suspend execution of task*

From Package

V_XTASKING

Syntax

```
procedure SUSPEND_TASK
              (task_name    : in     system.task_id);
pragma INLINE_ONLY(SUSPEND_TASK);

procedure SUSPEND_TASK
              (task_name    : in     system.task_id;
              result        : out    xtasking_result);
pragma INLINE_ONLY(SUSPEND_TASK);
```

Arguments

task_name
Task to suspend.

Description

Only use SUSPEND_TASK to suspend a task that is either running or ready-to-run.

Exceptions/Results

INVALID_SUSPEND/NOT_SUSPENDED
Task could not be suspended (task could not run).

SUSPENDED
The result value SUSPENDED is returned if the task is suspended.

Threaded Runtime

For the VADS MICRO kernel, SUSPEND_TASK always returns SUSPENDED (or no exception is raised). Each task has a suspend flag. SUSPEND_TASK always sets the task's suspend flag to TRUE. If the task is on the run queue, it is removed. The task is inhibited from being placed on the run queue until is resumed with the RESUME_TASK service.

The semantics of the SUSPEND_TASK service are dependent on the underlying operating system. SUSPEND_TASK is layered on ADA_KRN_I.TASK_SUSPEND.

function TERMINATED — *returns value of* P'TERMINATED *attribute*

From Package

V_XTASKING

Syntax

```
function TERMINATED
                (task_name      : in system.task_id)
                return boolean;
pragma INLINE_ONLY(TERMINATED);
```

Arguments

task_name

Specifies the ID of the task for which TERMINATED is to return the value of the P'TERMINATED attribute.

Description

The function TERMINATED returns the Boolean value of the P'TERMINATED attribute for the specified task. If the task terminates, TERMINATED returns the boolean value TRUE. Under all other conditions, TERMINATED returns the Boolean value FALSE. Referencing a nonexistent task or a task that is not created yields indeterminate values.

procedure TERMINATE_PROGRAM — *terminates the specified program*

From Package

V_XTASKING

Syntax

```
procedure TERMINATE_PROGRAM
            (status       : in integer;
             program_name : in system.program_id := current_program);
pragma INLINE_ONLY(TERMINATE_PROGRAM);
```

Arguments

status
The program exit status.

program_name
Indicates the ID of the program to terminate.

Description

This procedure terminates the specified program. If and only if the program to terminate is the current program, the EXIT_EVENT callouts installed for the program are called before the program is terminated. After the program terminates, the TERMINATE_CALLOUT, passed to START_PROGRAM, is called.

When a program terminates, all its tasks terminate and all memory allocated by the program is freed.

Threaded Runtime

This service is provided for VADS MICRO. However, this service may not be supported by other underlying threaded runtimes.

generic function V_ID — *returns the identifier for a task of a specified type*

From Package

V_XTASKING

Syntax

```
generic
  type task_type is limited private;

function V_ID
              (task_object    : in task_type)
              return task_id;
pragma INLINE_ONLY(V_ID);
```

Arguments

task_object
An object of the task type used to instantiate this generic.

Description

Instantiate this generic with a task type to create a function that returns the task identifier for any object of that task type. Use the resulting task identifier as a parameter to the SUSPEND_TASK and RESUME_TASK operations. V_ID is applicable only to tasks declared as types.

Example

The following code fragment declares a task type buffer and creates a function RECEIVER_ID, which returns a task identifier for a buffer:

```
task type DATA_RECEIVER;
function RECEIVER_ID is new V_XTASKING.V_ID(DATA_RECEIVER);
```

The following code fragment uses the function RECEIVER_ID to obtain a task identifier for a task object, DATA1, that is type DATA_RECEIVER. The resulting task ID is used to resume the task.

```
V_XTASKING.RESUME_TASK(RECEIVER_ID(DATA1));
```

4

"Let the great world spin forever down the ringing grooves of change."

Tennyson

A Summary of RTS Changes

A

A.1 Introduction

The Ada RTS is completely redesigned in this release so that Ada tasking can be layered upon any POSIX threads-like kernel. In prior releases, the Ada tasking subprograms resided in the kernel nucleus. Now, Ada tasking has been moved into user program space.

The RTS is partitioned into the following three layers:

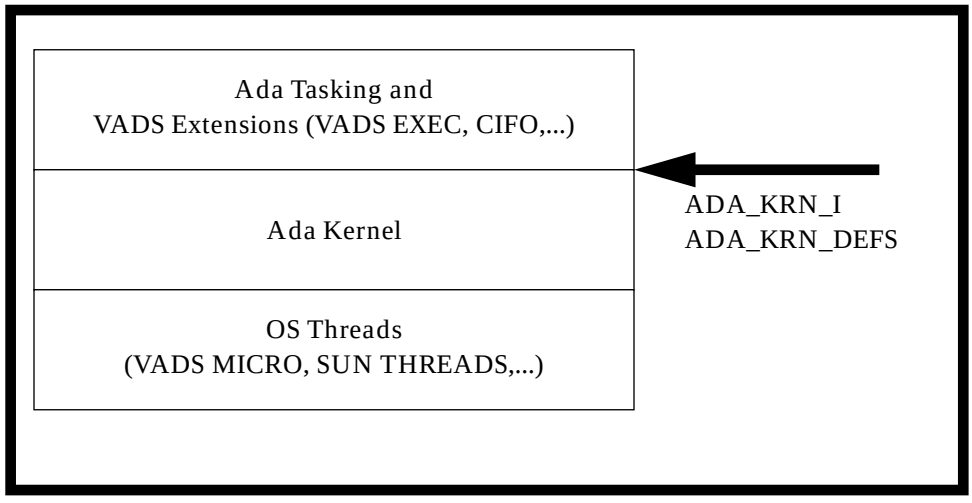


Figure A-1 Ada RTS Layers Ada Tasking and Extensions

A

The Ada Kernel provides all the threads and synchronization services needed by the Ada Tasking layer. The interface to the Ada Kernel services is defined in the `ADA_KRN_I` package. Its type definitions are provided in the `ADA_KRN_DEFS` package.

The OS threads layer contains either the OS provided threads services (SUN THREADS) or the Verdix micro kernel (VADS MICRO). The VADS MICRO does its own threads management independent of any threads services provided by the underlying OS. VADS MICRO combined with the other two layers replaces the monolithic Ada RTS provided in releases prior to SPARCompiler Ada 2.1.

The Ada Tasking layer is only dependent upon the services defined in `ADA_KRN_I` and the types in `ADA_KRN_DEFS`. It makes no direct calls to services in the OS threads layer. No changes are made in the Ada Tasking layer when the Ada RTS is ported to a new OS threads. All porting changes are made in the Ada Kernel layer. The Ada Kernel layer does what it takes to map the `ADA_KRN_I` services (`PROGRAM_INIT`, `TASK_CREATE`, `TASK_LOCK`, `TASK_WAIT`, ...) onto the services provided by the underlying OS.

A.2 Why Redesign the Ada RTS?

By layering Ada tasks upon threads, Ada tasks can coexist with and call thread based services written in other languages, such as threaded windows written in C.

In addition, a SUN workstation can have multiple CPUs. Their threads services have been designed to allow concurrent thread execution from a single program across multiple CPUs. By layering Ada tasks upon threads, we also obtain the multi-CPU capability.

A.3 Mutex and Condition Variable

The new Ada RTS has added two object types to complement semaphores: mutexes and condition variables. The definition of these object types is extracted from the POSIX 1003.4a standard, “IEEE Threads Extension for Portable Operating Systems.” See the latest draft of that standard for more details about POSIX threads.

A.3.1 mutex

mutex is a synchronization object used to allow multiple threads to serialize their access to shared data. The name derives from the capability it provides, MUTual EXclusion.

The thread that has locked a mutex becomes its owner and remains the owner until the same thread unlocks the mutex. Other threads that attempt to lock the mutex during this period suspend execution until the original thread unlocks it. The act of suspending the execution of a thread awaiting a mutex does not prevent other threads from making progress in their computations.

Verdix has also added an ABORT_SAFE option to mutexes. A task that has locked an ABORT_SAFE mutex is inhibited from being completed by an Ada abort until it unlocks the mutex.

A.3.2 condition variable

A condition variable is a synchronization object that allows a thread to suspend execution until some condition is true. Typically, a thread holding a mutex determines that it cannot proceed by examining the shared data guarded by the mutex. The thread then waits on a condition variable associated with some state of the shared data. Waiting on the condition variable atomically releases the mutex. If another thread modifies the shared data to make the condition true, that thread signals threads waiting on the condition variable. This wakes up the waiting thread which reacquires the mutex and resumes its execution.

An ABORT_SAFE option has been added to condition variables. A task locking an ABORT_SAFE mutex is inhibited from being completed by an Ada abort until it unlocks the mutex. However, if a task is aborted while waiting at a condition variable (after an implicit mutex unlock), it is allowed to complete.

A.4 Impact upon Existing Tasking Applications

Re-doing the Ada RTS to be layered upon threads has necessitated numerous changes in the user interface to Ada tasking and VADS EXEC. Furthermore, we have continued to improve and enhance the Ada RTS.

Changes and extensions have been made in the following areas:

- Link directives in `ada.lib`

- `pragma PASSIVE`
- `pragma TASK_ATTRIBUTE`s
- Interrupt entry
- Passive interrupt entry
- Ada I/O
- Memory allocation
- Fast rendezvous optimization
- VADS EXEC: `V_INTERRUPTS` services
- VADS EXEC: `V_XTASKING` services
- VADS EXEC: `V_SEMAPHORES` services
- VADS EXEC: `V_MAILBOXES` services
- VADS EXEC: `V_STACK` services
- ADA_KRN_I: interface to the Ada kernel services
- ADA_KRN_DEFS: Ada kernel type definitions
- Files added to standard
- `v_i_*` low level interfaces
- User program configuration (`v_usr_conf`)
- Kernel program configuration (`v_krn_conf`)
- TDM program configuration (`v_tdm_conf`)

Changes and improvements in each area are summarized below.

A.4.1 Link Directives in `ada.lib`

We have added the link directive, `MIN_TASKING` to the `ada.lib` in `standard`. `MIN_TASKING` points to the archive selected when the program does tasking but doesn't have any “aborts” or “select with terminates”. Since the program doesn't need this capability, its been `a.app` ifdefed away in the `MIN_TASKING` archive to reduce the size of the program and to eliminate unnecessary checks.

A.4.2 pragma PASSIVE

Previously, the PASSIVE pragma took the following arguments:

```
pragma passive; -- defaults to SEMAPHORE
pragma passive(SEMAPHORE);
pragma passive(INTERRUPT, v_i_types.disable_intr_status);
```

It has been changed to:

```
pragma passive; -- defaults to ABORT_UNSAFE,
                -- ada_krn_defs.DEFAULT_MUTEX_ATTR
pragma passive(ABORT_SAFE);
                -- defaults to ada_krn_defs.DEFAULT_MUTEX_ATTR
pragma passive(ABORT_SAFE, mutex_attr'address);
pragma passive(ABORT_UNSAFE);
                -- defaults to ada_krn_defs.DEFAULT_MUTEX_ATTR
pragma passive(ABORT_UNSAFE, mutex_attr'address);
```

An active task calling an ABORT_SAFE passive task entry is inhibited from being completed by an Ada abort until it finishes execution of the passive task's accept body. This inhibits the aborted task from holding a lock that is never released.

Alternatively, if an active task calling an ABORT_UNSAFE passive task entry is aborted, the lock isn't released and other active tasks are indefinitely blocked if they call an entry in the passive task. Previous releases supported only the ABORT_UNSAFE option. The ABORT_SAFE option is slightly slower.

The second argument is the address of an ADA_KRN_DEFS.MUTEX_ATTR_T record. The passive task's critical region is protected by locking and unlocking a mutex. The MUTEX_ATTR_T record is used to initialize the mutex. Omitting the second argument or setting it to ADA_KRN_DEFS.DEFAULT_MUTEX_ATTR selects the default mutex attributes.

The mutex attributes are OS dependent. See ada_krn_defs.a in ada_location/self/standard (single processor) or ada_location/self_thr/standard (multiprocessor or multithreaded Ada) for the type definition of MUTEX_ATTR_T and the different options supported.

ada_krn_defs.a has the following overloaded functions for initializing the mutex attributes. These functions will be supported for all versions of OS threads. If the mutex type is not supported by the underlying OS, the PROGRAM_ERROR exception is raised.

```
function DEFAULT_MUTEX_ATTR return address;
function intr_attr_init(
  disable_status : intr_status_t := DISABLE_INTR_STATUS)
                                        return address;
function DEFAULT_INTR_ATTR return address;
function fifo_mutex_attr_init return address;
function prio_mutex_attr_init return address;
function prio_inherit_mutex_attr_init return address;
function prio_ceiling_mutex_attr_init return address;
```

The following new passive arguments:

```
pragma passive(ABORT_UNSAFE,
    ada_krn_defs.intr_attr_init(disable_intr_status));
```

Or

```
pragma passive(ABORT_UNSAFE,
ada_krn_defs.DEFAULT_INTR_ATTR);
     -- all interrupts disabled
```

are equivalent to the previous passive arguments:

```
pragma passive(INTERRUPT, disable_intr_status);
```

A.4.3 pragma TASK_ATTRIBUTES

The TASK_ATTRIBUTES pragma has been added. It has the following arguments:

```
pragma task_attributes(task_attr'address);
pragma task_attributes(task_object_name, task_attr'address);
```

The first or second argument is the address of an ADA_KRN_DEFS.TASK_ATTR_T record. The TASK_ATTR_T record is passed to the underlying OS at task create.

The task attributes are OS dependent. See ada_krn_defs.a in standard for the type definition of TASK_ATTR_T and the different options supported. When there isn't a TASK_ATTRIBUTES pragma for a task, the DEFAULT_TASK_ATTRIBUTES found in the v_usr_conf_b.a configuration table are used.

All variations of the TASK_ATTR_T record contain at least the PRIO field. PRIO specifies the priority of the task. If the task also had a pragma PRIORITY(PRIO), the PRIO specified in the
record takes precedence.

The first argument in the second form of the pragma is the name of a task object. This allows task objects of the same task type to have different task attributes (including different task priorities).

ada_krn_defs.a has the following overloaded functions for initializing the task attributes:

```
function task_attr_init(
   prio            : priority;
    .
    .  OS dependent fields
    .
) return address;
```

A.4.4 Interrupt Entry

In the 2.1 Ada RTS, the address specified in the interrupt entry for use at clause points to an INTR_ENTRY_T record defined in ADA_KRN_DEFS. The INTR_ENTRY_T record contains two fields: interrupt vector and the task priority for executing the interrupt entry's accept body. In previous release the address in the for use at clause specified the interrupt vector.

To preserve backwards compatibility, the parameter, OLD_STYLE_MAX_INTR_ENTRY was added to the configuration table in v_usr_conf_b.a. If the address in the for use at clause is <= OLD_STYLE_MAX_INTR_ENTRY, then, it contains the interrupt vector value and not a pointer to an ADA_KRN_DEFS.INTR_ENTRY_T record. Setting OLD_STYLE_MAX_INTR_ENTRY to 0 (NO_ADDR), disables the old way of interpretation.

The default value for OLD_STYLE_MAX_INTR_ENTRY is 511.

ada_krn_defs.a has the following overloaded function for initializing the interrupt entry:

```
function intr_entry_init(
   intr_vector : intr_vector_id_t;
   prio        : priority := priority'last) return address;
```

For OLD_STYLE_MAX_INTRY_ENTRY = 511, the following two interrupt entries are identical:

```
task a is
   entry ctrl_c;
   for ctrl_c use at ada_krn_defs.intr_entry_init(
                           intr_vector => 2,
                           prio => priority'last);
end;
```

or

```
task a is
   pragma priority(priority’last -1);
   entry ctrl_c;
   for ctrl_c use at system.memory_address(2);
end;
```

Note – For the old style interrupt entry, the task priority for executing the interrupt entry's accept body is always the priority of the attached task containing the interrupt entry (per POSIX 1003.5). The priority cannot differ as it can for the new style.

A.4.4.1 Passive Interrupt Entry

Previously, you specified a passive interrupt entry as follows:

```
task a is
  entry ctrl_c;
  for ctrl_c use at system.memory_address(2);
  pragma passive(INTERRUPT, disable_intr_status);
end;
```

In this version, indicate a passive interrupt entry by:

```
task a is
  entry ctrl_c;
  for ctrl_c use at ada_krn_defs.intr_entry_init(
                           intr_vector => 2,
                           prio => priority'last);
  pragma passive(ABORT_UNSAFE,
      ada_krn_defs.intr_attr_init(disable_intr_status));
```

Or, to disable all interrupts

```
  pragma passive(ABORT_UNSAFE,
  ada_krn_defs.DEFAULT_INTR_ATTR);
                                -- all interrupts disabled
end;
```

If the underlying OS doesn't support passive interrupt entries, then, the PROGRAM_ERROR exception is raised.

A.4.5 Ada I/O

All SEQUENTIAL_IO, DIRECT_IO, TEXT_IO, INTEGER_IO, FLOAT_IO, FIXED_IO, and ENUMERATION_IO file operations were changed to be Ada tasking safe and abort safe. All I/O operations are locked on a per file basis.

You now are guaranteed atomic file operations on a per task basis. Furthermore, the task initiating the I/O request is inhibited from being completed by an Ada Abort until it finishes.

Since I/O operations were not protected in the past, you could call the TEXT_IO put subprograms from a passive ISR accept body or an ISR (signal) handler. Now, if you call `text_io.put()` from an ISR, a task may already be doing an I/O operation to the same file and holding its lock. Since an ISR cannot block waiting for the lock, a TASKING_ERROR exception must be raised. Note that this restriction does not apply to non-passive interrupt entries.

To allow diagnostic output from an ISR, we have added `package SIMPLE_IO`, to `standard` for self hosts. (It already exists in CROSS_IO for cross targets.) The SIMPLE_IO package contains a subset of the TEXT_IO put subprograms. The SIMPLE_IO subprograms are unprotected and make direct calls to the OS I/O services.

A.4.6 Memory Allocation

Before 2.1, all memory allocations were task safe. Now they are also abort safe. The task doing a memory allocation operation is inhibited from being completed by an Ada abort until it finishes the allocation operation and releases the lock.

A.4.7 Fast Rendezvous Optimization

Normally the accept body of an Ada rendezvous is only executed in the context of the acceptor task. The fast rendezvous optimization also executes the accept body in the context of the caller task. This optimization reduces the number of thread context switches that need to be executed by the underlying OS threads.

Here's an overview of the optimization: if the acceptor task gets to the accept statement before the caller task makes the call, the acceptor task saves its register and stack context, switches to a wait stack and does an `ADA_KRN_I.TASK_WAIT`. When the caller task gets around to doing the accept call, it saves its register and stack context, restores the acceptor task's register and stack context and returns to execute the accept body. When the end of the accept body is reached, the caller task overwrites the current register and stack context into the acceptor task's area, does an `ADA_KRN_I.TASK_SIGNAL` of the acceptor task, restores the caller task's register and stack context and returns to the code in the caller task. Eventually, when the signaled acceptor task is scheduled to run, it restores the acceptor task's register and stack context (this context was updated by the caller task to be at the point where the call was made to finish the accept body) and returns to the code in the acceptor task after the call was made to finish the accept body.

Two configuration parameters have been added to `v_usr_conf` on behalf of the fast rendezvous optimization:

`FAST_RENDEZVOUS`
: Setting this parameter to `TRUE` enables the fast rendezvous optimization. This parameter would only need to be set to `FALSE`, for multiprocessor Ada, where the accept body must execute in the acceptor task bound to a processor. It defaults to `TRUE`.

`WAIT_STACK_SIZE`
: This parameter specifies how much stack is needed for when the acceptor task switches from its normal task stack to a special stack it can use to call `ADA_KRN_I.TASK_WAIT`.

When using the debugger, the fast rendezvous optimization (accept body is executed by the caller task) has a few subtle differences from the normal rendezvous case (accept body is executed by the acceptor task).

Here's an example to illustrate the differences. I have two tasks doing a repetitive rendezvous. The caller task is RENDEZVOUS_SEND. The acceptor task is RENDEZVOUS_RECEIVE. I have placed a breakpoint in the acceptor body. I have two cases, either the breakpoint is reached when the acceptor task (RENDEZVOUS_RECEIVE) is executing the accept body or the caller task (RENDEZVOUS_SEND) is executing the acceptor body. Here's the debugger output for the two cases.

Case 1: at breakpoint when the acceptor task is executing the accept body (normal rendezvous)

```
1]  stopped at "/vc/test/task_rend2.a":15 in rendezvous_receive

>lt
Q  TASK                ADDR       STATUS
   rendezvous_send     01006e63c  in rendezvous
        rendezvous_receive[010068fbc].receive_item
*  rendezvous_receive  010068fbc  executing
        in rendezvous with rendezvous_send[01006e63c] at
                                  entry receive_item
>lt all
Q  TASK                ADDR       STATUS
   rendezvous_send     01006e63c  in rendezvous
        rendezvous_receive[010068fbc].receive_item
        thread id = 01006e7c0
*  rendezvous_receive  010068fbc  executing
        in rendezvous with rendezvous_send[01006e63c] at
                                  entry receive_item
        ENTRY         STATUS   TASKS WAITING
        receive_item           - no tasks waiting -
        thread id = 010069140
```

Case 2: at breakpoint when the caller task is executing accept body (fast rendezvous)

```
[1]  stopped at "/vc/test/task_rend2.a":15 in rendezvous_receive

>lt
Q  TASK                ADDR       STATUS
   rendezvous_send     01006e63c  doing rendezvous
        for rendezvous_receive[010068fbc].receive_item
*  rendezvous_receive  010068fbc  executing
        in rendezvous via rendezvous_send[01006e63c] at
                                  entry receive_item
>lt all
Q  TASK                ADDR       STATUS
   rendezvous_send     01006e63c  doing rendezvous
        for rendezvous_receive[010068fbc].receive_item
        thread id = 01006e7c0
*  rendezvous_receive  010068fbc  executing
        in rendezvous via rendezvous_send[01006e63c] at
                                  entry receive_item
        ENTRY         STATUS   TASKS WAITING
        receive_item           - no tasks waiting -
        thread id = 010069140
```

Here are the subtle differences for the fast rendezvous, case 2:

- Even though the breakpoint occurred in the RENDEZVOUS_SEND task, we still display RENDEZVOUS_RECEIVE as the current breakpointed task. You can select the caller task and still get the caller's callstack and see where it was making the rendezvous call from.
- The STATUS for RENDEZVOUS_SEND is “doing rendezvous” instead of “in rendezvous”. “doing” instead of “in” indicates that the caller task is executing the accept body.
- The second line for RENDEZVOUS_RECEIVE is “in rendezvous via” instead of “in rendezvous with”. “via” instead of “with” indicates that the caller task is executing the accept body.
- The only misleading piece of information is the current underlying thread that is executing. The debugger says that RENDEZVOUS_RECEIVE is the currently executing task. From this you would assume that its thread, 010069140, is the current one. However, for the fast rendezvous case, it is really RENDEZVOUS_SEND's thread, 01006e7c0.

A.4.8 VADS EXEC: V_INTERRUPTS *Services*

The following services were added to V_INTERRUPTS:

```
function ATTACH_ISR
            (vector     : in     vector_id;        isr
       : in     system.address)
                                          return system.address;
-- Overloads the existing ATTACH_ISR procedure.
-- The new function version returns the previously
-- attached vector.

function DETACH_ISR(vector : in vector_id)
                                          return system.address;

-- Overloads the existing DETACH_ISR procedure.
-- The new function version returns the previously
-- attached vector.

function CURRENT_SUPERVISOR_STATE return boolean;
-- Returns the supervisor/user state of the current task.
-- If the task is in supervisor state, returns TRUE.

function SET_SUPERVISOR_STATE(new_state : in boolean)
                                            return boolean;

-- Sets the supervisor/user state for the current task
-- to a different setting.  The previous state is returned.
```

A.4.9 VADS EXEC: V_XTASKING *Services*

package SYSTEM contains the type definitions for the Ada task control block (TCB), TASK_ID, and the Ada program control block (PCB), PROGRAM_ID. Since Ada tasking and VADS EXEC are layered upon the OS's tasks and programs, we also need to define types for the OS's TCB and PCB. The following types have been added:

```
type os_task_id is new ADA_KRN_DEFS.krn_task_id;
NULL_OS_TASK_NAME: constant os_task_id :=
 os_task_id(ADA_KRN_DEFS.NO_KRN_TASK_ID);
  -- Type of the underlying OS's task control block.
  -- The os_task_name parameter passed to the task callouts
  -- is of this type. The services ID() and OS_ID() are
  -- provided to map OS task id's to/from Ada task id's.
  --
  -- Note, except for the task callout procedures and the
  -- GET_TASK_STORAGE2 service, the task_name parameters
  -- identify the Ada task and not the underlying OS task
  -- or thread.

type os_program_id is new ADA_KRN_DEFS.krn_program_id;
NULL_OS_PROGRAM_NAME: constant os_program_id :=
 os_program_id(ADA_KRN_DEFS.NO_KRN_PROGRAM_ID);
  -- Type of the underlying OS's program control block. The
  -- os_program_name parameter passed to the program
  -- callouts is of this type. The services ID() and
  -- OS_ID() are provided to map OS program id's
  -- to and from Ada program id's.
  --
  -- Note, except for the program callout procedures,
  -- the program_name parameters identify the Ada program
  -- and not the underlying OS program or process.
```

The following services have been added for converting from an Ada TASK_ID to an underlying thread/OS_TASK_ID and vice versa. Services have also been added for converting program IDs.

```
function ID(os_task_name : in os_task_id)
                                    return system.task_id;
 -- Returns an id for an Ada task given the underlying OS's   --
task id. The
os_task_name is passed as a parameter
 -- to the task callouts. Returns NULL_TASK_NAME if the      --
OS task isn't
also an Ada task.

function OS_ID(task_name : in system.task_id)
                                    return os_task_id;
  -- Returns the underlying OS's task id given the
  -- Ada task id.

function ID(os_program_name : in os_program_id)
                                    return system.program_id;
  -- Returns an id for an Ada program given the underlying
  -- OS's program id. The os_program_name is passed as a
  -- parameter to the program callouts. Returns
  -- NO_PROGRAM_ID if the OS program isn't also an
  -- Ada program.

function OS_ID(program_name : in system.program_id)
                                    return os_program_id;
  -- Returns the underlying OS's program id given
  -- the Ada program id.
```

The following ABORT_SAFE services were added:

```
procedure DISABLE_TASK_COMPLETE;
procedure ENABLE_TASK_COMPLETE;
  -- Disables/enables the current task from being
  -- completed and terminated when aborted. These services
  -- must be paired.  They can be nested. No return, if
  -- not nested and the current task has been marked
  -- abnormal by a previous abort.
  --
  -- These services would be used as follows to inhibit a
  -- task from being completed after it has acquired a
  -- sharable resource such as a semaphore.
  --
  --      DISABLE_TASK_COMPLETE;
  --          acquire_resoure;
  --          use_resource;
  --          release_resource;
  --      ENABLE_TASK_COMPLETE;
```

The following FAST_RENDEZVOUS services have been added:

```
function CURRENT_FAST_RENDEZVOUS_ENABLED return boolean;
procedure SET_FAST_RENDEZVOUS_ENABLED (new_value : boolean);
  -- Gets/sets the fast rendezvous enabled
  -- flag for the current task.  See the
  -- "Fast Rendezvous Optimization" section
  -- in the overview for more details
  -- about the optimization.
  --
  -- Normally, fast rendezvous would only need
  -- to be disabled for multiprocessor Ada where
  -- the accept body must execute in the
  -- acceptor task that is bound to a
  -- processor.
```

The semantics of the RESUME_TASK and SUSPEND_TASK services depend on the underlying OS. These VADS EXEC services are layered upon ADA_KRN_I.TASK_RESUME and ADA_KRN_I.TASK_SUSPEND.

For the VADS MICRO kernel, RESUME_TASK always returns RESUMED (or no exception is raised). Each task has a suspend flag. RESUME_TASK sets the task's suspend flag to FALSE. If the task is READY to run, it is put on the run queue.

For the VADS MICRO kernel, SUSPEND_TASK always returns SUSPENDED (or no exception is raised). SUSPEND_TASK sets the task's suspend flag to TRUE. If the task is on the run queue, it is removed. The task is inhibited from being placed on the run queue until it is resumed via the RESUME_TASK service.

For SUN THREADS, RESUME_TASK/SUSPEND_TASK map directly upon the Solaris thread service THR_CONTINUE/THR_SUSPEND.

The time slicing services are supported only by the VADS MICRO kernel. These are the services: CURRENT_TIME_SLICE, SET_TIME_SLICE, CURRENT_TIME_SLICING_ENABLED, and SET_TIME_SLICING_ENABLED.

The program services, START_PROGRAM and GET_PROGRAM_KEY are supported only by the VADS MICRO kernel on cross targets.

The TERMINATE_CALLOUT passed to START_PROGRAM is called with the OS's PROGRAM_NAME and not the Ada PROGRAM_NAME.

For the INSTALL_CALLOUT service, only the events, EXIT_EVENT and UNEXPECTED_EXIT_EVENT are supported by all the underlying OSs. The IDLE_EVENT was added for the VADS MICRO. Also, only the VADS MICRO supports the task storage services.

For VADS MICRO, the PROGRAM_SWITCH_CALLOUT is called with the OS's PROGRAM_NAME and not the Ada PROGRAM_NAME.

For VADS MICRO, the TASK_CALLOUTs are called with the OS's TASK_NAME and not the Ada PROGRAM_NAME. The newly added service, GET_TASK_STORAGE2, must be called to get task storage using the OS_TASK_NAME.

The following task storage service was added:

```
function GET_TASK_STORAGE2
           (os_task_name : in     os_task_id;
            storage_id   : in     task_storage_id)
                                          return system.address;

-- Returns the starting address of the task storage area
-- associated with the storage_id using OS's id of the task
-- (instead of the Ada task_id)
```

The implementation of the DISABLE_PREEMPTION/ENABLE_PREEMPTION services was changed for the VADS MICRO. The VADS MICRO kernel maintains a preemption depth count for each task. This preemption depth is saved/restored at a task switch. Each call to DISABLE_PREEMPTION increments the depth. A nonzero depth count inhibits preemption. However, another task may run if the task calls a kernel service that causes it to block. Each call to ENABLE_PREEMPTION decrements the depth. When the depth is zero, the task may be preempted.

A.4.10 VADS EXEC: V_SEMAPHORES *Services*

The ATTR parameter has been added to the binary CREATE_SEMAPHORE services. The INTERRUPT_FLAG and INTERRUPT_STATUS parameters for the counting CREATE_SEMAPHORE services have been replaced with the ATTR parameter. For the binary CREATE_SEMAPHORE, ATTR points to an ADA_KRN_DEFS.SEMAPHORE_ATTR_T record. For the counting CREATE_SEMAPHORE, ATTR points to an ADA_KRN_DEFS.COUNT_SEMAPHORE_ATTR_T record.

The binary/counting semaphore attributes are OS dependent. See ada_krn_defs.a in standard for the type definition of SEMAPHORE_ATTR_T/COUNT_SEMAPHORE_ATTR_T and the different options supported.

The ATTR parameter has been defaulted to DEFAULT_SEMAPHORE_ATTR or DEFAULT_COUNT_SEMAPHORE_ATTR. Unless you want to do something special, the default should suffice.

For the VADS MICRO counting CREATE_SEMAPHORE: use the ADA_KRN_DEFS.COUNT_INTR_ATTR_T to protect the critical region for updating the semaphore's count by disabling interrupts. Setting ATTR to ADA_KRN_DEFS.DEFAULT_COUNT_INTR_ATTR disables all interrupts.

Fixed the DELETE_SEMAPHORE logic to always free memory allocated for the semaphore. Previously, memory wasn't freed if the semaphore was used for signaling.

A.4.11 VADS EXEC: V_MAILBOXES *Services*

The INTERRUPT_FLAG and INTERRUPT_STATUS parameters for the CREATE_MAILBOX services have been replaced with the ATTR parameter. ATTR points to an ADA_KRN_DEFS.MAILBOX_ATTR_T record.

The mailbox attributes are OS dependent. See ada_krn_defs.a in standard for the type definition of MAILBOX_ATTR_T and the different options supported.

The ATTR parameter has been defaulted to DEFAULT_MAILBOX_ATTR. Unless you want to do something special, the default should suffice.

For VADS MICRO, use the ADA_KRN_DEFS.MAILBOX_INTR_ATTR_T to protect the mailbox's critical region by disabling interrupts. Setting ATTR to ADA_KRN_DEFS.DEFAULT_MAILBOX_INTR_ATTR disables all interrupts.

A.4.12 VADS EXEC: V_STACK *Services*

The EXTEND_STACK service isn't supported. When called, it always raises STORAGE_ERROR exception.

A.4.13 ADA_KRN_I*: Interface To the Ada Kernel Services*

In earlier releases, the interface to the low level kernel services was scattered across multiple v_i_* files. In 2.1, the interface is consolidated in one package, ADA_KRN_I. Most of the services are needed to support the Ada tasking semantics. The remaining services are needed to support VADS EXEC. The VADS EXEC services are optional and not supported by all versions of the OS threads.

The interface to the services was designed from the viewpoint of the Ada tasking layer. For example, when a task is created, it returns the Ada `TASK_ID` and not the underlying kernel's `TASK_ID`.

The services are subdivided into the following groups.

- Program
- Kernel scheduling
- Task management
- Task masters synchronization
- Task synchronization
- Interrupt
- Time
- Allocation
- Mutex
- ISR mutex
- Semaphore
- Count semaphore
- Mailbox
- Callout
- Task storage

Here is list of the services provided in each group.

- Program services
  - `PROGRAM_INIT`
  - `PROGRAM_EXIT`
  - `PROGRAM_DIAGNOSTIC`
  - `PANIC_EXIT`
  - `PROGRAM_IS_ACTIVE`
  - `PROGRAM_SELF`
- Program services (VADS EXEC augmentation)
  - `PROGRAM_GET`
  - `PROGRAM_START`
  - `PROGRAM_TERMINATE`
  - `PROGRAM_GET_KEY`
  - `PROGRAM_GET_ADA_ID`
  - `PROGRAM_GET_KRN_ID`

Kernel scheduling services (VADS EXEC augmentation)
- KERNEL_GET_TIME_SLICING_ENABLED
- KERNEL_SET_TIME_SLICING_ENABLED

Task management services (VADS EXEC augmentation)
- TASK_SELF
- TASK_SET_PRIORITY
- TASK_GET_PRIORITY
- TASK_CREATE
- TASK_ACTIVATE
- TASK_STOP
- TASK_DESTROY
- TASK_STOP_SELF
- TASK_DESTROY_SELF

Task management services (VADS EXEC augmentation)
- TASK_DISABLE_PREEMPTION
- TASK_ENABLE_PREEMPTION
- TASK_GET_ADA_ID
- TASK_GET_KRN_ID
- TASK_SUSPEND
- TASK_RESUME
- TASK_GET_TIME_SLICE
- TASK_SET_TIME_SLICE
- TASK_GET_SUPERVISOR_STATE
- TASK_ENTER_SUPERVISOR_STATE
- TASK_LEAVE_SUPERVISOR_STATE

Task masters synchronization services
- MASTERS_LOCK
- MASTERS_TRYLOCK
- MASTERS_UNLOCK

Task synchronization services
- TASK_LOCK
- TASK_UNLOCK
- TASK_WAIT
- TASK_WAIT_LOCKED_MASTERS
- TASK_TIMED_WAIT
- TASK_SIGNAL

TASK_WAIT_UNLOCK
TASK_SIGNAL_UNLOCK
TASK_SIGNAL_WAIT_UNLOCK

Sporadic Task services (CIFO augmentation)
TASK_IS_SPORADIC
TASK_SET_FORCE_HIGH_PRIORITY

Interrupt services
INTERRUPTS_GET_STATUS
INTERRUPTS_SET_STATUS
ISR_ATTACH
ISR_DETACH
ISR_IN_CHECK

Time services
TIME_SET
TIME_GET
TIME_DELAY
TIME_DELAY_UNTIL

Allocation services
ALLOC
FREE

Mutex services
MUTEX_INIT
MUTEX_DESTROY
MUTEX_LOCK
MUTEX_TRYLOCK
MUTEX_UNLOCK
COND_INIT
COND_DESTROY
COND_WAIT
COND_TIMED_WAIT
COND_SIGNAL
COND_BROADCAST
COND_SIGNAL_UNLOCK

ISR mutex services
- ISR_MUTEX_LOCKABLE
- ISR_MUTEX_LOCK
- ISR_MUTEX_UNLOCK
- ISR_COND_SIGNAL

Priority ceiling mutex services (CIFO augmentation)
- CEILING_MUTEX_INIT
- CEILING_MUTEX_SET PRIORITY
- CEILING_MUTEX_GET PRIORITY

Semaphore services
- SEMAPHORE_INIT
- SEMAPHORE_DESTROY
- SEMAPHORE_WAIT
- SEMAPHORE_TRYWAIT
- SEMAPHORE_TIMED_WAIT
- SEMAPHORE_SIGNAL
- SEMAPHORE_GET_IN_USE

Count semaphore services (VADS EXEC augmentation)
- COUNT_SEMAPHORE_INIT
- COUNT_SEMAPHORE_DESTROY
- COUNT_SEMAPHORE_WAIT
- COUNT_SEMAPHORE_SIGNAL
- COUNT_SEMAPHORE_GET_IN_USE

Mailbox services (VADS EXEC augmentation)
- MAILBOX_INIT
- MAILBOX_DESTROY
- MAILBOX_READ
- MAILBOX_WRITE
- MAILBOX_GET_COUNT
- MAILBOX_GET_IN_USE
- CALLOUT SERVICES
- CALLOUT_INSTALL

Task storage services (VADS EXEC augmentation)
- TASK_STORAGE_ALLOC
- TASK_STORAGE_GET
- TASK_STORAGE_GET2

A.4.14 ADA_KRN_DEFS*: Ada Kernel Type Definitions*

All type definitions used by the Ada tasking layer that are OS threads specific are defined in ADA_KRN_DEFS. ADA_KRN_DEFS also contains numerous functions for allocating and initializing object attribute records.

ada_krn_defs.a contains type definitions for the following objects:

```
mutex
condition variable
semaphore
counting semaphore
mailbox
```

The following types are of interest to anyone using Ada tasking:

KRN_TASK_ID
: The type of the underlying thread. ADA_KRN_I has services for mapping between the Ada TASK_ID and KRN_TASK_ID.

KRN_PROGRAM_ID
: The type of the underlying program / process. ADA_KRN_I has services for mapping between the Ada PROGRAM_ID and KRN_PROGRAM_ID.

CALLOUT_EVENT_T
: All versions of the Ada Kernel / OS threads are expected to support at least EXIT_EVENT and UNEXPECTED_EXIT_EVENT.

TASK_STORAGE_ID
: Where supported, the ID or handle of a user defined object stored in every task.

INTR_VECTOR_ID_T
: For self: signal number range, for cross: interrupt number range

INTR_STATUS_T
: Signal mask in status register

DISABLE_INTR_STATUS
: Constant for disabling all asynchronous signals.

ENABLE_INTR_STATUS
: Constant for enabling all signals.

INTR_ENTRY_T

The address of an INTR_ENTRY_T object is specified in an interrupt entry for use at clause. The INTR_ENTRY_T record contains two fields: interrupt vector and the task priority for executing the interrupt entry's accept body See the section on Interrupt Entry for more details.

The INTR_ENTRY_T record can be initialized using one of the overloaded INTR_ENTRY_INIT subprograms:

```
procedure intr_entry_init(
    intr_entry : a_intr_entry_t;
    intr_vector: intr_vector_id_t;
    prio       : priority := priority'last);
function intr_entry_init(
    intr_entry : a_intr_entry_t;
    intr_vector: intr_vector_id_t;
    prio       : priority := priority'last) return address;
function intr_entry_init(
    -- does an implicit "intr_entry: a_intr_entry_t :=
    --                                 new intr_entry_t;"
    intr_vector: intr_vector_id_t;
    prio       : priority := priority'last) return address;
```

`intr_entry_init()` can be used as follows to define an interrupt entry:

```
with system;
with ada_krn_defs;
package one is
    -- Does an implicit allocation of the
    -- intr_entry_t record
    task a is
        entry ctrl_c;
        for ctrl_c use at ada_krn_defs.intr_entry_init(
                        intr_vector => 2,
                        prio => priority'last);
    end;
end one;

with system;
with ada_krn_defs;
package two is
    -- No implicit allocation is done
    ctrl_c_intr_entry_rec: ada_krn_defs.intr_entry_t;
    ctrl_c_intr_entry: system.address :=
        ada_krn_defs.intr_entry_init(
            intr_entry  => ada_krn_defs.to_a_intr_entry_t(
                            ctrl_c_intr_entry_rec'address),
            intr_vector => 2,
            prio        => priority'last);
    task a is
        entry ctrl_c;
        for ctrl_c use at ctrl_c_intr_entry;
        -- OR
        -- for ctrl_c use at ctrl_c_intr_entry_rec'address;
    end;
end two;
```

TASK_ATTR_T

The address of a TASK_ATTR_T record is the first argument of the TASK_ATTRIBUTES pragma and is passed to the underlying OS threads at task create. The definition of the TASK_ATTR_T record is OS specific. However, all variations of the TASK_ATTR_T record contain at least the PRIO field. PRIO specifies the priority of the task. If the task also had a pragma PRIORITY(PRIO), then, the PRIO specified in the TASK_ATTR_T record takes precedence. See the section Pragmas for more details.

The TASK_ATTR_T record can be initialized using one of the overloaded TASK_ATTR_INIT subprograms:

```
procedure task_attr_init(
    task_attr   : a_task_attr_t;
    prio        : priority := priority'first;
    -- ...  OS threads specific fields
);
function task_attr_init(
    task_attr   : a_task_attr_t;
    prio        : priority := priority'first;
    -- ...  OS threads specific fields
) return address;
function task_attr_init(
    -- does an implicit "task_attr: a_task_attr_t :=
    --                            new task_attr_t;"
    prio        : priority := priority'first;
    -- ...  OS threads specific fields
) return address;
```

`task_attr_init()` can be used as follows in a `TASK_ATTRIBUTES` pragma:

```
with system;
with ada_krn_defs;
package one is
   -- Does an implicit allocation of the task_attr_t record
    task a is
        pragma task_attributes(ada_krn_defs.task_attr_init(
                               prio => 20,
                               ... OS threads specific fields
                              ));
    end;
    task type tt;
    b: tt;
        pragma task_attributes(b, ada_krn_defs.task_attr_init(
                               prio => 30,
                               ... OS threads specific fields
                              ));
end one;

with system;
with ada_krn_defs;
package two is
    -- No implicit allocation is done
    a_attr_rec: ada_krn_defs.task_attr_t;
    a_attr: system.address :=
        ada_krn_defs.task_attr_init(
            task_attr   => ada_krn_defs.to_a_task_attr_t(
                                a_attr_rec'address),
            prio        => 20,
            ... OS threads specific fields
        );
    b_attr_rec: ada_krn_defs.task_attr_t;
    b_attr: system.address :=
        ada_krn_defs.task_attr_init(
            task_attr   => ada_krn_defs.to_a_task_attr_t(
                                b_attr_rec'address),
            prio        => 30,
            ... OS threads specific fields        );
```

```
(Continued)
    task a is
        pragma task_attributes(a_attr);
        -- or
        -- pragma task_attributes(a_attr_rec'address);
    end;
    task type tt;
    b: tt;
        pragma task_attributes(b, b_attr);
        -- or
        -- pragma task_attributes(b, b_attr_rec'address);
end two;
```

MUTEX_ATTR_T

The address of a MUTEX_ATTR_T record is the second argument of a PASSIVE pragma. The passive task's critical region is protected by locking and unlocking a mutex. The MUTEX_ATTR_T record is used to initialize the mutex. See the section *Pragmas* for more details on usage in passive tasks.

The mutex services in ADA_KRN_I can be used directly by the user program. The address of a MUTEX_ATTR_T record is passed directly to ADA_KRN_I.MUTEX_INIT.

The mutex attributes are OS threads dependent. See ada_krn_defs.a in standard for the different options supported. (The VADS MICRO supports FIFO, priority or priority inheritance waiting when the mutex is locked by another task.) In the CIFO add-on product, VADS MICRO also supports priority ceiling mutexes using the priority ceiling protocol emulation algorithm documented in the POSIX 1003.4a standard.

The VADS MICRO has the following variant mutex attribute record type:

INTR_ATTR_T

Disables interrupts (signals) to provide mutual exclusion

The function, DEFAULT_MUTEX_ATTR, is provided to select the default mutex attributes.

To provide mutual exclusion by disabling all interrupts, use DEFAULT_INTR_ATTR. If the underlying OS threads doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised.

The following subprograms are provided to initialize the MUTEX_ATTR_T record:

```
fifo_mutex_attr_init()
prio_mutex_attr_init()
prio_inherit_mutex_attr_init()
prio_ciling_mutex_attr_init()
intr_attr_init()
```

If the underlying OS threads doesn't support the type of mutex being initialized, the PROGRAM_ERROR exception is raised.

Here are the overloaded subprograms for initializing the MUTEX_ATTR_T record:

```
procedure fifo_mutex_attr_init(
    attr           : a_mutex_attr_t);
function fifo_mutex_attr_init(
    attr           : a_mutex_attr_t) return a_mutex_attr_t;
function fifo_mutex_attr_init(
    attr           : a_mutex_attr_t) return address;
function fifo_mutex_attr_init return a_mutex_attr_t;
    -- does an implicit
    --      "attr: a_mutex_attr_t := new mutex_attr_t;"
function fifo_mutex_attr_init return address;
    -- does an implicit
    --      "attr: a_mutex_attr_t := new mutex_attr_t;"

procedure prio_mutex_attr_init(
    attr           : a_mutex_attr_t);
function prio_mutex_attr_init(
    attr           : a_mutex_attr_t) return a_mutex_attr_t;
function prio_mutex_attr_init(
    attr           : a_mutex_attr_t) return address;
function prio_mutex_attr_init return a_mutex_attr_t;
    -- does an implicit
    -- "attr: a_mutex_attr_t := new mutex_attr_t;"
function prio_mutex_attr_init return address;
    -- does an implicit
    -- "attr: a_mutex_attr_t := new mutex_attr_t;"

procedure prio_inherit_mutex_attr_init(
    attr           : a_mutex_attr_t);
function prio_inherit_mutex_attr_init(
    attr           : a_mutex_attr_t) return a_mutex_attr_t;
function prio_inherit_mutex_attr_init(
    attr           : a_mutex_attr_t) return address;
function prio_inherit_mutex_attr_init return
                                  a_mutex_attr_t;
    -- does an implicit
    -- "attr: a_mutex_attr_t := new mutex_attr_t;"
function prio_inherit_mutex_attr_init return address;
    -- does an implicit
    --      "attr: a_mutex_attr_t := new mutex_attr_t;"
```

A

(Continued)

```
procedure prio_ceiling_mutex_attr_init(
        attr                    : a_mutex_attr_t;
        ceiling_prio    : priority := priority'last);
function prio_ceiling_mutex_attr_init(
        attr                    : a_mutex_attr_t;
        ceiling_prio    : priority := priority'last)
           return a_mutex_attr_t;
function prio_ceiling_mutex_attr_init(
        attr                    : a_mutex_attr_t;
        ceiling_prio    : priority := priority'last) return
address;
function prio_ceiling_mutex_attr_init(
        -- does an implicit "attr: a_mutex_attr_t := new
mutex_attr_t;"
        ceiling_prio    : priority := priority'last)
           return a_mutex_attr_t;
function prio_ceiling_mutex_attr_init(
        -- does an implicit "attr: a_mutex_attr_t :=
        -- new mutex_attr_t;"
        ceiling_prio    : priority := priority'last) return
address;
procedure intr_attr_init(
    attr           : a_mutex_attr_t;
                          disable_status  : intr_status_t :=
                          DISABLE_INTR_STATUS);
function intr_attr_init(
    attr           : a_mutex_attr_t;
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
         return a_mutex_attr_t;
function intr_attr_init(
    attr           : a_mutex_attr_t;
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
return address;
function intr_attr_init(
    -- does an implicit "attr: a_mutex_attr_t :=
    -- new mutex_attr_t;"
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
return a_mutex_attr_t;
function intr_attr_init(
    -- does an implicit "attr: a_mutex_attr_t :=
    -- new mutex_attr_t;"
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
       return address;
```

The above init subprograms can be used as follows in a PASSIVE pragma:

```
with system;
with ada_krn_defs;
package one is

    task a is
        pragma passive(ABORT_SAFE,

ada_krn_defs.fifo_mutex_attr_init);
    end;

    prio_mutex_attr_rec: ada_krn_defs.mutex_attr_t;
    prio_mutex_attr: system.address :=
        ada_krn_defs.prio_mutex_attr_init(
            ada_krn_defs.to_a_mutex_attr_t(
                prio_mutex_attr_rec'address));

    task b is
        pragma passive(ABORT_SAFE, prio_mutex_attr);
        -- or
        -- pragma passive(ABORT_SAFE,

prio_mutex_attr_rec'address);
    end;
end one;
```

COND_ATTR_T

The address of a COND_ATTR_T record is passed to the Ada kernel service, cond_init().

The condition variable attributes are OS threads dependent. See ada_krn_defs.a in standard for the different options supported. The VADS MICRO supports FIFO or priority waiting.

The function, DEFAULT_COND_ATTR, is provided to select the default condition variable attributes.

The following subprograms are provided to initialize the COND_ATTR_T record:

```
fifo_cond_attr_init()
prio_cond_attr_init()
```

If the underlying OS threads doesn't support the type of condition variable being initialized, the PROGRAM_ERROR exception is raised.

Here are the overloaded subprograms for initializing the COND_ATTR_T record:

```
procedure fifo_cond_attr_init(
    attr            : a_cond_attr_t);
function fifo_cond_attr_init(
    attr            : a_cond_attr_t) return a_cond_attr_t;
function fifo_cond_attr_init return a_cond_attr_t;
    -- does an implicit
    --      "attr: a_cond_attr_t := new cond_attr_t;"

procedure prio_cond_attr_init(
    attr            : a_cond_attr_t);
function prio_cond_attr_init(
    attr            : a_cond_attr_t) return a_cond_attr_t;
function prio_cond_attr_init return a_cond_attr_t;
    -- does an implicit
    --      "attr: a_cond_attr_t := new cond_attr_t;"
```

SEMAPHORE_ATTR_T

The address of a SEMAPHORE_ATTR_T record is passed to the VADS EXEC service, v_semaphores.create_semaphore() which returns a BINARY_SEMAPHORE_ID or the Ada kernel service, ada_krn_i.semaphore_init().

The semaphore attributes are OS threads dependent. See ada_krn_defs.a in standard for the different options supported. (The VADS MICRO only supports FIFO queuing when the task waits on a semaphore.)

The function, DEFAULT_SEMAPHORE_ATTR, is provided to select the default semaphore attributes.

COUNT_SEMAPHORE_ATTR_T

The address of a COUNT_SEMAPHORE_ATTR_T record is passed to the VADS EXEC service, v_semaphores.create_semaphore() which returns a COUNT_SEMAPHORE_ID or the Ada kernel service, ada_krn_i.count_semaphore_init().

The COUNT_SEMAPHORE attributes are OS threads dependent. See ada_krn_defs.a in standard for the different options supported. (The VADS MICRO uses a mutex to protect the count. It waits on a condition variable. The COUNT_SEMAPHORE_ATTR_T is a subtype of MUTEX_ATTR_T. The COND_ATTR_T is derived from the MUTEX_ATTR_T. A FIFO condition variable is used for a FIFO mutex. A priority condition variable is used for either a priority, priority inheritance, or priority ceiling mutex.)

The VADS MICRO has the following variant COUNT_SEMAPHORE attribute record type:

```
count_intr_attr_t - interrupts (unix signals) are disabled
                    when accessing the semaphore count
```

The function, DEFAULT_COUNT_SEMAPHORE_ATTR, is provided to select the default COUNT_SEMAPHORE attributes.

To protect COUNT_SEMAPHORE operations by disabling all interrupts, use DEFAULT_COUNT_INTR_ATTR. If the underlying OS threads doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised. However, if the DEFAULT_COUNT_SEMAPHORE_ATTR is interrupt (UNIX signal) safe, then, DEFAULT_COUNT_INTR_ATTR returns DEFAULT_COUNT_SEMAPHORE_ATTR and doesn't raise PROGRAM_ERROR.

Alternatively, the COUNT_SEMAPHORE attributes can be initialized to select the disable interrupts options by using one of the overloaded COUNT_INTR_ATTR_INIT subprograms:

```
procedure count_intr_attr_init(
    attr            : a_count_semaphore_attr_t;
    disable_status  : intr_status_t :=
                                          DISABLE_INTR_STATUS);
function count_intr_attr_init(
    attr            : a_count_semaphore_attr_t;
    disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                                        return
a_count_semaphore_attr_t;
function count_intr_attr_init(
    -- does an implicit
    --  "attr: a_count_semaphore_attr_t :=
    --                          new count_semaphore_attr_t;"
    disable_status  : intr_status_t := DISABLE_INTR_STATUS)
                                                        return
a_count_semaphore_attr_t;
```

MAILBOX_ATTR_T

The address of a MAILBOX_ATTR_T record is passed to the VADS EXEC service, v_mailboxes.create_mailbox() or the Ada kernel service, ada_krn_i.mailbox_init().

The mailbox attributes are OS threads dependent. See ada_krn_defs.a in standard for the different options supported. (The VADS MICRO uses a mutex to protect the mailbox. It waits on a condition variable. The MAILBOX_ATTR_T is a subtype of MUTEX_ATTR_T. The COND_ATTR_T is derived from the MUTEX_ATTR_T. A FIFO condition variable is used for a FIFO mutex. A priority condition variable is used for either a priority, priority inheritance, or priority ceiling mutex.)

The VADS MICRO has the following variant mailbox attribute record type:

```
mailbox_intr_attr_t - interrupts (unix signals) are
                      disabled when accessing the mailbox
```

The function, DEFAULT_MAILBOX_ATTR, is provided to select the default COUNT_SEMAPHORE attributes.

To protect mailbox operations by disabling all interrupts, use DEFAULT_MAILBOX_INTR_ATTR. If the underlying OS threads doesn't support interrupt attributes, the PROGRAM_ERROR exception is raised. However, if the DEFAULT_MAILBOX_ATTR is interrupt (UNIX signal) safe, then, DEFAULT_MAILBOX_INTR_ATTR returns DEFAULT_MAILBOX_ATTR and doesn't raise PROGRAM_ERROR.

Alternatively, the mailbox attributes can be initialized to select the disable interrupts options by using one of the overloaded MAILBOX_INTR_ATTR_INIT subprograms:

```
procedure mailbox_intr_attr_init(
    attr           : a_mailbox_attr_t;
    disable_status : intr_status_t := DISABLE_INTR_STATUS);

function mailbox_intr_attr_init(
    attr           : a_mailbox_attr_t;
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
                                 return a_mailbox_attr_t;
function mailbox_intr_attr_init(
    -- does an implicit
    --  "attr: a_mailbox_attr_t :=
    --                           new mailbox_attr_t;"
    disable_status : intr_status_t := DISABLE_INTR_STATUS)
                                 return a_mailbox_attr_t;
```

A.4.15 Files Added to Standard

The following files have been added to standard

Table A-1 Files Added to `standard`

`ada_krn_i.a`	interface to the Ada kernel services
`ada_krn_defs.a`	Ada kernel type definitions
`krn_call_i.a`	interface to the routines resident in the user program that call the kernel services
krn_cpu_defs.a	kernel program's type definitions that are CPU specific
krn_defs.a	kernel program's type definitions
krn_entries.a	kernel program's service entry IDs and arguments
simple_io.a	
simple_io_b.a	unprotected I/O subprograms that can be called from an ISR (UNIX signal handler)
usr_defs.a	type definitions for services resident in the user program
v_i_cifo.a	interface to the cifo type definitions used by Ada tasking
v_i_except.a	interface to the Ada exception services
v_i_mutex.a	interface to the ABORT_SAFE mutex services
v_usr_conf_i.a	interface for configuring the user program (moved from usr_conf)

A.4.16 New `v_i_*` Low Level Interfaces

The following `v_i_*` files were added:

`v_i_cifo.a`
This package contains the interface to the CIFO type definitions used by Ada tasking

`v_i_except.a`
This package contains the interface to the Ada exception services for:

[1] getting the ID and PC of the current Ada exception

[2] returning the string name of an exception ID

[3] installing a callout to be called whenever an exception is raised

V_I_MUTEX.A
This package interfaces to the mutex and condition variable services that are Ada tasking ABORT_SAFE. After locking a mutex the task is inhibited from being completed by an Ada abort until it unlocks the mutex.

However, if the task is aborted while waiting at a condition variable (after an implicit mutex unlock), it is allowed to complete. The V_I_MUTEX services also address the case where multiple ABORT_SAFE mutexes can be locked. A task is inhibited from being completed until all the mutexes are unlocked or it does a condition variable wait with only one mutex locked. There are services to init, destroy, lock, trylock and unlock an ABORT_SAFE mutex. There are services to init, destroy, wait on, timed wait on, signal and broadcast an ABORT_SAFE condition variable. In the CIFO add-on product, there are also services to init, set priority of and get priority of an ABORT_SAFE priority ceiling mutex.

v_i_mutex.a
This package interfaces to the mutex services that are Ada tasking ABORT_SAFE. After locking a mutex the task is inhibited from being completed by an Ada abort until it unlocks the mutex.

There are services to initialize, destroy, lock, and unlock an ABORT_SAFE mutex.

A.4.17 Modified v_i_* *Low Level Interfaces*

Changes made to v_i* files that existed previously are summarized below.

v_i_alloc.a
Preserve backward compatibility by layering KRN_AA_GLOBAL_NEW on ADA_KRN_I.ALLOC and KRN_AA_GLOBAL_FREE on ADA_KRN_I.FREE.

v_i_callout.a
The interface to the low level callout kernel services is now provided in ada_krn_i.a. Types used by these services are defined in ada_krn_defs.a.

This package preserves backward compatibility by layering upon the callout data structures and subprograms found in ada_krn_defs.a and ada_krn_i.a.

Differences from earlier releases:

[1] Only the callout events, EXIT_EVENT and UNEXPECTED_EXIT_EVENT are supported by all the underlying RTS kernels. The VADS MICRO RTS continues to support the events: PROGRAM_SWITCH_EVENT, TASK_CREATE_EVENT, TASK_SWITCH_EVENT, and TASK_COMPLETE_EVENT. The event, IDLE_EVENT has been added for the VADS MICRO RTS.

[2] For VADS MICRO: the task events are called with a pointer to the micro kernel's task control block, not the Ada TASK_ID as was done in earlier releases.

[3] For VADS MICRO: the program events are called with a pointer to the micro kernel's program control block, not the Ada PROGRAM_ID as was done in earlier releases.

[4] Added the service, get_task_storage2() to get the address of task storage using the underlying kernel's TASK_ID (not the Ada TASK_ID as is used for get_task_storage()). This was added because the task callouts are called with the kernel's TASK_ID and not the Ada TASK_ID.

v_i_csema.a
The interface to the low level counting semaphore services is now provided in ada_krn_i.a. Types used by these services is defined in ada_krn_defs.a.

This package preserves backward compatibility by layering upon the counting semaphore data structures and subprograms found in ada_krn_defs.a and ada_krn_i.a.

Differences from earlier releases:

[1] The INTR_FLAG and INTR_STATUS are only applicable to the VADS MICRO.

[2] For the delete() service, if the CONDITIONAL_DELETE_FLAG is TRUE, the semaphore might not be deleted even though no tasks are waiting on it. This caveat isn't applicable to the VADS MICRO.

v_i_intr.a

The interface to the low level interrupt services is now provided in ada_krn_i.a. Types used by these services is defined in ada_krn_defs.a.

This package preserves backward compatibility by layering upon the interrupt data structures and subprograms found in ada_krn_defs.a and ada_krn_i.a.

Differences from earlier releases:

[1] The following services aren't supported: enter_isr(), complete_isr(). If called, they raise the exception, V_I_INTR_NOT_SUPPORTED. Check, V_INTERRUPTS in VADS EXEC, V_PASSIVE_ISR in V_USR_CONF or V_SIGNAL_ISR in V_USR_CONF for the routines to be called.

v_i_mbox.a

The interface to the low level mailbox services is now provided in ada_krn_i.a. Types used by these services is defined in ada_krn_defs.a.

This package preserves backward compatibility by layering upon the mailbox data structures and subprograms found in ada_krn_defs.a and ada_krn_i.a.

Differences from earlier releases:

[1] The INTR_FLAG and INTR_STATUS are only applicable to the VADS MICRO RTS.

[2] For the delete() service, if the CONDITIONAL_DELETE_FLAG is TRUE, the mailbox might not be deleted even though no tasks are waiting to read. This caveat isn't applicable to the VADS MICRO RTS.

[3] For mailbox write, only the DO_NOT_WAIT option is supported. Earlier releases also supported timed and WAIT_FOREVER write options.

`v_i_pass.a`
The passive task header record was changed to accommodate changes in the compiler and the RTS. Added `ABORT_SAFE` versions of the passive enter and leave services. In the CIFO add-on product, we also support priority ceiling server tasks.

`v_i_sema.a`
The interface to the low level semaphore services is now provided in `ada_krn_i.a`. Types used by these services is defined in `ada_krn_defs.a`.

This package preserves backward compatibility by layering upon the semaphore data structures and subprograms found in `ada_krn_defs.a` and `ada_krn_i.a`.

Differences from earlier releases:

[1] Semaphore must be initialized by calling the newly added routine, `init_sema()`.

[2] For VADS MICRO, only FIFO queuing is supported. For priority queuing use the mutex and condition variable services provided in `ada_krn_i.a`.

[3] The following services aren't supported: `suspend()`, `timed_suspend()` or `resume()`.

`v_i_sig.a`
The `A_SIGNAL_T` type was renamed to `SIGNAL_ID`. `create_signal()` is passed the address of an `INTR_ENTRY_T` record instead of the interrupt vector (`SIGNAL_CODE`). However, if the address is less than or equal to `OLD_STYLE_MAX_INTR_ENTRY` defined in `V_USR_CONF`, its still treated as the `SIGNAL_CODE`.

In addition, added `ignore` and `unignore` signal services for supporting POSIX Signals (per 1003.5).

v_i_taskop.a
The subprograms were changed to use the types, SYSTEM.TASK_ID, SYSTEM.PROGRAM_ID, MASTER_ID, and A_LIST_ID. Backward compatibility is preserved by using the following subtypes also defined here:

```
subtype a_task_t is system.task_id;
subtype a_program_t is system.program_id;
subtype a_master_t is MASTER_ID;
subtype a_alist_t is A_LIST_ID;
```

DAY_T type is now defined in SYSTEM and not V_I_TYPES.

We have added two subprograms to support ABORT_SAFE operations:

```
ts_disable_complete
ts_enable_complete
```

The services, TS_INITIALIZE and TS_EXIT now have subprogram parameters. Two parameters, TASK_ATTR and HAS_PRAGMA_PRIO were added to the services, TS_CREATE_TASK and TS_CREATE_TASK_AND_LINK. The parameters passed to TS_ATTACH_INTERRUPT were redefined to be the ATTACHED_ENTRY and INTR_ENTRY.

The routine, TS_GET_STACK_LIMIT, was added to return the STACK_LIMIT of the current task. It handles the case where the caller task is executing code in a fast rendezvous using the acceptor's stack. It also handles the case for multiprocessor or multithreaded Ada, where the compiler can't reference the stack limit directly from memory.

Added subprograms to get/put information on the last exception raised in the current task:

```
ts_get_last_exception
ts_put_last_exception
```

Added subprograms to support interrupt tasks:

```
ts_create_intr_task
ts_activate_intr_task
ts_complete_intr_task
ts_get_intr_task_vector
ts_get_intr_task_handler
ts_set_intr_task_state
```

Added subprograms to support CIFO:

```
ts_caller
ts_cifo_term_callout
ts_trivial_conditional_Call
ts_trivial_accept
ts_set_entry_criteria
ts_set_select_criteria
```

v_i_tasks.a

The subprograms were changed to use the types, SYSTEM.TASK_ID, SYSTEM.PROGRAM_ID and INTEGER. Backward compatibility is preserved by using the following subtypes defined in V_I_TYPES:

```
subtype v_i_types.a_task_t is system.task_id;
subtype v_i_types.a_program_t is system.program_id;
subtype v_i_types.user_field_t is integer;
```

Added subprograms to support CIFO:

```
task_has_pragma_priority
get_cifo_tcb
set_cifo_tcb
get_task_master
task_is_valid
in_passive_rendezvous
```

Added subprograms to support fast rendezvous optimization:

```
get_fast_rendezvous_enabled
set_fast_rendezvous_enabled
```

The following miscellaneous subprograms were added:

```
get_task_sequence_number
check_in_rendezvous
get_configuration_table
```

v_i_time.a

DAY_T is now defined in system. It was previously defined in V_I_TYPES.

The SET_TIME_SERVICE was fixed so that it properly adjusts the time for both delta delays and delay until time events.

The XCALENDAR.SET clock routine was also fixed.

`v_i_trap.a`
It was removed from the self host `standard`. Its only needed for cross.

`v_i_types.a`
Interrupt types moved to `ada_krn_defs.a`. `DAY_T` moved to `system.a`. `EXCEPTION_STACK_SIZE` moved to the configuration table in `v_usr_conf_b.a`.

Eliminated the different address types. Now only use `SYSTEM.ADDRESS`. Eliminated the miscellaneous types:

```
A_SIGNAL_T
UNIVERSAL_INTEGER_T
LONG_INTEGER
PHYSICAL_ADR_AS_INT.
```

A.4.18 User Program Configuration

The following configuration parameters were deleted from the self host `v_usr_conf`:

```
KRN_STACK_SIZE
INTR_STACK_SIZE
PENDING_OVERFLOW_CALLOUT
     -- the added routine,
     -- V_PENDING_OVERFLOW_CALLOUT
     -- is called directly
```

The following configuration parameters were deleted from the self host and cross target `v_usr_conf`:

```
EXIT_USER_PROGRAM_CALLOUT
     -- replaced by the ada_krn_i.callout_install
     -- service using either EXIT_EVENT or
     -- UNEXPECTED_EXIT_EVENT
```

The configuration parameter, `PRIORITY_INHERITANCE_ENABLED` was deleted. Priority inheritance is only supported in the CIFO add-on product. It is enabled by placing pragma `SET_PRIORITY_INHERITANCE_CRITERIA` in the main procedure.

The following configuration parameters were added to `v_usr_conf` for both self hosts and cross targets:

```
IDLE_STACK_SIZE
EXCEPTION_STACK_SIZE
SIGNAL_TASK_STACK_SIZE
FAST_RENDEZVOUS_ENABLED
WAIT_STACK_SIZE
FLOATING_POINT_SUPPORT
OLD_STYLE_MAX_INTR_ENTRY
DEFAULT_TASK_ATTRIBUTES
MAIN_TASK_ATTR_ADDRESS
SIGNAL_TASK_ATTR_ADDRESS
MASTERS_MUTEX_ATTR_ADDRESS
MEM_ALLOC_MUTEX_ATTR_ADDRESS
ADA_IO_MUTEX_ATTR_ADDRESS
```

The following configuration parameter was added to `V_USR_CONF` for UNIX self hosts with more than 32 signals:

```
DIABLE_SIGNALS_33_64_MASK
```

SUN THREADS specific configuration parameters were added:

```
CONCURRENCY_LEVEL
ENABLE_SIGNALS_MASK
ENABLE_SIGNALS_33_64_MASK
EXIT_SIGNALS_MASK
EXIT_SIGNALS_33_64_MASK
INTR_TASK_PRIO
INTR_TASK_STACK_SIZE
INTR_TASK_ATTR_ADDRESS
```

Check `v_usr_conf.a` for information on these newly added parameters.

`V_START_PROGRAM` was rewritten to call `TS_INITIALIZE`. Added `V_START_PROGRAM_CONTINUE`. Its address is passed to `TS_INITIALIZE` and is called when `TS_INITIALIZE` completes.

`V_PASSIVE_ISR` was rewritten to reflect compiler changes.

`V_CIFO_ISR` was added to support CIFO interrupt tasks.

For VADS MICRO self hosts, the routine, `V_PENDING_OVERFLOW_CALLOUT` and V_KRN_ALLOC_CALLOUT were added.

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