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VAX/VMS
System Services Reference Manual

Order No. AA-D018B-TE

VAX11

March 1980

This manual describes the VAX/VMS system services. It provides coding conventions, examples of how to use system services, and detailed reference information on the arguments required by each system service.

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PREFACE

This manual provides users of the VAX/VMS operating system with detailed usage and reference information on the system services.

VAX/VMS system services can be used only in programs written in languages that produce native code for the VAX-11 hardware. At present, these languages include VAX-11 MACRO and the following high-level languages:

VAX-11 BLISS-32
VAX-11 COBOL-74
VAX-11 FORTRAN
VAX-11 BASIC
VAX-11 PASCAL
VAX-11 CORAL

Other languages may be added in the future.

INTENDED AUDIENCE

This manual is intended for system and application programmers who are already familiar with VAX/VMS system concepts. For an overview of the operating system and an introduction to some of the concepts used in system services, see the VAX/VMS Summary Description and Glossary.

STRUCTURE OF THIS DOCUMENT

This manual is organized into two parts and three appendixes, as follows:

Part I provides tutorial information on the use of system services:

- Chapter 1 contains introductory information. It presents overviews of the categories of system services and summarizes the services in each category.
- Chapter 2 describes how to call system services. It contains detailed information for the VAX-11 MACRO programmer and general information for the high-level language programmer. For specific information about a high-level language and programming examples in that language, see the appropriate language user's guide.
- Chapters 3 through 10 guide new users in understanding how the system services work and how to use them. Each category of services has its own chapter. Examples are provided in VAX-11 MACRO, although they are explained in a way meaningful to high-level language programmers.

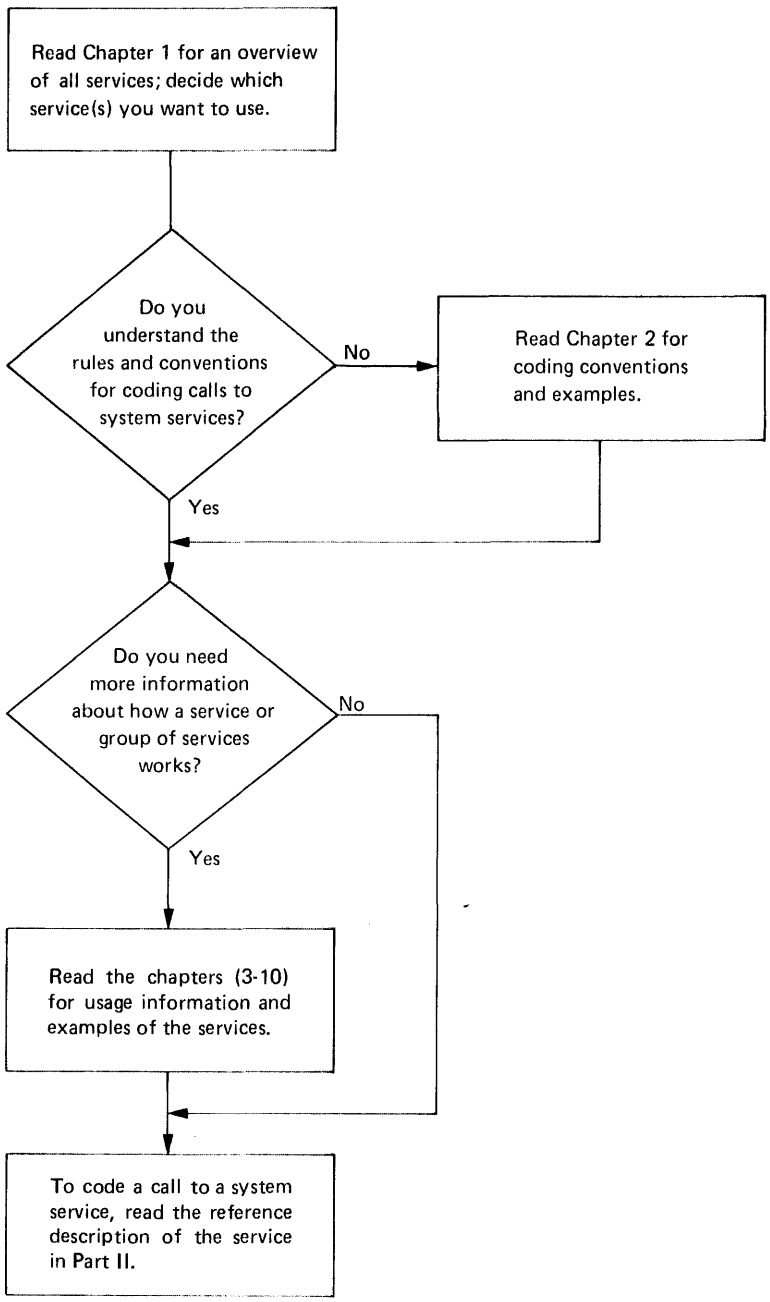
Part II provides detailed reference information on each system service. The descriptions are presented in alphabetical order for ease of reference.

Appendix A lists the system-provided macro instructions that define symbolic names for frequently used system constants.

Appendix B contains sample programs that use various system services.

Appendix C summarizes the system service formats for easy reference.

The following figure illustrates how to use this book.



How to Use This Book

ASSOCIATED DOCUMENTS

The following documents are prerequisite for

- All Users:

  VAX/VMS Summary Description and Glossary

- MACRO Programmers:

  VAX-11 MACRO Language Reference Manual
  VAX-11 MACRO User's Guide

- High-Level Language Programmers:

  The language reference manual for your language
  The user's guide for your language

The following documents may also be useful:

- VAX/VMS Real-Time User's Guide
- VAX/VMS Command Language User's Guide
- Introduction to VAX-11 Record Management Services
- VAX-11 Record Management Services Reference Manual
- VAX/VMS I/O User's Guide
- DECnet-VAX User's Guide

For a complete list of VAX-11 documents, including descriptions of each, see the VAX-11 Information Directory and Index.

CONVENTIONS USED IN THIS DOCUMENT

The following syntactical conventions are used in this manual:

- Brackets ([ ]) in system service descriptions indicate optional arguments.
- Horizontal ellipsis (...) indicates: (1) when shown in the format of a system service call, that additional optional arguments have been omitted; (2) when shown in an example, that additional arguments required by a service but not pertinent to the example are not shown.
- Vertical ellipsis in coding examples indicates that lines of code not pertinent to the example are not shown. For example:

  .
  .
  .

- Uppercase letters in a system service format show keywords that must be entered as shown; lowercase letters show variable data.

SUMMARY OF TECHNICAL CHANGES

This manual applies to Version 2.0 of VAX/VMS. This section summarizes the main technical changes from the Version 1.0 manual.

This manual contains detailed, language-specific information for VAX-11 MACRO only. Detailed information about calling system services from a high-level language can be found in the user's guide for that language. However, to provide some help to high-level language programmers, Section 2.2 contains general information about calling system services from such languages, and Section 2.3 provides "equivalents" of a VAX-11 MACRO coding example in the following languages:

- VAX-11 FORTRAN
- VAX-11 COBOL-74
- VAX-11 BLISS-32
- VAX-11 CORAL
- VAX-11 PASCAL
- VAX-11 BASIC

The ability to have multiport memory shared by multiple processors has expanded the capabilities of the following services:

$ASCEFC - Associate Common Event Flag Cluster

$CREMBX - Create Mailbox and Assign Channel

$CRMPSC - Create and Map Section

$DACEFC - Disassociate Common Event Flag Cluster

$DELMBX - Delete Mailbox

$DGBLSC - Delete Global Section

$DLCEFC - Delete Common Event Flag Cluster

$UPDSEC - Update Section File on Disk

and to services that can set, clear, or wait for event flags in shared memory.

Other changes include the following:

- $CREMBX (Create Mailbox and Assign Channel) operates differently if a mailbox with the specified name already exists. It now assigns a channel to the existing mailbox, whereas before it replaced the previous equivalence name with a new equivalence name and returned the status code SS$_SUPERSEDE.

- $DASSGN (Deassign I/O Channel) does not require that all additional channels assigned to a device be deassigned before clearing the linkage to an associated mailbox.

- $GETJPI (Get Job/Process Information) accepts additional arguments, allows "wildcard" process searching, and no longer has the restriction that a process requesting information about another process can obtain only information contained in that other process's PCB (process control block). This service returns immediately (often before obtaining the desired information) if the information is about another process.

- $GETMSG (Get Message) can process user-defined messages, in addition to messages from the system message file.

- $SETIME (Set System Time) is a new service.

- $SETPRV (Set Privileges) is a new service.

- Quota descriptions and values in the explanation of $CREPRC (Create Process) contain changes. Most quotas that were deductible are now pooled.

- Page frame number (PFN) mapping is available with the $CRMPSC service.

- The .ASCID assembler directive is used to create input character string descriptors in MACRO coding examples, replacing the user-written DESCRIPTOR macro.

- Appendix A includes new symbols defined by $SSDEF and other macros.

- Appendix B is rewritten so that the explanations of the program examples stand out more clearly and the examples are easier to follow.

Errors and omissions in the Version 1.0 manual are corrected. For example, certain message formatting and time conversion services are not affected by system service failure exception mode.

PART I

USING SYSTEM SERVICES

CHAPTER 1

INTRODUCTION TO SYSTEM SERVICES

System services are procedures that the VAX/VMS operating system uses to control resources available to processes; to provide for communication among processes; and to perform basic operating system functions, such as the coordination of input/output operations.

Although most system services are used primarily by the operating system itself on behalf of logged-in users, many are available for general use and provide techniques that can be used in application programs. For example, when you log into the system, the Create Process system service is called to create a process on your behalf. You may, in turn, code a program that calls the Create Process system service to create a subprocess to perform certain functions for an application.

1.1 WHO CAN USE SYSTEM SERVICES: PRIVILEGE AND PROTECTION

Many system services are available and suitable for application programs, but the use of some services must be restricted to protect the performance of the system and the integrity of user processes.

For example, because the creation of permanent mailboxes uses system dynamic memory, the unrestricted use of permanent mailboxes could decrease the amount of memory available to other users. Therefore, the ability to create permanent mailboxes is controlled: a user must be specifically assigned the privilege to use the Create Mailbox system service to create a permanent mailbox.

The various controls and restrictions applied to system service usage are described below. The tables in Section 1.2 that summarize the system services note any restrictions on the use of specific services.

1.1.1 User Privileges and Resource Quotas

The system manager, who maintains the user authorization file for the system, grants privileges to use protected system services. The user authorization file contains, in addition to profile information on each user, a list of specific user privileges and resource quotas.

When you log into the system, the privileges and quotas you have been assigned are associated with the process created on your behalf. These privileges and quotas are applied to every image that the process executes.

When an image issues a call to a system service that is protected by privilege, the privilege list is checked. If you have been granted the specific privilege required, the image is allowed to execute the system service; otherwise, a status code indicating an error is returned.

When a system service that uses a resource controlled by a quota is called, the process's quota for that resource is checked. If the process has exceeded its quota, or if it has no quota allotment, an error status code may be returned. In some cases, the process may be placed in a wait state until the resource becomes available; see Section 2.1.5.4, "Special Return Conditions."

1.1.2 Control by Group Association

Some system services provide techniques for coordinating and synchronizing the execution of different processes. These services require cooperating processes to be in the same group; that is, the group fields in the user identification codes (UICs) for the processes must match.

For example, event flags are used to post the occurrence of events in a program and can be shared among cooperating processes. However, the processes that share a cluster of event flags must be in the same group.

1.1.3 Protection by Access Mode

A process can execute at any one of four access modes: user, supervisor, executive, or kernel. The access modes determine a process's ability to access pages of virtual memory. Each page has a protection code associated with it, specifying the type of access -- read, write, or no access -- allowed for each mode. The VAX-11/780 Architecture Handbook provides additional information on access modes.

For the most part, user-written programs execute in user mode; system programs executing at the user's request (system services, for example) may execute at one of the other three, more privileged, access modes.

In some system service calls, the access mode of the caller is checked. For example, when a process tries to cancel timer requests, it can cancel only those requests that were issued from the same or less privileged access modes. For example, a process executing in user mode cannot cancel a timer request made from supervisor, executive, or kernel mode, which are more privileged access modes.

1.2 SUMMARY OF VAX/VMS SYSTEM SERVICES

The following sections summarize the VAX/VMS system services in functional groups, with tables listing the services that belong in each group. Each table lists:

- The full name of the service and the short, macro name by which it is alphabetized in this book.
- The functions performed by the service, with distinctions based on privilege (where applicable).
- Restrictions on the use of the service, if any. This column is keyed as follows:

  None — indicates that no restriction is placed on the use of the service for this function.

  xxx privilege — indicates the specific user privilege that is required to use the service for the requested function.

  yyy quota — indicates the specific resource quota that is required to use the service for the requested function.

  Access mode — indicates that this service uses the access mode of the caller to determine whether the caller can execute the function requested.

  Processor — indicates restrictions when the function is used with memory that is shared by multiple processors.

  UIC protection — indicates that this service may restrict access based on the caller's UIC.

  For detailed information about a restriction applied to any specific service, see that service's description in Part II.

Chapters 3 through 10 provide additional information, including examples, on the services listed in Tables 1-1 through 1-8.

1.2.1 Event Flag Services

A process can use event flags to synchronize sequences of operations in a program. Event flag services clear, set, and read event flags, and place a process in a wait state pending the setting of an event flag or flags.

Table 1-1 lists the event flag services.

Table 1-1
Event Flag Services

Service Name	Function(s)	Restriction(s)[1]
Associate Common Event Flag Cluster ($ASCEFC)	Creates a temporary common event flag cluster	TQELM quota
	Creates a permanent common event flag cluster	PRMCEB privilege
	Creates a common event flag cluster in memory shared by multiple processors	SHMEM privilege
	Establishes association with an existing common event flag cluster	Group association
Disassociate Common Event Flag Cluster ($DACEFC)	Cancels association with a common event flag cluster	None
Delete Common Event Flag Cluster ($DLCEFC)	Marks a permanent common event flag cluster for deletion	PRMCEB privilege Group association
Set Event Flag ($SETEF)	Turns on an event flag in a process-local event flag cluster	None
	Turns on an event flag in a common event flag cluster	Group association
Clear Event Flag ($CLREF)	Turns off an event flag in a process-local event flag cluster	None
	Turns off an event flag in a common event flag cluster	Group association
Read Event Flags ($READEF)	Returns the status of all event flags in a process-local event flag cluster	None
	Returns the status of all event flags in a common event flag cluster	Group association

1. For an explanation of the terms used in this column, see Page 1-3.

(continued on next page)

Table 1-1 (Cont.)
Event Flag Services

Service Name	Function(s)	Restriction(s)[1]
Wait for Single Event Flag ($WAITFR)	Places the current process in a wait state pending the setting of an event flag in a process-local event flag cluster	None
	Places the current process in a wait state pending the setting of an event flag in a common event flag cluster	Group association
Wait for Logical OR of Event Flags ($WFLOR)	Places the current process in a wait state pending the setting of any one of a specified set of flags in a process-local event flag cluster	None
	Places the current process in a wait state pending the setting of any one of a specified set of flags in a common event flag cluster	Group association
Wait for Logical AND of Event Flags ($WFLAND)	Places the current process in a wait state pending the setting of all specified flags in a process-local event flag cluster	None
	Places the current process in a wait state pending the setting of all specified flags in a common event flag cluster	Group association

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.2 AST (Asynchronous System Trap) Services

Process execution can be interrupted by events (such as I/O completion) for the execution of designated subroutines. These software interrupts are called asynchronous system traps (ASTs) because they occur asynchronously to process execution. System services are provided so that a process can control the handling of ASTs.

Table 1-2 lists the AST services.

Table 1-2
AST (Asynchronous System Trap) Services

Service Name	Function(s)	Restriction(s)[1]
Set AST Enable ($SETAST)	Enables or disables the delivery of ASTs	None
Declare AST ($DCLAST)	Queues an AST for delivery	ASTLM quota Access mode
Set Power Recovery AST ($SETPRA)	Establishes AST routine to receive control following power recovery condition	ASTLM quota

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.3 Logical Name Services

Logical name services provide a generalized technique for maintaining and accessing character string logical name and equivalence name pairs. Logical names can provide device-independence for system and application program input and output operations.

Table 1-3 lists the logical name services.

Table 1-3
Logical Name Services

Service Name	Function(s)	Restriction(s)1
Create Logical Name ($CRELOG)	Places logical name/equivalence name pair in process logical name table	Access mode
	Places logical name/equivalence name pair in group logical name table	GRPNAM privilege Group association
	Places logical name/equivalence name pair in system logical name table	SYSNAM privilege

(continued on next page)

Table 1-3 (Cont.)
Logical Name Services

Service Name	Function(s)	Restriction(s)[1]
Delete Logical Name ($DELLOG)	Removes logical name/equivalence name pair from process logical name table	None
	Removes logical name/equivalence name pair from group logical name table	GRPNAM privilege Group association
	Removes logical name/equivalence name pair from system logical name table	SYSNAM privilege
Translate Logical Name ($TRNLOG)	Searches logical name tables for a specified logical name and return its equivalence name when the first match is found	None

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.4 Input/Output Services

I/O services perform input and output operations directly, rather than through the file-handling services of the VAX-11 Record Management Services (RMS). I/O services:

- Perform logical and virtual input/output operations
- Format output lines converting binary numeric values to ASCII strings and substituting variable data in ASCII strings
- Create mailboxes for interprocess communication
- Perform network operations
- Queue messages to system processes

Table 1-4 lists the I/O services. The following manuals provide additional information on aspects of input/output operations not covered in this manual:

- Introduction to VAX-11 Record Management Services
- VAX-11 Record Management Services Reference Manual
- VAX/VMS I/O User's Guide
- DECnet-VAX User's Guide

Table 1-4 (Part 1)
Input/Output Services for Device-Dependent I/O

Service Name	Function(s)	Restriction(s)[1]
Assign I/O Channel ($ASSIGN)	Establishes a path for an I/O request	None
	Establishes a path for network operations	NETMBX privilege
Deassign I/O Channel ($DASSGN)	Releases linkage for an I/O path	Access mode
	Releases a path from the network	
Queue I/O Request ($QIO)	Initiates an input or output operation	Access mode[2]
Queue I/O Request and Wait for Event Flag ($QIOW)	Initiates an input or output operation and causes the process to wait until it is completed before continuing execution	Access mode[2]
$INPUT	Initiates virtual input operation and waits for completion	Access mode
$OUTPUT	Initiates virtual output operation and waits for completion	Access mode
Formatted ASCII Output ($FAO)	Performs ASCII string substitution, and converts numeric data to ASCII representation and substitutes in output	None
Formatted ASCII Output with List Parameter ($FAOL)		
Allocate Device ($ALLOC)	Reserves a device for exclusive use by a process and its subprocesses	None
	Reserves a spooled device for exclusive use	ALLSPOOL privilege

1. For an explanation of the terms used in this column, see Page 1-3.

2. Depending on the specific nature of the input or output request, the service may require the PHY_IO, LOG_IO, or MOUNT privileges, or quotas for buffered I/O (BIOLM), direct I/O (DIOLM), buffer space (BYTLM), or AST limit (ASTLIM).

(continued on next page)

Table 1-4 (Part 1) (Cont.)
Input/Output Services for Device-Dependent I/O

Service Name	Function(s)	Restriction(s)[1]
Deallocate Device ($DALLOC)	Relinquishes exclusive use of a device	Access mode
Get I/O Channel Information ($GETCHN)	Provides information about a device to which an I/O channel has been assigned	Access mode
Get I/O Device Information ($GETDEV)	Provides information about a device	None
Cancel I/O on Channel ($CANCEL)	Cancels pending I/O requests on a channel	Access mode

1. For an explanation of the terms used in this column, see Page 1-3.

Table 1-4 (Part 2)
Input/Output Services for Mailboxes and Messages

Service Name	Function(s)	Restriction(s)[1]
Create Mailbox and Assign Channel ($CREMBX)	Creates a temporary mailbox	BYTLM quota TMPMBX privilege SHMEM privilege[2]
	Creates a permanent mailbox	PRMMBX privilege SHMEM privilege[2]
Delete Mailbox ($DELMBX)	Marks a permanent mailbox for deletion	PRMMBX privilege Access mode Processor
Broadcast ($BRDCST)	Sends a high-priority message to an assigned terminal	None
	Sends a high-priority message to a nonassigned terminal or to all terminals	OPER privilege

1. For an explanation of the terms used in this column, see Page 1-3.

2. The SHMEM privilege is required only if the mailbox is created in memory that is being shared by multiple processors.

(continued on next page)

Table 1-4 (Part 2) (Cont.)
Input/Output Services for Mailboxes and Messages

Service Name	Function(s)	Restriction(s)[1]
Send Message to Accounting Manager ($SNDACC)	Controls accounting log file activity	OPER privilege
	Writes an arbitrary message to the accounting log file	None
Send Message to Symbiont Manager ($SNDSMB)	Requests symbiont manager to initialize, modify, or delete a printer or batch job queue, or a device queue	OPER privilege
	Requests symbiont manager to delete or change characteristics of a queued file	Group association
Send Message to Operator ($SNDOPR)	Writes a message to designated operator(s) terminal(s)	None
	Enables or disables an operator's terminal, sends a reply to a user request or initializes the operator's log file	OPER privilege
Send Message to Error Logger ($SNDERR)	Writes arbitrary data to the system error log file	BUGCHK privilege
Get Message ($GETMSG)	Returns text of system error message from message file	None
Put Message ($PUTMSG)	Writes a message to the current output and error devices	None

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.5 Process Control Services

Process control services allow you to create, delete, and control the execution of processes.

Table 1-5 lists the process control services.

Table 1-5
Process Control Services

Service Name	Function(s)	Restriction(s)[1]
Create Process ($CREPRC)	Creates a subprocess	PRCLM quota
	Creates a detached process	DETACH privilege
Delete Process ($DELPRC)	Deletes the current process or a subprocess	None
	Deletes another process in the same group	GROUP privilege Group association
	Deletes any process in the system	WORLD privilege
Suspend Process ($SUSPND)	Makes the current process or a subprocess nonexecutable and unable to receive ASTs until a subsequent resume or delete request	None
	Makes another process in the same group non-executable and unable to receive ASTs until a subsequent resume or delete request	GROUP privilege Group association
	Makes any process in the system nonexecutable and noninterruptible until a subsequent resume or delete request	WORLD privilege
Resume Process ($RESUME)	Restores executability of a suspended subprocess	None
	Restores executability of a suspended process in the same group	GROUP privilege Group association
	Restores executability of any suspended process in the system	WORLD privilege
Hibernate ($HIBER)	Makes the current process dormant but able to receive ASTs until a subsequent wakeup request	None

1. For an explanation of the terms used in this column, see Page 1-3.

(continued on next page)

Table 1-5 (Cont.)
Process Control Services

Service Name	Function(s)	Restriction(s)[1]
Wake ($WAKE)	Restores executability of the current process or a hibernating subprocess	None
	Restores executability of a hibernating process in the same group	GROUP privilege Group association
	Restores executability of any hibernating process in the system	WORLD privilege
Schedule Wakeup ($SCHDWK)	Wakes a process after a specified time interval or at a specific time[2]	
Cancel Wakeup ($CANWAK)	Cancels a scheduled wakeup request[2]	
Exit ($EXIT)	Terminates execution of an image and returns to command interpreter	None
Force Exit ($FORCEX)	Causes image exit for the current process or a subprocess	None
	Causes image exit for a process in the same group	GROUP privilege Group association
	Causes image exit for any process in the system	WORLD privilege
Declare Exit Handler ($DCLEXH)	Designates a routine to receive control when image exits	None
Cancel Exit Handler ($CANEXH)	Cancels a previously established exit handling routine	Access mode
Set Process Name ($SETPRN)	Establishes a text name string to be used to identify the current process	None

1. For an explanation of the terms used in this column, see Page 1-3.

2. Functions performed by these services are listed in detail in Table 1-6.

(continued on next page)

Table 1-5 (Cont.)
Process Control Services

Service Name	Function(s)	Restriction(s)[1]
Set Priority ($SETPRI)	Increases the execution priority for any process	ALTPRI privilege
	Changes the execution priority for the current process or a subprocess	None
	Changes the execution priority for a process in the same group	GROUP privilege Group association
	Changes the execution priority for any process in the system	WORLD privilege
Set Resource Wait Mode ($SETRWM)	Requests wait, or that control be returned immediately, when a system service call cannot be executed because a system resource is not available	None
Get Job/Process Information ($GETJPI)	Returns information about the current process	None
	Returns information about the current context of other processes in the same group	GROUP privilege Group association
	Returns information about any other process in the system	WORLD privilege

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.6 Timer and Time Conversion Services

Timer services schedule program events for a particular time of day, or for after a specified interval of time has elapsed. The time conversion services provide a way to obtain and format binary time values for use with the timer services.

Table 1-6 lists the timer and time conversion services.

Table 1-6
Timer and Time Conversion Services

Service Name	Function(s)	Restriction(s)[1]
Get Time ($GETTIM)	Returns the date and time in system format	None
Convert Binary Time to Numeric Time ($NUMTIM)	Converts a date and time from system format to numeric integer values	None
Convert Binary Time to ASCII String ($ASCTIM)	Converts a date and time from system format to an ASCII string	None
Convert ASCII String to Binary Time ($BINTIM)	Converts a date and time in an ASCII string to the system date and time format	None
Set Timer ($SETIMR)	Requests setting of an event flag or queueing of an AST based on an absolute or delta time value	TQELM quota[2]
Cancel Timer Request ($CANTIM)	Cancels previously issued timer requests	Access mode
Schedule Wakeup ($SCHDWK)	Schedules a wakeup for the current process or a hibernating subprocess	ASTLM quota
	Schedules a wakeup for a hibernating process in the same group	GROUP privilege ASTLM quota Group association
	Schedules a wakeup for any hibernating process in the system	WORLD privilege ASTLM quota
Cancel Wakeup ($CANWAK)	Cancels a scheduled wakeup request for the current process or a hibernating subprocess	None

1. For an explanation of the terms used in this column, see Page 1-3.

2. Setting an event flag in a common event flag cluster requires association based on group number; a timer request with an AST requires ASTLM quota.

(continued on next page)

Table 1-6 (Cont.)
Timer and Time Conversion Services

Service Name	Function(s)	Restriction(s)[1]
Cancel Wakeup ($CANWAK) (Cont.)	Cancels a scheduled wakeup request for a hibernating process in the same group	GROUP privilege Group association
	Cancels a scheduled wakeup request for any hibernating process in the system	WORLD privilege
Set System Time ($SETIME)	Sets or recalibrates the current system time	OPER privilege LOG_IO privilege

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.7 Condition-Handling Services

Condition handlers are procedures that can be designated to receive control when a hardware or software exception condition occurs during image execution. Condition-handling services designate condition handlers for special purposes.

Table 1-7 lists the condition-handling services.

Table 1-7
Condition Handling Services

Service Name	Function(s)	Restriction(s)[1]
Set Exception Vector ($SETEXV)	Defines condition handlers to receive control in case of hardware- or software-detected exception conditions	Access mode
Set System Service Failure Exception Mode ($SETSFM)	Requests or disables generation of a software exception condition when a system service call returns an error or severe error	None
Unwind from Condition Handler Frame ($UNWIND)	Deletes a specified number of call frames from the call stack following a nonrecoverable exception condition	None

1. For an explanation of the terms used in this column, see Page 1-3.

(continued on next page)

Table 1-7 (Cont.)
Condition Handling Services

Service Name	Function(s)	Restriction(s)[1]
Declare Change Mode or Compatibility Mode Handler ($DCLCMH)	Designates a routine to receive control when change mode to user instructions are encountered	Access mode
	Designates a routine to receive control when change mode to supervisor instructions are encountered	Access mode
	Designates a routine to receive control when compatibility mode exceptions occur	None

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.8 Memory Management Services

Memory management services provide ways to use the virtual address space available to a program. Included are services that:

- Allow an image to increase or decrease the amount of virtual memory available
- Control the paging and swapping of virtual memory
- Create and access in memory files that contain shareable code or data

Table 1-8 lists the memory management services.

Table 1-8
Memory Management Services

Service Name	Function(s)	Restriction(s)[1]
Expand Program/ Control Region ($EXPREG)	Adds pages at the end of the program or control region	None
Contract Program/ Control Region ($CNTREG)	Deletes pages from the end of the program or control region	None
Create Virtual Address Space ($CRETVA)	Adds pages to the virtual address space available to an image	None

1. For an explanation of the terms used in this column, see Page 1-3.

(continued on next page)

Table 1-8 (Cont.)
Memory Management Services

Service Name	Function(s)	Restriction(s)[1]
Delete Virtual Address Space ($DELTVA)	Makes a range of virtual addresses unavailable to an image	None
Create and Map Section ($CRMPSC)	Identifies a disk file as a private section and establishes correspondence between virtual blocks in the file and the process's virtual address space	Access mode
	Identifies a disk file containing shareable code or data as a temporary global section and establishes correspondence between virtual blocks in the file and the process's virtual address space	Access mode
	Identifies a disk file containing shareable code or data as a permanent global section and establishes correspondence between virtual blocks in the file and the process's virtual address space	PRMGBL privilege SHMEM privilege[2] Access mode
	Identifies a disk file containing shareable code or data as a system global section and establishes correspondence between virtual blocks in the file and the process's virtual address space	SYSGBL privilege SHMEM privilege[2] Access mode

1. For an explanation of the terms used in this column, see Page 1-3.

2. The SHMEM privilege is required only if the section is created in memory that is being shared by multiple processors. In addition, calls to $UPDSEC and $DGBLSC are valid only from processes on the processor that created the section.

(continued on next page)

Table 1-8 (Cont.)
Memory Management Services

Service Name	Function(s)	Restriction(s)[1]
Create and Map Section ($CRMPSC) (Cont.)	Identifies one or more page frames in physical memory as a private or global section and establishes correspondence between the page frames and the process's virtual address space.	PFNMAP privilege[3] Access mode
Update Section File on Disk ($UPDSEC)	Writes modified pages of a private or global section into the section file	Access mode Processor[2]
Map Global Section ($MGBLSC)	Establishes correspondence between a global section and a process's virtual address space	UIC protection
Delete Global Section ($DGBLSC)	Marks a permanent global section for deletion	PRMGBL privilege Processor[2]
	Marks a system global section for deletion	SYSGBL privilege Access mode Processor[2]
Lock Pages in Working Set ($LKWSET)	Specifies that particular pages cannot be paged out of the process's working set	Access mode
Unlock Pages from Working Set ($ULWSET)	Allows previously locked pages to be paged out of working set	Access mode
Purge Working Set ($PURGWS)	Removes all pages within a specified range from the current working set	None

1. For an explanation of the terms used in this column, see Page 1-3.

2. The SHMEM privilege is required only if the section is created in memory that is being shared by multiple processors. In addition, calls to $UPDSEC and $DGBLSC are valid only from processes on the processor that created the section.

3. The PRMGBL or SYSGBL privilege is also required for a permanent global section or system global section, respectively. The SHMEM privilege is also required if the section is located in memory that is being shared by multiple processors.

(continued on next page)

Table 1-8 (Cont.)
Memory Management Services

Service Name	Function(s)	Restriction(s)[1]
Lock Page in Memory ($LCKPAG)	Specifies that particular pages may not be swapped out of memory	User privilege Access mode
Unlock Page in Memory ($ULKPAG)	Allows previously locked pages to be swapped out of memory	User privilege Access mode
Adjust Working Set Limit ($ADJWSL)	Changes maximum number of pages that the current process can have in its working set	WSQUOTA quota
Set Protection on Pages ($SETPRT)	Controls access to a range of virtual addresses	Access mode
Set Process Swap Mode ($SETSWM)	Controls whether or not the current process can be swapped out of the balance set	PSWAPM privilege

1. For an explanation of the terms used in this column, see Page 1-3.

1.2.9 Change Mode Services

Change mode services alter the access mode of a process to a more privileged mode to execute particular routines, or change the stack pointer for a less privileged mode. These services are used primarily by the operating system.

Table 1-9 lists the change mode services.

Table 1-9
Change Mode Services

Service Name	Function(s)	Restriction(s)[1]
Change to Executive Mode ($CMEXEC)	Executes a specified routine in executive mode	CMEXEC privilege Access mode
Change to Kernel Mode ($CMKRNL)	Executes a specified routine in kernel mode	CMKRNL privilege Access mode
Adjust Outer Mode Stack Pointer ($ADJSTK)	Modifies the current stack pointer for a less privileged access mode	Access mode

1. For an explanation of the terms used in this column, see Page 1-3.

CHAPTER 2

CALLING THE SYSTEM SERVICES

System service procedures are called using the standard VAX-11 procedure calling conventions. The programming languages that generate VAX-11 native mode instructions provide mechanisms for coding the procedure calls. These languages and supporting documentation are listed in the Preface.

When you code a system service call, you must supply whatever arguments the service requires.

When the service completes execution, it returns control to the calling program with a return status code. The caller should analyze the status code to determine the success or failure of the service call, so the program can alter the flow of execution, if necessary.

If you are a VAX-11 MACRO programmer, you should read Section 2.1 for details on how to code the macro instructions that generate system service calls.

If you program in any other language, you should read Section 2.2 for general information on how to call system services. For detailed information and examples, however, see the user's guide for your language.

Each of these sections also discusses conventions for coding arguments and methods of checking for the successful completion of a system service.

Both the MACRO programmer and the high-level language programmer should read Section 2.3, which provides help in interpreting the coding examples that appear throughout Chapters 3-10.

2.1 MACRO CODING

System service macros generate argument lists and CALL instructions to call system services. These macros are located in the system library STARLET.MLB; this library is searched automatically for unresolved references when you assemble a source program.

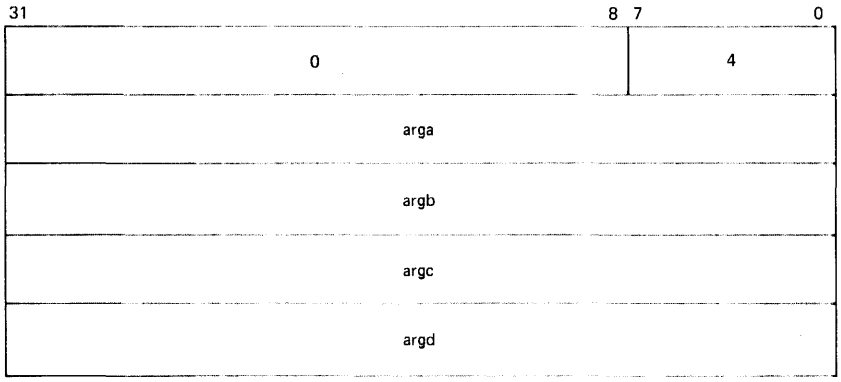
Knowledge of MACRO rules for assembly language coding is required for understanding the material presented in this section. The VAX-11 MACRO Language Reference Manual and the VAX-11 MACRO User's Guide contain the necessary prerequisite information.

2.1.1 Argument Lists

You can determine the arguments required by a system service from the service description in Part II. The "Macro Format" for each system service indicates the positional dependencies and keyword names of each argument as shown in the following sample:

```
$SERVICE arga ,argb ,argc ,argd
```

This format indicates that the macro name of the service is $SERVICE and that it requires four arguments, ordered as shown and with keyword names ARGA, ARGB, ARGC, and ARGD. The argument list for this service must have the format:



All arguments are longwords. The first longword in the list must always contain, in its low-order byte, the number of arguments in the remainder of the list. The remaining three bytes must be zeros.

Many arguments to system services are optional; these are indicated in the macro formats by brackets. For example, if the second and third arguments of $SERVICE are optional, the macro format would appear as:

```
$SERVICE arga ,[argb] ,[argc] ,argd
```

If you omit an optional argument in a system service macro instruction, the macro supplies a default value for the argument.

There are two generic macro forms for coding calls to system services:

```
$name_G
$name_S
```

The form of the macro to use depends on how the argument list for the system service is constructed:

- The $name_G form requires you to construct an argument list elsewhere in the program and specify the address of this list as an argument to the system service. (A macro is provided to create an argument list for each system service.) With this form, you can use the same argument list, with modifications if necessary, for more than one invocation of the macro.

- The $name_S form requires you to supply the arguments to the system service in the macro instruction. The macro generates code to push the argument list onto the call stack during program execution. With this form, you can use registers to contain or point to arguments so you can write re-entrant programs.

The $name_G macro form generates a CALLG instruction; the $name_S macro form generates a CALLS instruction. The services are called according to the standard procedure calling conventions. System services save all registers except R0 and R1, and restore the saved registers before returning control to the caller.

The following sections describe how to code system service calls using each of these macro forms.

2.1.2 $name_G Form

The $name_G macro form requires a single operand:

```
$name_G label
```

label
address of the argument list.

You can use the $name macro to create the argument list. The format of the $name macro is:

```
label:  $name argl,...,argn
```

label
symbolic address of the generated argument list. This is the label given as an argument in the $name_G macro form.

$name
the service macro name.

argl,...,argn
arguments to be placed in successive longwords in the argument list.

2.1.2.1 **Specifying Arguments with the $name Macro** - When you use the $name macro to construct an argument list for a system service, you can specify the arguments in any of three ways:

1. By using keywords to describe the arguments. A keyword must be followed by an equal sign (=) and then by the value of the argument.

2. By using positional order, with omitted arguments indicated by commas in the argument positions. You can omit commas for optional trailing arguments.

3. By using both positional dependence and keyword names (you must list positional arguments first).

For example, $SERVICE may have the format:

```
$SERVICE arga ,[argb] ,[argc] ,argd
```

Assume, for the purposes of this example, that ARGA and ARGB are arguments that require you to code numeric values and that ARGC and ARGD require you to code addresses.

The two following examples show valid ways of coding a $name macro to construct an argument list for a later call to $SERVICE.

Example 1: Using Keywords

```
LIST:  $SERVICE ARGB=0,ARGC=0,ARGA=1,ARGD=MYARGD
```

Example 2: Specifying Arguments in Positional Order

```
LIST:  $SERVICE 1,,,MYARGD
```

The argument list generated in both cases is:

```
LIST:   .LONG   4
        .LONG   1
        .LONG   0
        .LONG   0
        .LONG   MYARGD
```

Note that all arguments, whether coded in positional order or by keyword, must be expressions that the assembler can evaluate to generate .LONG data directives.

2.1.2.2 **Example of $name and $name_G Macro Calls** - This example shows how you can code a call to the Read Event Flags ($READEF) system service using an argument list created by $name.

As shown in Part II, the macro format of the $READEF system service is:

```
$READEF efn ,state
```

The EFN argument must specify the number of an event flag cluster, and the STATE argument must supply the address of a longword to receive the contents of the cluster.

These arguments might be specified using the $name macro form as follows:

```
READLST: $READEF EFN=1,STATE=TESTFLAG ;ARGUMENT LIST FOR $READEF
```

This $READEF macro generates the code:

```
READLST:        .LONG    2              ;ARGUMENT LIST FOR $READEF
                .LONG    1
                .LONG    TESTFLAG
```

To execute the $READEF macro now requires only the line:

```
$READEF_G READLST
```

The macro generates the following code to call the Read Event Flags system service:

```
CALLG  READLST,@#SYS$READEF
```

SYS$READEF is the name of a vector to the entry point of the Read Event Flags system service. The linker automatically resolves the entry point addresses for all system services.

2.1.2.3 **Symbolic Names for Argument List Offsets** - The $name_G macro form (used with the $name macro) is especially useful for:

- Coding calls to system services that have long argument lists
- Services that may be called repeatedly during the execution of a single program with the same, or essentially the same, argument list

When you use this form, you can refer to arguments in the list symbolically. Each argument in an argument list has an offset from the beginning of the list; a symbolic name is defined for the numeric offset of each argument. If you use the symbolic names to refer to the arguments in a list, you do not have to remember the numeric offset (which is based on the position of the argument shown in the macro format). There are two additional advantages to referring to arguments by their symbolic names:

1. Your code is more readable.
2. If an argument list for a system service changes with a later release of a system, the symbols will not change.

The offset names for all system service argument lists are formed by concatenating the service macro name with $_ and the keyword name of the argument, as follows:

```
name$_keyword
```

where name is the macro name for the system service and keyword is the keyword argument.

Similarly, the number of arguments required by a particular macro is defined symbolically as:

```
name$_NARGS
```

Symbolic names for argument list offsets are defined automatically whenever you use the $name form of the macro for a particular system service.

For example, the $READEF macro defines the following values:

Symbolic Name	Value
READEF$_NARGS	Number of arguments in the list (2)
READEF$_EFN	Offset of EFN argument (4)
READEF$_STATE	Offset of STATE argument (8)

Thus, the $READEF macro can be coded to build an argument list for a $READEF system service call as follows:

```
READLST:    $READEF   EFN=1,STATE=TEST1
```

Later, the program may want to use a different value for the STATE argument in calling the service. The following lines show how this can be accomplished.

```
        MOVAL    TEST2,READLST+READEF$_STATE
        $READEF_G READLST
```

The MOVAL instruction replaces the address TEST1 in the $READEF argument list with the address TEST2; the $READEF_G macro calls the system service with the modified list.

2.1.2.4 **The $nameDEF Macro** - You can also define symbolic names for system service argument lists using the $nameDEF macro. This macro does not generate any executable code; it merely defines the symbolic names so they can be used later in the program. For example:

```
$QIODEF
```

This macro defines the symbol QIO$_NARGS and symbolic names for the $QIO argument list offsets.

You may need to use the $nameDEF macro if you code an argument list to a system service without using the $name macro form, or if a program refers to an argument list in a separately assembled module.

2.1.3 The $name_S Form

The format of $name_S macro call is:

```
$name_S argl, ..., argn
```

The macro generates code to push the arguments on the stack in reverse order. The actual instructions used to place the arguments on the stack are determined as follows:

- If the system service requires a value for an argument, either a PUSHL instruction or a MOVZWL to -(SP) instruction is generated.
- If the system service requires an address for an argument, a PUSHAB, PUSHAW, PUSHAL, or PUSHAQ instruction is generated, depending on the context.

The macro then generates a call to the system service in the format:

```
CALLS #n,@#SYS$name
```

where n is the number of arguments on the stack.

2.1.3.1 **Specifying Arguments with the $name_S Macro** - When you use the $name_S macro to construct an argument list for a system service, you can specify arguments in any of three ways:

1. By using keywords to describe the arguments. All keywords must be followed by an equal sign (=) and then by the value of the argument.
2. By using positional order, with omitted arguments indicated by commas in the argument positions. You can omit commas for optional trailing arguments.
3. By using both positional dependence and keyword names (positional arguments must be listed first).

For example, $SERVICE might have the format:

```
$SERVICE arga ,[argb] ,[argc] ,argd
```

Assume, for the purposes of this example, that ARGA and ARGB are arguments that require you to code numeric values and that ARGC and ARGD require you to code addresses.

The two following examples show valid ways of coding the $name_S macro form to call $SERVICE.

Example 1: Using Keywords

```
MYARGD: .LONG   100
          .
          .
          .
        $SERVICE_S ARGB=#0,ARGC=0,ARGA=#1,ARGD=MYARGD
```

Example 2: Specifying Arguments in Positional Order

```
MYARGD: .LONG   100
          .
          .
          .
        $SERVICE_S #1,,,,MYARGD
```

The argument list is pushed on the stack as follows:

```
        PUSHAL      MYARGD
        PUSHL       #0
        PUSHL       #0
        PUSHL       #1
```

Note that all arguments, whether coded positionally or with keywords, must be valid assembler expressions, since they are used as source operands in instructions. Contrast this with the arguments for the $name argument list, which the assembler uses for data-generating directives.

2.1.3.2 **Example of $name_S Macro Call** - Since a $name_S macro constructs the argument list at execution time, addresses and values can be supplied using register addressing modes. The $READEF macro used in the example of the $name_G form can be coded as follows using the $name_S form:

```
        $READEF_S EFN=#1,STATE=(R10)
```

where R10 contains the address of the longword to receive the status of the flags.

This macro instruction is expanded as follows:

```
        PUSHAL  (R10)
        PUSHL   #1
        CALLS   #2,@#SYS$READEF
```

2.1.4 Conventions for Coding Arguments to System Services

The arguments must be specified according to the macro assembler rules for operand coding and addressing.

The way to specify a particular argument depends on:

- Whether the system service requires an address or a value as the argument. In Part II, the descriptions of the arguments following a system service macro format always indicate if the argument is an address. An indicator, number, or mask takes a value as the argument.

- The form of the system service macro being used. The expansions of the $name and $name_S macros in the examples in the preceding sections showed the code generated by each macro form.

If you are in doubt as to whether you have coded a value or an address argument correctly, you can assemble the program with the .LIST MEB directive to check the macro expansion. See the VAX-11 MACRO Language Reference Manual for more details.

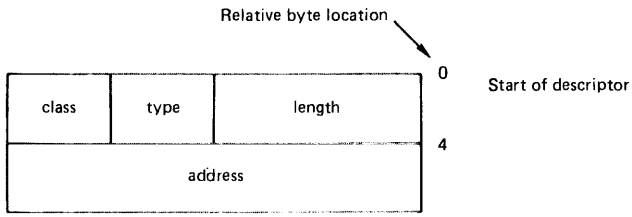
Arguments that are optional to system services always have default values, regardless of whether they are value or address arguments. In almost every case, an optional argument defaults to 0.

When an argument is optional, the description of the argument always describes what action the service takes when the default value is used.

Address arguments may be optional when the system service returns information; if the program does not require the information, you can omit the optional argument.

2.1.4.1 **Conventions for Coding Character String Arguments** - Many system services require ASCII text strings as arguments or return ASCII text strings. Character strings are identified to system services by specifying the address of a quadword character string descriptor containing the length of the string and its starting address. The string itself may or may not follow the descriptor.

Descriptors are explained fully in the VAX-11 Procedure Calling and Condition Handling Standard, which is printed in the VAX-11 Architecture Handbook and in the VAX-11 Run-Time Library Reference Manual. The format of a descriptor is as follows.



length
is a word specifying the length of the string (in bytes).

type
is a byte specifying the data type of the argument. This field is ignored by system services.

class
is a byte specifying the class of descriptor. This field is ignored by system services; therefore, dynamic string descriptors are treated as fixed-length string descriptors.

address
is a longword containing the address of the string.

To define a descriptor for input to a service and specify the ASCII data, you can use the .ASCID directive. For example,

```
DESC:  .ASCID  /Hello!/
```

creates a descriptor followed by 6 bytes representing the string "Hello!" The linker inserts a length value of 6 and the correct address value in the descriptor when it binds the module into an image.

To define a descriptor to hold data output from a service, define the descriptor and allocate enough bytes to hold the data. For example, if the service will return a string of up to 23 bytes, you can code the descriptor and the 23-byte buffer as follows:

```
DESC:       .LONG  23
            .LONG  DESC+8
            .BLKB  23
```

When a service returns a string, you can optionally specify the address of a word to receive the actual length of the string returned.

Example of Coding a Character String Descriptor: The Translate Logical Name ($TRNLOG) system service uses character string descriptors for both input and output: it accepts a logical name for input and returns the equivalence name, if any, for the logical name. The following example shows how these descriptors might be coded to translate the logical name CYGNUS.

```
CYGNUSDESC:     .ASCID /CYGNUS/ ;DESCRIPTOR FOR CYGNUS LOGICAL NAME
NAMEDESC:                       ;DESCRIPTOR FOR TRANSLATED OUTPUT
        .LONG   63              ;LENGTH OF THE BUFFER
        .LONG   NAMEDESC+8      ;ADDRESS OF THE BUFFER
        .BLKB   63              ;THE BUFFER
NAMELENGTH:
        .BLKW   1               ;RECEIVE OUTPUT LENGTH HERE
          .
          .
          .
        $TRNLOG_S LOGNAM=CYGNUSDESC,RSLLEN=NAMELENGTH,-
                  RSLBUF=NAMEDESC
```

The input string for this service call is defined at the label CYGNUSDESC. The output string that is returned from the service will be written into the 63-byte buffer defined in the descriptor at the label NAMEDESC. The actual length of the returned string will be written in the word at the label NAMELENGTH.

When an output buffer is provided for a character string and the string returned is longer than the buffer, the string returned is truncated, and the service returns a status code (SS$_BUFFEROVF) indicating that fact. (Note that SS$_BUFFEROVF is a "success" return code. Status codes returned by system services are discussed in Section 2.1.5.)

2.1.4.2 **Conventions for Coding Numeric Values** - Many system services accept numeric values for particular arguments. In some cases, the services check only the low-order portion of the longword argument they are passed. These cases are:

- Indicators. Indicators can only have values of 0 or 1. System services check only the low-order bit of these arguments.

- Event flag numbers. Event flag numbers can have values of 0 through 255. System services check only the low-order byte of these arguments.

- Access modes. Access modes can have values of 0 through 3. System services check only the low-order 2 bits of these arguments.

- Channel numbers. Channel numbers as input arguments are passed by immediate value. However, if you use the $service or $service_S form of the call, specify the label associated with the address containing the channel number; for example:

```
$QIO_S    ...,CHAN=DEVCHAN,...
```

  The macro expansion in these cases places the value of the channel number onto the stack. System services check only the low-order word of an input CHAN argument.

When you code any of the above types of argument, the high-order portion of the argument should be zeros.

Note that many system services use access modes to protect system resources, and thus employ a special convention for interpreting access mode arguments (keyword ACMODE). You can specify an access mode using a numeric value or a symbolic name. The access modes, their numeric values, and symbolic names are:

Access Mode	Numeric Value	Symbolic Name
Kernel	0	PSL$C_KERNEL
Executive	1	PSL$C_EXEC
Supervisor	2	PSL$C_SUPER
User	3	PSL$C_USER

The symbolic names are defined in the $PSLDEF macro.

When you specify an access mode, the actual mode used is determined after the service has compared the specified access mode with the access mode from which the service was called. If the modes are different, the less privileged access mode is always used. Because this operation results in an access mode with a higher numeric value (when the access mode of the caller is different from the specified access mode), the access modes are said to be maximized.

Since much of the code you write will execute in user mode, you can omit the access mode argument. The argument value defaults to 0, and when this value is compared with the current execution mode, the mode with the higher value, 3 for user mode, is used.

2.1.5 Status Codes Returned from System Services

When a system service finishes execution, a numeric status value is always returned in general register R0. Successful completion is indicated by a status code with the low-order bit set. The low-order three bits, taken together, represent the severity of the error. Severity code values are:

Value	Meaning	Symbolic Name
0	Warning	STS$K_WARNING
1	Success	STS$K_SUCCESS
2	Error	STS$K_ERROR
3	Informational	STS$K_INFO
4	Severe or fatal error	STS$K_SEVERR
5-7	Reserved	

The symbolic names are defined in the $STSDEF macro.

The remaining bits in the low-order word classify the particular return condition. The high-order word indicates that a system service issued this status code.

Each numeric status code has a unique symbolic name in the format:

SS$_code

where code is a mnemonic describing the return condition. For example, a successful return is usually indicated by

SS$_NORMAL

An example of an error return status code is:

SS$_ACCVIO

This status code indicates that an access violation occurred because a service could not read an input field or write an output field.

The symbolic definitions for status codes are included in the default system library. You can obtain a listing of these symbolic codes at assembly time by invoking the system macro $SSDEF (see Appendix A). Use the symbolic names for system status codes to check return conditions.

2.1.5.1 **Information Provided by Status Codes** - Status codes returned by system services may provide information; that is, they do not always just indicate whether or not the service completed successfully. SS$_NORMAL is the usual status code indicating success, but others are defined. For example, the status code SS$_BUFFEROVF, which is returned when a character string returned by a service is longer than the buffer provided to receive it, is a success code. This status code, however, gives the program additional information.

Warning returns and some error returns indicate that the service may have performed some part, but not all, of the requested function.

The possible status codes that each service can return are described with the individual service descriptions in Part II. When you are coding calls to system services, read the descriptions of the return status codes to determine whether you want the program to check for particular return conditions.

2.1.5.2 **Testing Return Status Codes** - To test for successful completion following a system service call, the program can test the low-order bit of R0 and branch to an error checking routine if this bit is not set, as follows:

```
BLBC    R0,errlabel             ;ERROR IF LOW BIT CLEAR
```

The error checking routine may check for specific values or for specific severity levels. For example, the following instruction checks for an illegal event flag number error condition:

```
CMPL    #SS$_ILLEFC,R0          ;IS EVENT FLAG NUMBER ILLEGAL?
```

Note that return status codes are always longword values; however, the high-order words of all status codes returned by system services are always the same.

2.1.5.3 **System Messages Generated by Status Codes** - When you execute a program with the DCL command RUN, the command interpreter uses the contents of R0 to issue a descriptive message if the program completes with a nonsuccessful status.

The following example shows a simple error-checking procedure in a main program:

```
        $READEF_S EFN=#64,STATE=TEST
        BSBW  ERROR
          .
          .
          .
ERROR:  BLBC  R0,10$            ;CHECK REGISTER 0
        RSB                     ;SUCCESS, RETURN
10$:    RET                     ;EXIT WITH R0 STATUS
```

Following a system service call, the BSBW instruction calls the subroutine ERROR. The subroutine checks the low-order bit in register 0 and if the bit is clear, branches to a RET instruction that causes the program to exit with the status of R0 preserved. Otherwise, the subroutine issues an RSB to return to the main program.

If the event flag cluster requested in this call to $READEF is not currently available to the process, the program exits and the command interpreter displays the message:

```
%SYSTEM-F-UNASEFC, unassociated event flag cluster
```

The keyword UNASEFC in the message corresponds to the status code SS$_UNASEFC.

2.1.5.4 **Special Return Conditions** - Two process execution modes affect how control is returned to the calling program when an error occurs during the execution of a system service. These modes are:

- Resource wait mode
- System service failure exception mode

If you change the default setting for either of these modes in a program, the program must handle the special return conditions that result. The next two sections discuss considerations for using these modes.

Resource Wait Mode: Many system services require certain system resources for execution. These resources include system dynamic memory and process quotas for I/O operations. Normally, when a system service is called and a required resource is not available, the process is placed in a wait state until the resource becomes available. Then, the service completes execution. This mode is called resource wait mode.

In a real-time environment, however, it may not be practical or desirable for a program to wait. In these cases, you can choose to disable resource wait mode, so that when a required resource is unavailable, control returns immediately to the calling program with an error status code. You can disable (and re-enable) resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

How a program responds to the unavailability of a resource depends very much on the application and the particular service that is being called. In some instances, the program may be able to continue execution and retry the service call later. In other instances, it may be necessary only to note that the program is being required to wait.

System Service Failure Exception Mode: When an error occurs during the execution of a system service, control normally returns to the next instruction in the calling program, which can check the return status code in R0 to determine the success or failure of the service call.

To detect and respond to system service call failures, you can use the condition-handling mechanism of VAX/VMS to respond to system service failures. Then, when an error occurs, a software exception condition is generated, and control is passed to a condition-handling routine.

This mode is called system service failure exception mode, and can be enabled (and disabled) with the Set System Service Failure Exception Mode ($SETSFM) system service. For example:

```
$SETSFM_S ENBFLG=#1
```

This call enables the generation of exceptions when errors or severe errors occur during execution of a system service (exceptions are not generated for warning returns).

Certain formatting and conversion services are not affected by the enabling of system service failure exception mode. The following services will not generate exceptions when failures occur and system service failure exception mode is enabled:

```
$ASCTIM
$BINTIM
$FAO/$FAOL
$GETMSG
$PUTMSG
```

If you code a program to execute with this mode enabled, you can code a condition-handling routine. Information on condition handlers is provided in Chapter 9, "Condition-Handling Services." If no user-specified routine is available when an exception occurs and the program was run with the DCL command RUN, the default condition handler causes the program to exit and displays descriptive information about the exception condition.

2.2 HIGH-LEVEL LANGUAGE CODING

Each high-level language supported by VAX/VMS provides some mechanism for calling an external procedure and passing arguments to that procedure. The specifics of the mechanism and the terminology used, however, vary from one language to another.

VAX/VMS system services are external procedures that accept arguments. There are three ways to pass arguments to system services:

- By immediate value. The argument is the actual value to be passed (a number or a symbolic representation of a numeric value)

- By address (also called "by reference"). The argument is the address of an area or field that contains the value. An argument passed by address is usually expressed as a reference name or label associated with an area or field. (In fact, one common error is to pass a numeric value without indicating that it is passed by value; if the compiler assumes the numeric value is an address, a run-time "access violation" error occurs when, for example, the image tries to access virtual address 0 or 1.)

- By descriptor. This argument is also an address, but of a special data structure called a character string descriptor. The format of a descriptor is explained in the next section.

The description of each service in Part II of this manual indicates how each argument is to be passed. Phrases such as "an address" and "address of a character string descriptor" identify address and descriptor arguments, respectively. Words like "indicator," "number," "value," or "mask" indicate an argument passed by immediate value.

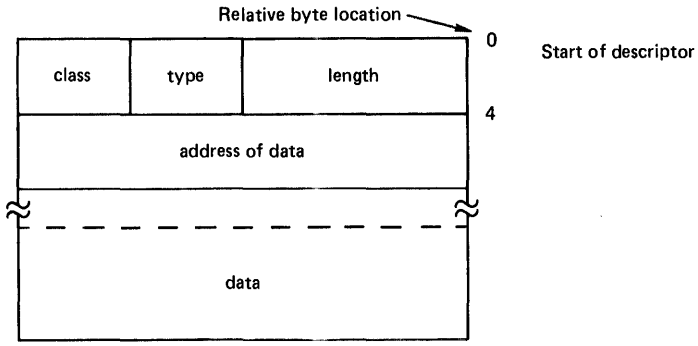
Some services also require service-specific data structures that indicate functions to be performed or hold information to be returned. For example, the Get Job/Process Information ($GETJPI) service requires you to define an item list describing the specific information requested and pointing to buffers to receive the information. The description of this service in Part II includes the format of the item list and a simple example in VAX-11 MACRO. You can use this information and information from your programming language manuals to define such an item list.

When a service returns control to your program, it places a return status value in the general register R0. The value in the low-order word indicates either that the service completed successfully or that some specific error prevented the service from performing some or all of its functions. After each call to a system service, you must check whether it completed successfully. You can also test for specific error conditions. (See Section 2.2.2 for more information on return status values.)

2.2.1 Descriptors

A character string descriptor is a quadword (8-byte) area that contains the length of the string data and the starting address of the data. In most cases, the compiler automatically generates the descriptor and the data; in some cases, you may need to define all the fields yourself. (See the appropriate language user's guide.)

Descriptors are explained fully in the VAX-11 Procedure Calling and Condition Handling Standard, which appears in the VAX-11 Architecture Handbook and in the VAX-11 Run-Time Library Reference Manual. The format of a descriptor is as follows.



- Length of data. Specifies the number of ASCII characters for the data or the number of bytes in the buffer; this value is placed in the low-order word of the longword. In some cases you may want to move a value into this field during program execution.

- Type. Specifies the data type of the argument. This byte is ignored by system services.

- Class. Specifies the class of descriptor. This byte is ignored by system services; therefore, dynamic string descriptors are treated as fixed-length string descriptors.

- Address of data. Indicates the starting address of the data in a manner appropriate to your language. You may have to specify the reference name or label associated with the data.

- Data. If the descriptor is for input data for the service, specify the data. If the descriptor is for output from the service, simply allocate enough bytes to hold the data returned by the service. (The data is not part of the descriptor.)

2.2.2 Return Status

The operating system does not automatically handle system service failure or warning conditions; you must test for them and handle them yourself. This contrasts with the operating system's handling of exception conditions detected by the hardware or software; the system handles these exceptions by default, although you can intervene in or override the default handling by declaring a condition handler (see Chapter 9, "Condition Handling Services").

Each high-level language has some mechanism for obtaining the return status, which is stored as a binary value in a longword. Depending on your specific needs, you can test just the low-order bit, the low order three bits, or the entire value:

- The low-order bit indicates successful 1 or nonsuccessful (0) completion of the service.

- The low-order three bits, taken together, represent the severity of the error. Severity code values are:

Value	Severity Level
0	Warning
1	Success
2	Error
3	Informational
4	Severe (or fatal) error
5-7	(Reserved)

- The remaining bits (3 through 31) classify the particular return condition and the operating system component that issued the status code. For system service return status values, the high-order word (bits 16 through 31) contains zeros.

Each numeric status code has a symbolic name in the format:

SS$_code

where "code" is a mnemonic code describing the return condition. For example, the most common successful return is indicated by SS$_NORMAL, and a common error status code is SS$_ACCVIO ("access violation," indicating that the service could not read an input argument or write an output argument).

The symbols associated with the different return status value are defined in the default system library.

2.2.2.1 **Information Provided by Status Codes** - Status codes returned usually indicate whether the service completed successfully, although sometimes they simply provide information to the calling program. Moreover, a "success" return (severity level =1) does not necessarily mean that the program achieved the desired result, but only that the service completed all its functions and returned control to the calling program. For example, the status code SS$_BUFFEROVF, which is returned when a character string returned by a service is longer than the buffer provided to receive it, is a "success" code.

Warning returns and some error returns indicate that the service may have performed part but not all of the requested function(s).

The possible status codes that each service can return are described with the individual service descriptions in Part II. When you are coding calls to system services, read the descriptions of the return status codes to determine whether you want the program to check for particular return conditions.

2.2.2.2 **Testing the Return Status Code** - Each language provides some mechanism for testing the return status. Often you need only check the low-order bit, such as by a test for TRUE (success or informational return) or FALSE (error or warning return).

To check the entire value for a specific return condition, each language provides a way for your program to determine the values associated with specific symbolically-defined codes. You should always use these symbolic names when you code tests for specific conditions.

Appendix A, Section A.7, lists the symbolic codes and their meanings. For information on how to test for these codes, see the user's guide for your programming language.

2.2.2.3 **Special Return Conditions** - Two process execution modes affect how control is returned to the calling program when an error occurs during the execution of a system service. These modes are:

- Resource wait mode
- System service failure exception mode

If you choose to change the default setting for either of these modes, your program must handle the special conditions that result.

Resource Wait Mode: Many system services require certain system resources for execution. These resources include system dynamic memory and process quotas for I/O operations. Normally, when a system service is called and a required resource is not available, the program is placed in a wait state until the resource becomes available. Then the service completes execution. This mode is called resource wait mode.

In a real-time environment, however, it may not be practical or desirable for a program to wait. In these cases you can choose to disable resource wait mode, so that when such a condition occurs, control returns immediately to the calling program with an error status code. You can disable (and reenable) resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

How a program responds to the unavailability of a resource depends very much on the application and the particular service that is being called. In some instances, the program may want to continue execution and retry the service call later. In other instances, it may be necessary only to note that the program is being required to wait.

System Service Failure Exception Mode: System service failure exception mode determines whether control is returned to the caller in the normal manner following an error in a system service call, or whether an exception is generated. System service failure exception mode is disabled by default; the calling program receives control following an error. You can enable and disable system service failure exception mode with the Set System Service Failure Exception Mode ($SETSFM) service.

Certain formatting and conversion services are not affected by the enabling of system service failure exception mode. The following services will not generate exceptions when failures occur and system service failure exception mode is enabled:

$ASCTIM
$BINTIM
$FAO/$FAOL
$GETMSG
$PUTMSG

It is recommended that high-level language programs not enable system service failure exception mode, except perhaps in certain debugging situations. If you enable system service failure exception mode and do not declare your own condition handler, many error messages displayed at run time will be meaningless. High-level language compilers generate calls to system services for many statements or instructions in source programs. (For example, reads and writes to

files generate calls to VAX-11 RMS, which uses the $QIO and $QIOW services.) If you enable system service failure exception mode, many different types of errors-- such as an I/O attempt to a nonexistent device or non-numeric input to a math routine-- will generate the message "%SYSTEM-F-SSFAIL, system service failure exception,...".

2.2.3 Obtaining Values for Other Symbolic Codes

In addition to the symbolic codes for specific return conditions, many individual services also have symbolic codes for offsets, identifiers, or flags associated with these services. For example, the Create Process ($CREPRC) service, which is used to create a subprocess or a detached process, has symbolic codes associated with the various privileges and quotas you can grant to the created process.

Appendix A lists the system symbolic definition macros available to the VAX-11 MACRO programmer, as well as the symbols defined and their meanings for several macros. Page references for symbols and meanings for the remaining macros can be found in the index.

If your language has a method of obtaining values for these symbols, this method is explained in the user's guide. If your language does not have such a method, you may do the following:

- Write a short VAX-11 MACRO program containing the desired macro(s).
- Assemble the program and generate a listing. Using the listing, find the desired symbols and their hexadecimal values.
- Define each symbol with its value within your source program.

For example, to use the Get Job/Process Information ($GETJPI) service to find out the accumulated CPU time (in 10-millisecond ticks), you must obtain the value associated with the item identifier JPI$_CPUTIM. To do this:

- Create the following two-line VAX-11 MACRO program named JPIDEF.MAR (although you may choose any name you wish):

```
$JPIDEF
.END
```

- Assemble the program:

```
$ MACRO/LIST JPIDEF
```

- Find the value of JPI$_CPUTIM and define the symbol in your program.

2.3 INTERPRETING THE CODING EXAMPLES

Chapters 3 through 10 contain many coding examples (using VAX-11 MACRO) designed to familiarize you with the system services and their arguments. The examples do not show complete programming sequences; rather, they show only the code and/or arguments that are pertinent to a particular discussion.

In some of the more complex examples, explanatory text is keyed to the example using a special numeric symbol, for example, 1.

Although the examples are coded using VAX-11 MACRO, they are designed to be as meaningful as possible to high-level language programmers. Figure 2-1 provides additional help to high-level language programmers in interpreting the MACRO examples. This figure shows a portion of VAX-11 MACRO code and the "equivalent" in the following languages:

VAX-11 FORTRAN

VAX-11 COBOL-74

VAX-11 BLISS-32

VAX-11 CORAL

VAX-11 PASCAL

VAX-11 BASIC

MACRO Example

```
CYGDES: .ASCID (2)/CYGNUS/          ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                    ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 (3)
        .BLKB 63                    ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 (4)                 ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY  ORION,0 (1)                 ;ROUTINE ENTRY POINT & MASK
      (5) $TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                    DSBMSK=#4       ;DON'T SEARCH PROCESS TABLE
      (6) BLBC  R0, ERROR           ;CHECK FOR ERROR
          .
          .
          .
        .END
```

FORTRAN Equivalent

```
SUBROUTINE ORION (1)                !PROCEDURE ORION
          .
          .
          .
CHARACTER*63 NAMDES (3)             !OUTPUT BUFFER
INTEGER*2 NAMLEN (4)                !WORD TO RECEIVE LENGTH
INTEGER*4 SYS$TRNLOG                !DEFINE SYSTEM SERVICE FUNCTION
          .
          .
          .                  (2)
(5)ICODE = SYS$TRNLOG('CYGNUS',NAMLEN,NAMDES,,,%VAL(4))
(6)IF (.NOT. ICODE) GOTO 90000      !BRANCH IF ERROR
          .
          .
          .
        END
```

Figure 2-1 Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

FORTRAN Notes

❶ The routine and its entry mask are defined by the SUBROUTINE statement.

❷ Specify the input character string directly in the system service call. The compiler builds the descriptor.

❸ The CHARACTER*63 declaration allocates 63 bytes for the output data. The compiler builds the descriptor.

❹ The INTEGER*2 declaration reserves a word for the output value.

❺ Call the service using the SYS$ form of the service name.

Enclose the arguments in parentheses, and code them in positional order only. Code a comma for each optional argument that you omit (including trailing arguments).

Use the %VAL function to indicate a literal value for an argument.

❻ The IF statement makes a FALSE logical test following the function reference. (A FALSE value means that the low bit of the status code is zero, indicating an error or warning.)

MACRO Example

```
CYGDES: .ASCID ❷ /CYGNUS/              ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                       ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 ❸
        .BLKB 63                       ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 ❹                      ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY  ORION,0 ❶                      ;ROUTINE ENTRY POINT & MASK
      ❺ $TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                  DSBMSK=#4            ;DON'T SEARCH PROCESS TABLE
      ❻ BLBC  R0,ERROR                 ;CHECK FOR ERROR
          .
          .
          .
        .END
```

COBOL Equivalent

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  ORION.❶
   .
   .
01 CYGDES PIC X(6) VALUE "CYGNUS".❷
01 DUMMY-ARG PIC S9(9) COMP VALUE 0.
01 NAMDES PIC X(63) VALUE SPACES.❸
01 NAMLEN PIC S9(4) COMP.❹
01 DISABLE-MASK PIC S9(9) COMP VALUE 4.
01 RESULT PIC S9(9) COMP.
   88 SUCCESSFUL VALUE 1.
   .
   .
PROCEDURE DIVISION.
START-ORION.
   CALL "SYS$TRNLOG"❺
     USING BY DESCRIPTOR CYGDES,
         BY REFERENCE NAMLEN,
         BY DESCRIPTOR NAMDES,
         BY VALUE DUMMY-ARG, DUMMY-ARG, DISABLE-MASK
       GIVING RESULT.
   IF NOT SUCCESSFUL ❻
     GO TO ERROR-CHECK.
   .
   .
   STOP RUN.
```

Figure 2-1 (Cont.) Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

COBOL Notes

❶ The PROGRAM-ID paragraph identifies the program by specifying the program name, which is the global symbol associated with the entry point. The compiler builds the entry mask.

❷ Define the input string as alphanumeric (ASCII) data. The compiler generates a descriptor when you specify "USING BY DESCRIPTOR" in the CALL statement.

❸ Allocate enough bytes for the alphanumeric output data. The compiler generates a descriptor when you specify "USING BY DESCRIPTOR" in the CALL statement.

❹ This definition reserves a signed word with COMP (binary) usage to receive the output value.

❺ Call the service using the "SYS$" form of the service name, and enclose the name in quotes.

Specify arguments in positional order only, with "USING..." You cannot omit arguments; if you are accepting the default for an argument, you must explicitly pass the default value (DUMMY-ARG in this example).

You can specify explicitly how each argument is being passed: BY DESCRIPTOR, BY REFERENCE (that is, by address), or BY VALUE. You can also implicitly specify how an argument is being passed: through the default mechanism (BY REFERENCE), or through association with the last specified mechanism (thus, the last two arguments in the example are implicitly passed BY VALUE). Note, however, that all defaulted arguments must be passed BY VALUE (even address arguments).

❻ The IF statement tests RESULT for a value of 1 (SS$_NORMAL). If RESULT is not equal to 1, control is passed to the routine ERROR-CHECK.

MACRO Example

```
                    ❷
CYGDES: .ASCID /CYGNUS/              ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                     ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 ❸
        .BLKB 63                     ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 ❹                    ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY ORION,0 ❶                     ;ROUTINE ENTRY POINT & MASK
      ❺ $TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                  DSBMSK=#4          ;DON'T SEARCH PROCESS TABLE
      ❻ BLBC  R0,ERROR               ;CHECK FOR ERROR
          .
          .
          .
        .END
```

BLISS Equivalent

```
MODULE ORION(IDENT = '1-1')=

BEGIN
EXTERNAL ROUTINE
    ERROR_PROC: NOVALUE;                  ! Error processing routine

LIBRARY 'SYS$LIBRARY:STARLET.L32';        ! Library containing VMS macros (including
                                          ! $TRNLOG).  This declaration is required.

GLOBAL ROUTINE ORION: NOVALUE= ❶

    BEGIN
    OWN
      ❸ NAMSTR: VECTOR[63, BYTE],         ! Translated string buffer
        NAMDES: VECTOR[2] INITIAL(63,NAMSTR), ! Translated string descriptor
      ❹ NAMLEN: WORD;                     ! Translated string length
    LOCAL                                  ! Return status from system service
        STATUS;

    MACRO
        DESCRIPTOR(S) = ❷      ! Macro to build descriptor for string literal
            UPLIT( %CHARCOUNT(S), UPLIT BYTE(S) ) %;

  ❺ STATUS = $TRNLOG(LOGNAM = DESCRIPTOR('CYGNUS'),
        RSLLEN=NAMLEN, RSLBUF=NAMDES,DSBMSK=4);

  ❻ IF NOT .STATUS THEN ERROR_PROC(.STATUS);

    END;
```

Figure 2-1 (Cont.) Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

BLISS Notes

❶ The routine is defined by a GLOBAL ROUTINE declaration.

❷ Define a constant input string argument using the DESCRIPTOR macro.

❸ The declarations of NAMSTR and NAMDES reserve space for a 63-byte output buffer and a 2-longword output buffer descriptor. The INITIAL attribute initializes the descriptor at compilation time.

❹ The word element NAMLEN will receive the output string value.

❺ Invoke the macro by its service name, without a suffix.

Enclose the arguments in parentheses, and specify them by keyword. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.)

Since BLISS uses call-by-value argument transmission, no special notation is required in passing DSBMSK=4.

❻ The return status, which is assigned to the variable STATUS, is tested for TRUE or FALSE. FALSE (low bit = 0) indicates failure or warning.

MACRO Example

```
CYGDES: .ASCID ❷ /CYGNUS/              ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                       ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 ❸
        .BLKB 63                       ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 ❹                      ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY ORION,0 ❶                       ;ROUTINE ENTRY POINT & MASK
      ❺$TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                 DSBMSK=#4             ;DON'T SEARCH PROCESS TABLE
      ❻BLBC  R0,ERROR                  ;CHECK FOR ERROR
          .
          .
          .
        .END
```

CORAL Equivalent

```
'CORAL' EXAMPLE
'COMMON'        ('LABEL' ORION);
'DEFINE'        VI      "'VALUE''INTEGER'";
'DEFINE'        LI      "'LOCATION''INTEGER'";
'DEFINE'        LB      "'LOCATION''BYTE'";

'LIBRARY' ❶     ('INTEGER''PROCEDURE' SYS$TRNLOG(VI,LI,VI,LB,LB,VI));
'ENTER'         ORION;
'SEGMENT'       ORION
'BEGIN'
        'DEFINE'        LOC "'LOCATION'";
        'DEFINE'        NULL "[0]";
        'INTEGER'       STATUS,OUTSTRING;
        'BYTE''ARRAY'   NAMSTR[1:63];    (space for return string)
      ❸ 'INTEGER''ARRAY'NAMDES[1:2];     (space for return string descriptor)
        'OVERLAY' NAMDES[1] 'WITH' 'INTEGER' NAMLEN;

      ❹ NAMLEN:=63;                      (set size in descriptor)
        NAMDES[2]:=LOC(NAMSTR[1]);       (set address in descriptor)
        OUTSTRING:=LOC(NAMDES[1]);       (point to descriptor)
                                  ❷
      ❺ STATUS:=SYS$TRNLOG("CYGNUS",NAMLEN,OUTSTRING,NULL,NULL,4);
        'COMMENT'       Since NAMLEN has been updated OUTSTRING is
                        now usable to represent the returned string
                        in another system service or OTS call;

      ❻ 'IF' STATUS 'MASK' 1 = 0 'THEN'
        'BEGIN'
                'COMMENT'       Error action would go here;
        'END';

        'COMMENT'       Other code would go here
                        as required by the application;

'END';
'FINISH'
```

Figure 2-1 (Cont.) Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

CORAL Notes

❶ The system service routine and all its arguments are specified in a 'LIBRARY' statement. CORAL manipulates strings by pointers to descriptors. These pointers may be contained in an integer variable so string arguments are specified as 'VALUE''INTEGER'. All other argument specifications are taken directly from the specification of the system service in this manual. (Note: this example shows Release 1 of VAX-11 CORAL. The implementation of 'VALUE''INTEGER' may be changed in a subsequent release of the language. Refer to the VAX-11 CORAL User's Guide.)

❷ Specify the input character string directly in the system service call. CORAL builds string descriptors for string literals, so the input string may be passed directly as an argument.

❸ While CORAL passes arrays by descriptor, the VAX/VMS descriptor for a byte array is different from the descriptor for a character string, so it is necessary to build a descriptor for the output string.

❹ CORAL does not support a 16-bit data type. If the return length was required in a different context it might be necessary to extract the low-order 16 bits from the return location. Here the high-order bits are zeroed by the assignment to NAMLEN. By using the same location for available length and returned length, a result string descriptor is automatically constructed for further use.

❺ Use the SYS$ form of the system service, and code the arguments in positional order in parentheses.

CORAL does not permit arguments of a call to be omitted. VAX/VMS system services accept the address of location 0 to represent the address of an omitted argument. The NULL macro provides this in the example.

❻ The low order bit of STATUS is extracted and compared with 0 to determine the success of the system service call.

MACRO Example

```
CYGDES: .ASCID ❷ /CYGNUS/              ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                       ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 ❸
        .BLKB 63                       ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 ❹                      ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY  ORION,0 ❶                      ;ROUTINE ENTRY POINT & MASK
      ❺ $TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                  DSBMSK=#4            ;DON'T SEARCH PROCESS TABLE
      ❻ BLBC  R0,ERROR                 ;CHECK FOR ERROR
          .
          .
          .
        .END
```

PASCAL Equivalent

```
PROGRAM ORION;
    .
    .
    TYPE POS_WORD = 0..65535;
         SUB63 = 1..63;
         WORD_TYPE = PACKED RECORD
                       SHORTWD : POS_WORD
                       END;
         STRING_BUF = PACKED ARRAY [1..128] OF CHAR;

    VAR  ICODE : INTEGER;
     ❹   NAMLEN : WORD_TYPE;
     ❸   NAMDES : STRING_BUF;
    .
    .
    .

  PROCEDURE ERROR;
    .
    .
  FUNCTION SYS$TRNLOG (%STDESCR CYGNUS : PACKED ARRAY [SUB63] OF CHAR;
          ❶              VAR RSLLEN : WORD_TYPE;
                         %STDESCR RSLBUF : STRING_BUF;
                         %IMMED TABLE, ACMODE, DSBMSK : INTEGER) : INTEGER;
                         EXTERN;
    BEGIN
    .
    .                                ❷
     ❺ ICODE := SYS$TRNLOG ('CYGNUS', NAMLEN, NAMDES, 0, 0, 4);
     ❻ IF NOT ODD (ICODE) THEN ERROR;
    .
    .
    END.
```

Figure 2-1 (Cont.) Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

PASCAL Notes

❶ The system service routine must be declared in an external function declaration in the function and procedure declaration section. Note that all the parameters for the system service call must be formally declared here.

❷ Specify the input character string directly to the system service call. The string descriptor is built by the compiler.

❸ The VAR declaration for the identifier NAMDES allocates a packed array of 128 characters for the associated name which is output from the system service. The packed array of characters is used as the string data type in PASCAL. The formal parameter RSLBUF in the external function declaration corresponds to the actual parameter NAMDES.

❹ The VAR declaration for the identifier NAMLEN allocates a word for the output length. The formal parameter RSLLEN in the external function declaration corresponds to the actual parameter NAMLEN.

❺ Call the system service using the SYS$ form of the service name. Enclose the arguments in parentheses and code them in positional order. You cannot omit optional arguments. To accept the default value for an argument, specify either the default value if the argument is to be passed by immediate value or a variable that has been assigned the default value if the argument is to be passed by address (reference).

❻ The IF statement makes a logical test following the function reference to see if the service completed successfully. If an error or warning occurred during the service call, the procedure ERROR will be called.

MACRO Example

```
CYGDES: .ASCID ❷/CYGNUS/          ;DESCRIPTOR FOR CYGNUS STRING
NAMDES: .LONG 63                  ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG NAMDES+8 ❸
        .BLKB 63                  ;OUTPUT BUFFER (63 BYTES)
NAMLEN: .BLKW 1 ❹                 ;WORD TO RECEIVE LENGTH
          .
          .
          .
.ENTRY  ORION,0 ❶                 ;ROUTINE ENTRY POINT & MASK
      ❺ $TRNLOG_S LOGNAM=CYGDES,RSLLEN=NAMLEN,RSLBUF=NAMDES,-
                  DSBMSK=#4       ;DON'T SEARCH PROCESS TABLE
      ❻ BLBC  R0,ERROR            ;CHECK FOR ERROR
          .
          .
          .
        .END
```

BASIC Equivalent

```
SUB ORION ❶                                ! Subprogram ORION
COM NAMDES$=63 ❸                           ! Define the fixed string output
EXTERNAL SYS$TRNLOG                        ! Declare the system service
DECLARE WORD NAMLEN,❹                      ! Word to receive length        &
        LONG SYS_STATUS                    ! Longword to receive status
        .
        .
        .
❺SYS_STATUS = SYS$TRNLOG('CYGNUS',NAMLEN,NAMDES$,,,4% BY VALUE) ❷
❻IF (SYS_STATUS% AND 1%) = 0%              &
    THEN ....                              ! Error path)     &
    ELSE ....                              ! Success path
        .
        .
        .
SUBEND
```

Figure 2-1 (Cont.) Interpreting MACRO Examples

MACRO Notes

❶ A routine name and entry mask show the beginning of executable code in a routine or subroutine.

❷ The input character string descriptor argument is defined using the .ASCID directive.

❸ For an output character string argument, define the two longwords (length and address) for the descriptor, and allocate enough bytes to hold the output data.

❹ The MACRO directive .BLKW reserves a word to hold the output length.

❺ Call the service by a macro name that has the suffix _S or _G.

You can specify arguments by keyword (as in this example) or in positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in Part II.) If you omit any optional arguments (that is, accept the defaults), you can omit them completely if you specify arguments by keyword, but you must code the comma for each missing argument if you specify arguments by positional order.

Use the number sign (#) to indicate a literal value for an argument.

❻ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the status code returned from the service is clear (low bit clear = failure or warning). You can use a BSBW instruction to branch unconditionally to a routine that checks the return status.

BASIC Notes

❶ The routine and its entry mask are defined by the SUB statement.

❷ Specify the input character string directly in the system service call; the compiler builds the descriptor.

❸ The COM NAMDES$=63 declaration allocates 63 bytes for the output data in a static area. The compiler builds the descriptor.

❹ The DECLARE WORD NAMLEN declaration reserves a 16-bit word for the output value.

❺ Invoke the system service as a function using the SYS$ form.

Enclose the arguments in parentheses, and code them in positional order only. Code a comma for each optional argument that you omit (including trailing arguments).

Use the modifier BY VALUE to indicate an immediate value literal.

❻ The IF statement makes a test on the low-order bit of the return status. This form is recommended for all status returns.

CHAPTER 3

EVENT FLAG SERVICES

Event flags are status posting bits maintained by VAX/VMS for general programming use. Some system services set an event flag to indicate the completion or the occurrence of an event: the calling program can test the flag. For example, the Queue I/O Request ($QIO) system service sets an event flag when the requested input or output operation completes.

Programs can use event flags to perform a variety of signaling functions:

- Setting or clearing specific flags
- Testing the current status of flags
- Placing the current process in a wait state pending the setting of a specific flag or a group of flags

Moreover, event flags can be used in common by more than one process, as long as the cooperating processes are in the same group. Thus, if you have developed an application that requires the concurrent execution of several processes, you can use event flags to establish communication among them and to synchronize their activity.

3.1 EVENT FLAG NUMBERS AND EVENT FLAG CLUSTERS

Each event flag has a unique decimal number; event flag arguments in system service calls refer to these numbers. For example, if you specify event flag 1 when you code a $QIO system service, then event flag number 1 is set when the I/O operation completes.

To allow manipulation of groups of event flags, the flags are ordered in clusters, with 32 flags in each cluster, numbered from right to left, corresponding to bits 0 through 31 in a longword. The clusters are also numbered. The range of event flag numbers encompasses the flags in all clusters: event flag 0 is the first flag in cluster 0, event flag 32 is the first flag in cluster 1, and so on.

There are two types of clusters:

1. A local event flag cluster can only be used internally by a single process. Local clusters are automatically available to each process.

2. A common event flag cluster can be shared by cooperating processes in the same group. Before a process can refer to a common event flag cluster, it must explicitly "associate" with the cluster. Association is described in Section 3.4, "Common Event Flag Clusters."

The ranges of event flag numbers and the clusters to which they belong are summarized in Table 3-1.

Table 3-1
Summary of Event Flag and Cluster Numbers

Cluster Number	Event Flag Numbers	Description	Restriction
0	0-31	Process-local event flag clusters for general use	Event flags 24 through 31 are reserved for system use
1	32-63		
2	64-95	Assignable common event flag cluster	Must be associated before use
3	96-127		

3.1.1 Specifying Event Flag and Event Flag Cluster Numbers

The same system services manipulate flags in both local and common event flag clusters. Since the event flag number implies the cluster number, you do not have to specify the cluster number when you code a system service call that refers to an event flag.

When a system service requires an event flag cluster number as an argument, you need only specify the number of any event flag that is in the cluster. Thus, to read the event flags in cluster 1, you could specify any number in the range 32 through 63.

The VAX-11 Run-Time Library Reference Manual describes routines you can use to allocate (LIB$GET_EF), deallocate (LIB$FREE_EF), and reserve (LIB$RESERVE_EF) an event flag from the process-wide pool of available event flags.

3.2 EXAMPLES OF EVENT FLAG SERVICES

Local event flags are most commonly used in coordination with other system services. For example, with the Set Timer ($SETIMR) system service you can request that an event flag be set at a specific time of day or after a specific interval of time has passed. If you want to place a process in a wait state for a specified period of time, you could code an event flag number for the $SETIMR service and then use the Wait for Single Event Flag ($WAITFR) system service, as follows:

```
TIME:   .BLKQ   1                ;WILL CONTAIN TIME INTERVAL TO WAIT
          .
          .
          .
        $SETIMR_S EFN=#33,DAYTIM=TIME ;SET THE TIMER
        $WAITFR_S EFN=#33             ;WAIT UNTIL TIMER EXPIRES
```

In this example, the DAYTIM argument refers to a 64-bit time value. Details on how to obtain a time value in the proper format for input to this service are contained in Chapter 8, "Timer and Time Conversion Services."

3.2.1 Event Flag Waits

Three system services place the process in a wait state pending the setting of an event flag:

- The Wait for Single Event Flag ($WAITFR) system service places the process in a wait state until a single flag has been set.
- The Wait for Logical OR of Event Flags ($WFLOR) system service places the process in a wait state until any one of a specified group of event flags has been set.
- The Wait for Logical AND of Event Flags ($WFLAND) system service places the process in a wait state until all of a specified group of flags have been set.

Another system service that accepts an event flag number as an argument is the Queue I/O Request ($QIO) system service. Figure 3-1 shows a program that issues two $QIO system service calls, and uses the $WFLAND system service to wait until both I/O operations complete before it continues execution.

```
(1) $QIO_S EFN=#1,...                ;ISSUE FIRST QUEUE I/O REQUEST
    BSBW  ERROR                      ;CHECK FOR ERROR
    $QIO_S EFN=#2,...                ;ISSUE SECOND I/O REQUEST
    BSBW  ERROR                      ;CHECK FOR ERROR
(2) $WFLAND_S EFN=#1,MASK=#^B0110    ;WAIT UNTIL BOTH COMPLETE
    BSBW  ERROR                      ;CHECK FOR ERROR
      .
      .                              ;CONTINUE EXECUTION
      .
```

Figure 3-1 Using Local Event Flags

Notes on Figure 3-1:

(1) The event flag argument is specified in each $QIO request. Both of these event flags are in cluster 0.

(2) After both I/O requests are successfully queued, the program calls the Wait for Logical AND of Event Flags ($WFLAND) system service to wait until the I/O operations are completed. In this service call, the EFN argument can specify any event flag number in the cluster containing the event flags to be waited for. The MASK argument specifies which flags in the cluster are to be waited for: flags 1 and 2.

3.3 SETTING AND CLEARING EVENT FLAGS

The $SETIMR and $QIO system services clear the event flag specified in the system service call before they queue the timer or I/O request. This ensures the integrity of the event flag with respect to the process. If you are using event flags in local clusters for other purposes, be sure the flag's initial value is what you want before you use it.

The Set Event Flag ($SETEF) and Clear Event Flag ($CLREF) system services set and clear specific event flags. For example, the following system service call clears event flag 32:

```
$CLREF_S EFN=#32
```

The $SETEF and $CLREF services return successful status codes that indicate whether the flag specified was set or clear when the service was called. The caller can thus determine the previous state of the flag, if necessary. The codes returned are SS$_WASSET and SS$_WASCLR.

Event flags in common event flag clusters are all initially clear when the cluster is created. The next section describes the creation of common event flag clusters.

3.4 COMMON EVENT FLAG CLUSTERS

Before any processes can use event flags in a common event flag cluster, the cluster must be created. The Associate Common Event Flag Cluster ($ASCEFC) system service creates a common event flag cluster. Once a cluster has been created, other processes in the same group can call $ASCEFC to establish their association with the cluster, so they can access flags in it.

When a common event flag cluster is created, it must be identified by a name string. (Section 3.7.1 explains the format of this string.) All processes that associate with the cluster must use the same name to refer to the cluster; the $ASCEFC system service establishes the correspondence between the cluster name and the cluster number that a process assigns to it.

The following example shows how a process might create a common event flag cluster named COMMON_CLUSTER and assign it a cluster number of 2:

```
CLUSTER:
        .ASCID /COMMON_CLUSTER/         ;CLUSTER NAME
          .
          .
          .
        $ASCEFC_S EFN=#65,NAME=CLUSTER ;CREATE CLUSTER 2
```

Subsequently, other processes in the same group may associate with this cluster. Those processes must use the same character string name to refer to the cluster; however, the cluster numbers they assign do not have to be the same.

Common event flag clusters are either temporary or permanent. The PERM argument to the $ASCEFC system service defines whether the cluster is temporary or permanent.

Temporary clusters:

- Require an element of the creating process's quota for timer queue entries (TQELM quota).
- Are deleted when all processes associated with the cluster have disassociated. Disassociation can be performed explicitly, with the Disassociate Common Event Flag Cluster ($DACEFC) system service, or implicitly, when the image exits.

Permanent clusters:

- Require the creating process to have the PRMCEB user privilege.
- Continue to exist until they are explicitly marked for deletion with the Delete Common Event Flag Cluster ($DLCEFC) system service.

If cooperating processes that are going to use a common event flag cluster all have the requisite privilege or quota to create a cluster, the first process to call the $ASCEFC system service creates the cluster.

3.5 DISASSOCIATING AND DELETING COMMON EVENT FLAG CLUSTERS

When a process no longer needs access to a common event flag cluster, it issues the Disassociate Common Event Flag Cluster ($DACEFC) system service. When all processes associated with a temporary cluster have issued a $DACEFC system service, the system deletes the cluster. If a process does not explicitly disassociate itself from a cluster, the system performs an implicit disassociation when the image that called $ASCEFC exits.

Permanent clusters, however, must be explicitly marked for deletion with the Delete Common Event Flag Cluster ($DLCEFC) system service. After the cluster has been marked for deletion, it is not deleted until all processes associated with it have been disassociated.

3.6 EXAMPLE OF USING A COMMON EVENT FLAG CLUSTER

Figure 3-2 shows an example of four cooperating processes that share a common event flag cluster. The processes named ORION, CYGNUS, LYRA, and PEGASUS are in the same group.

```
Process ORION

CNAME:  .ASCID /COMMON_CLUSTER/ ;DESCRIPTOR FOR CLUSTER NAME
          .
          .                          ❷
    ❶     $ASCEFC_S EFN=#64,NAME=CNAME ;CREATE COMMON CLUSTER
          BSBW    ERROR                ;CHECK FOR ERROR
          .
          .
    ❸     $WFLAND_S EFN=#64,MASK=#^XE  ;WAIT FOR FLAGS 1,2,3
          BSBW    ERROR                ;CHECK FOR ERROR
    ❼     $DACEFC_S EFN=#64            ;DISASSOCIATE CLUSTER

Process CYGNUS

ORION_FLAGS: .ASCID /COMMON_CLUSTER/ ;DESCRIPTOR FOR
          .                          ;CLUSTER NAME
          .
    ❹     $ASCEFC_S EFN=#64,NAME=ORION_FLAGS
          BSBW    ERROR                ;CHECK FOR ERROR
          $SETEF_S EFN=#65             ;SET EVENT FLAG 1
          BSBW    ERROR                ;CHECK FOR ERROR
          $DACEFC_S EFN=#64            ;DISASSOCIATE

Process LYRA

SHARE:  .ASCID /COMMON_CLUSTER/ ;DESCRIPTOR FOR CLUSTER NAME
          .
          .
    ❺     $ASCEFC_S EFN=#96,NAME=SHARE ;ASSOCIATE WITH CLUSTER 3
          BSBW    ERROR                ;CHECK FOR ERROR
          $SETEF_S EFN=#99             ;SET FLAG 3
          BSBW    ERROR                ;CHECK FOR ERROR
          $DACEFC_S EFN=#96            ;DISASSOCIATE

Process PEGASUS

CLUSTER: .ASCID /COMMON_CLUSTER/ ;DESCRIPTOR FOR CLUSTER NAME
          .
          .
    ❻     $ASCEFC_S EFN=#64,NAME=CLUSTER ;ASSOCIATE WITH CLUSTER
          BSBW    ERROR                ;CHECK FOR ERROR
          $WAITFR_S EFN=#65            ;WAIT FOR FLAG 1
          BSBW    ERROR                ;CHECK FOR ERROR
          .                            ;CONTINUE
          .
          $SETEF_S EFN=#66             ;SET FLAG 2
          BSBW    ERROR                ;CHECK FOR ERROR
          $DACEFC_S EFN=#64            ;DISASSOCIATE
```

Figure 3-2 Example of a Common Event Flag Cluster

Notes on Figure 3-2:

❶ Assume for this example that ORION is the first process to issue the $ASCEFC system service and therefore is the creator of the cluster. Since this is a newly created cluster, all event flags in it are 0.

❷ The argument NAME in the $ASCEFC system service call is a pointer to the descriptor CNAME for the name to be assigned to the cluster; in this example, the cluster is named COMMON_CLUSTER. This service call associates this name with cluster 2, containing event flags 64 through 95. Cooperating processes CYGNUS, LYRA, and PEGASUS must use the same character string name to refer to this cluster.

❸ The continuation of process ORION depends on work done by processes CYGNUS, LYRA, and PEGASUS. The Wait For Logical AND of Event Flags ($WFLAND) system service call specifies a mask indicating the event flags that must be set before Process ORION can continue. The mask in this example, ^XE is the hexadecimal equivalent of binary 1110: it indicates that the second, third, and fourth flags in the cluster must be set.

❹ Process CYGNUS executes, associates with the cluster, sets event flag 65, and disassociates.

❺ Process LYRA associates with the cluster, but instead of referring to it as cluster 2, it refers to it as cluster 3 (with event flags in the range 96 through 127). Thus, when process LYRA sets flag 99, it is setting the fourth bit in COMMON_CLUSTER.

❻ Process PEGASUS associates with the cluster, waits for an event flag set by process CYGNUS, and sets an event flag itself.

❼ When all three event flags are set, Process ORION continues execution and calls the $DACEFC system service. Since ORION did not specify the PERM argument when it created the cluster, COMMON_CLUSTER is deleted.

3.7 COMMON EVENT FLAG CLUSTERS IN SHARED MEMORY

A common event flag cluster in memory shared by multiple processors is a vehicle by which processes executing on different CPUs can communicate with each other. A process can create a common event flag cluster using the Associate Common Event Flag Cluster ($ASCEFC) service, specifying a cluster name that locates the cluster in memory shared by multiple processors (see Section 3.7.1). Other processes on the same or a different processor can associate with that cluster by specifying the same cluster name.

The SHMEM user privilege is required to create or delete a common event flag cluster in memory shared by multiple processors, but not to associate with an existing cluster.

3.7.1 Cluster Name

The NAME argument to the Associate Common Event Flag Cluster ($ASCEFC) service identifies the cluster that the process is creating or associating with. The NAME argument specifies a descriptor pointing to a character string that determines whether the cluster is in memory shared by multiple processors. The format of this string is as follows:

```
[shared-memory-name:]cluster-name
```

shared-memory-name
: Identifies the memory shared by multiple processors in which the cluster exists or is to be created. (This name was assigned when the memory unit was connected at system generation time.) If this field is not included, the cluster exists or is created in memory that is local to the processor on which the calling process is executing.

cluster-name
: Is the name of the cluster. You may choose any valid name, from 1 to 15 characters; however, all processes associating with the same common event flag cluster must specify the same name.

If you wish, you can include both the shared-memory-name and the cluster-name for an event flag cluster in memory shared by multiple processors. However, if you want to use existing programs without recompiling or relinking, you can specify just a cluster-name and have the system translate it to a complete specification. The system attempts to perform logical name translation of the string specified by the NAME argument in the following manner:

1. CEF$ is prefixed to the string (to the part before the colon if both parts are present), and the result is subjected to logical name translation.

2. The part of the name after the colon (if any) is appended to the translated name.

3. If the result contains a logical name, steps 1 and 2 are repeated (up to 9 more times, if necessary) until translation does not succeed.

For example, assume that you have made the following logical name assignment:

```
$ DEFINE CEF$CLUS_RT SHRMEM$1:CLUS_RT
```

Assume also that your program contains the following statements:

```
NAMEDESC:  .ASCID  /CLUS_RT/     ;DESCRIPTOR FOR LOGICAL NAME OF CLUSTER
                .
                .
           $ASCEFC_S  ...,NAME=NAMEDESC,...
```

The following logical name translation takes place.

1. CEF$ is prefixed to CLUS_RT.

2. CEF$CLUS_RT is translated to SHRMEM$1:CLUS_RT. (No further translation is successful. When logical name translation fails, the string is passed to the service.)

There is one exception to the translation method described in this section. If the name string starts with an underscore (_), the VAX/VMS system strips the underscore and considers the resultant string to be the actual name (that is, no further translation is performed).

CHAPTER 4

AST (ASYNCHRONOUS SYSTEM TRAP) SERVICES

Some system services allow a process to request that it be interrupted when a particular event occurs. Since the interrupt occurs asynchronously (out of sequence) with respect to the process's execution, the interrupt mechanism is called an asynchronous system trap (AST). The trap provides a transfer of control to a user-specified routine that handles the event.

The system services that use the AST mechanism accept as an argument the address of an AST service routine, that is, a routine to be given control when the event occurs.

These services are:

- Queue I/O Request ($QIO)
- Set Timer ($SETIMR)
- Set Power Recovery AST ($SETPRA)
- Update Section File on Disk ($UPDSEC)
- Get Job/Process Information ($GETJPI)
- Declare AST ($DCLAST)

For example, if you code a Set Timer ($SETIMR) system service, you can specify the address of a routine to be executed when a time interval expires or at a particular time of day. The service sets the timer and returns; the program image continues executing. When the requested timer event occurs, the system "delivers" an AST by interrupting the process and calling the specified routine.

Figure 4-1 shows a typical program that calls the $SETIMR system service with a request for an AST when a timer event occurs.

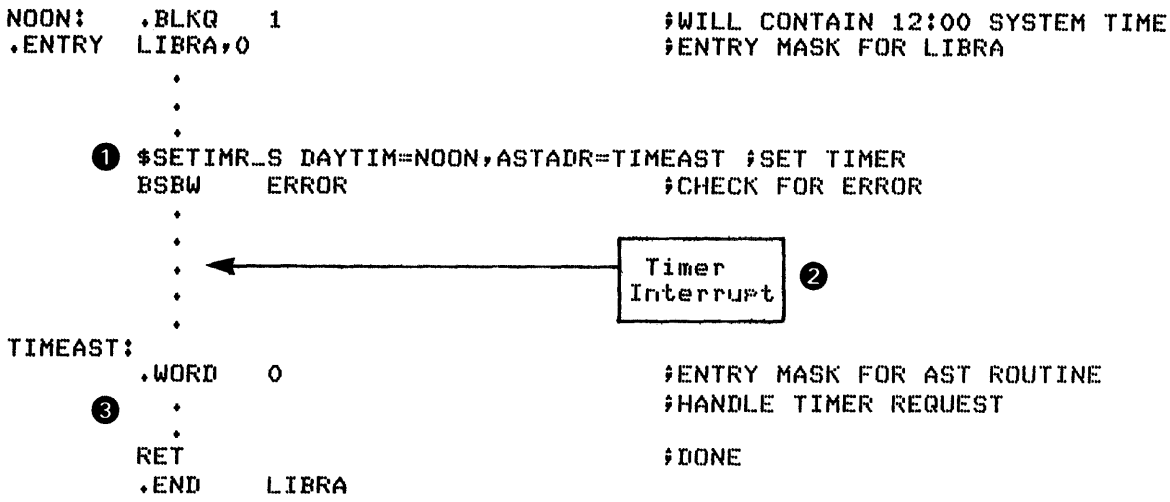


Figure 4-1 Example of an AST

Notes on Figure 4-1:

❶ The call to the $SETIMR system service requests an AST at 12:00 noon.

The DAYTIM argument refers to the quadword NOON, which must contain the time in system time (64-bit) format. For details on how this is done, see Chapter 8, "Timer and Time Conversion Services." The ASTADR argument refers to TIMEAST, the address of the AST service routine.

When the call to the system service completes, the process continues execution.

❷ The timer expires at 12:00 and notifies the system. The system interrupts execution of the process and gives control to the AST service routine.

❸ The user routine TIMEAST handles the interrupt. When the AST routine completes, it issues a RET instruction to return control to the program. The program resumes execution at the point at which it was interrupted.

The following sections describe in more detail how ASTs work and how to use them.

4.1 ACCESS MODES FOR AST EXECUTION

Each request for an AST is qualified by the access mode from which the AST is requested. Thus, if an image executing in user mode requests notification of an event by means of an AST, the AST service routine executes in user mode.

Since the ASTs you use will almost always execute in user mode, you do not need to be concerned with access modes. However, you should be aware of some system considerations for AST delivery. These considerations are described in Section 4.5, "AST Delivery."

4.2 ASTS AND PROCESS WAIT STATES

A process that is in a wait state can be interrupted for the delivery of an AST and the execution of an AST service routine. When the AST service routine completes execution, the process is returned to the wait state, if the condition that caused the wait is still in effect.

The following wait states may be interrupted:

- Event flag waits
- Hibernation
- Resource waits and page faults

4.2.1 Event Flag Waits

If a process is waiting for an event flag and is interrupted by an AST, the wait state is restored following execution of the AST service routine. If the flag is set during the execution of the AST service routine (for example, by completion of an I/O operation), then the process continues execution when the AST service routine completes.

Event flags are described in detail in Chapter 3, "Event Flag Services."

4.2.2 Hibernation

A process can place itself in a wait state with the Hibernate ($HIBER) system service. This wait state can be interrupted for the delivery of an AST. When the AST service routine completes execution, the process continues hibernation. The process can, however, "wake" itself in the AST service routine or be awakened by another process or as the result of a timer-scheduled wakeup request. Then, it continues execution when the AST service routine completes.

Process suspension is another form of wait; however, a suspended process cannot be interrupted by an AST. Process hibernation and suspension are described in Chapter 7, "Process Control Services."

4.2.3 Resource Waits And Page Faults

When a process is executing an image, the system can place the process in a wait state until a required resource becomes available, or until a page in its virtual address space is paged into memory. These waits, which are generally transparent to the process, can also be interrupted for the delivery of an AST.

4.3 HOW ASTS ARE DECLARED

Most ASTs occur as the result of the completion of an asynchronous event initiated by a system service, for example, a $QIO or $SETIMR request, when the process requests notification by means of an AST.

There is also a system service that creates ASTs, the Declare AST ($DCLAST) system service. With this service, a process can declare an AST only for the same or for a less privileged access mode.

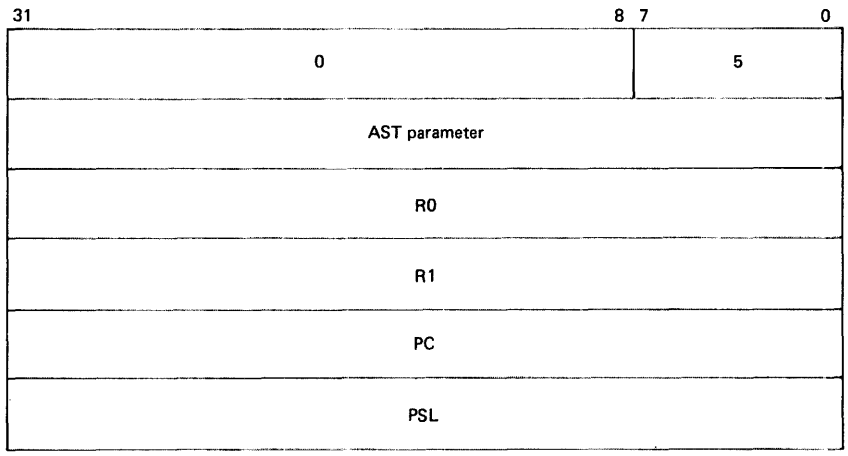
You may find occasional use for the $DCLAST system service in your programming applications; you may also find the $DCLAST service useful when you want to test an AST service routine.

4.4 THE AST SERVICE ROUTINE

An AST service routine must be a separate routine. The system calls the AST with a CALLG instruction; the routine must return using a RET instruction. If the service routine modifies any registers other than R0 or R1, it must set the appropriate bits in the entry mask so that the contents of those registers are saved.

Since it is impossible to know when the AST service routine will begin executing, you must take care when you code the AST service routine that it does not modify any data or instructions used by the main procedure.

On entry to the AST service routine, the Argument Pointer register (AP) points to an argument list that has the format:



The registers R0 and R1, the PC, and PSL in this list are those that were saved when the process was interrupted by delivery of the AST.

The AST parameter is an argument passed to the AST service routine so that it can identify the event that caused the AST. When you code a call to a system service requesting an AST, or when you code a $DCLAST system service, you can supply a value for the AST parameter. If you do not specify a value, it defaults to 0.

Figure 4-2 illustrates an AST service routine. In this example, the ASTs are created by the $DCLAST system service: the ASTs are delivered to the process immediately, so that the service routine is called following each $DCLAST system service call.

```
.ENTRY          PEGASUS,0 ;ENTRY MASK
                  .
                ❶ $DCLAST_S ASTADR=ASTRTN,ASTPRM=#1 ;AST WITH PARM=1
                  .
                  $DCLAST_S ASTADR=ASTRTN,ASTPRM=#2 ;AST WITH PARM=2
                  .
                  RET  ;RETURN CONTROL
ASTRTN: .WORD     0 ;ENTRY MASK
                ❷ CMPL #1,4(AP) ;CHECK AST PARAMETER 1
                  BEQL 10$ ;IF 1 GOTO 10$
                  CMPL #2,4(AP) ;CHECK FOR PARM=2
                  BEQL 20$ ;IF 2 GOTO 20$
                  .
10$:              .  ;HANDLE FIRST AST
                  RET  ;RETURN
20$:              .  ;HANDLE SECOND AST
                  RET  ;RETURN
                  .
                  .END PEGASUS
```

Figure 4-2 An AST Service Routine

Notes on Figure 4-2:

❶ The program PEGASUS calls the Declare AST system service twice to queue ASTs. Both ASTs specify the AST service routine, ASTRTN. However, a different parameter is passed for each call.

❷ The first action that this AST routine takes is to check the AST parameter, so that it can determine if the AST being delivered is the first or second one declared. The value of the AST parameter determines the flow of execution.

4.5 AST DELIVERY

When an AST occurs, the system may not be able to deliver the AST to the process immediately. An AST cannot be delivered if any of the following conditions exist:

- An AST service routine is currently executing at the same or at a more privileged access mode.

  Because ASTs are implicitly disabled when an AST service routine executes, one AST routine cannot be interrupted by another AST routine declared for the same access mode. It can, however, be interrupted for an AST declared for a more privileged access mode.

- AST delivery is explicitly disabled for the access mode.

  A process can disable the delivery of AST interrupts with the Set AST Enable ($SETAST) system service. This service may be useful when a program is executing a sequence of instructions that should not be interrupted for the execution of an AST routine.

- The process is executing at an access mode more privileged than that for which the AST is declared.

  For example, if a user mode AST is declared as the result of a system service but the program is currently executing at a higher access mode (because of another system service call, for example), the AST is not delivered until the program is once again executing in user mode.

If an AST cannot be delivered when the interrupt occurs, the AST is queued until the condition(s) disabling delivery are removed. Queued ASTs are ordered by the access mode from which they were declared, with those declared from more privileged access modes at the front of the queue. If more than one AST is queued for an access mode, the ASTs are delivered in the order in which they are queued.

CHAPTER 5

LOGICAL NAME SERVICES

The VAX/VMS logical name services provide a technique for manipulating and substituting character string names. Logical names are commonly used to specify devices or files for input or output operations. You can code programs with logical, or symbolic, names to refer to physical devices or files, and then establish an equivalence, or actual, name by issuing the ASSIGN command from the command stream before program execution. When the program executes, a reference to the logical name results in the use of the equivalence name.

This chapter describes how to use system services to establish logical names for general application purposes. The system performs special logical name translation procedures for names associated with I/O services and with services that can deal with facilities located in shared (multiport) memory; for further information see the following sections:

- Device names for I/O services: Section 6.10 in this manual and the discussion of logical names in the VAX/VMS Command Language User's Guide.
- Common event flag cluster names: Section 3.7.1
- Mailbox names: Section 6.13.1
- Global section names: Section 10.6.5.1

5.1 LOGICAL NAMES AND EQUIVALENCE NAMES

Logical name and equivalence name strings can have a maximum of 63 characters. You can establish logical name and equivalence name pairs:

- At the command level, with the ALLOCATE, ASSIGN, DEFINE, or MOUNT commands
- In a program, with the Create Logical Name ($CRELOG) and Create Mailbox and Assign Channel ($CREMBX) system services

For example, you could use the symbolic name TERMINAL to refer to an output terminal in a program. For a particular run of the program, you could use the ASSIGN command to establish the equivalence name TTA2:.

To perform an assignment in a program, you must provide character string descriptors for the name strings and use the $CRELOG system service as shown in the following example. In either case, the result is the same: the logical name TERMINAL is equated to the physical device name TTA2:.

```
TERMNAME: .ASCID /TERMINAL/          ;DESCRIPTOR FOR LOGICAL NAME
TTNAME: .ASCID /TTA2:/               ;DESCRIPTOR FOR EQUIVALENCE NAME
          .
          .
          .
        $CRELOG_S TBLFLG=#2,LOGNAM=TERMNAME,EQLNAM=TTNAME
```

The TBLFLG argument in this example indicates the logical name table number (in this case, the process logical name table). Logical name tables and logical name table numbers are discussed in the following sections.

5.2 LOGICAL NAME TABLES

Logical name and equivalence name pairs are maintained in three logical name tables:

- Process
- Group
- System

A process logical name table contains names used exclusively by the process. A process logical name table exists for each process in the system. Some entries in the process logical name table are made by system programs executing at more privileged access modes; these entries are qualified by the access mode from which the entry was made. For example, logical names created at the command level are supervisor mode entries.

The group logical name table contains names that cooperating processes in the same group can use. The GRPNAM privilege is required to place a name in the group logical name table.

The system logical name table contains names that all processes in the system can access. This table includes the default names for all system-assigned logical names. The SYSNAM privilege is required to place a name in the system logical name table.

Figure 5-1 illustrates some sample logical name table entries.

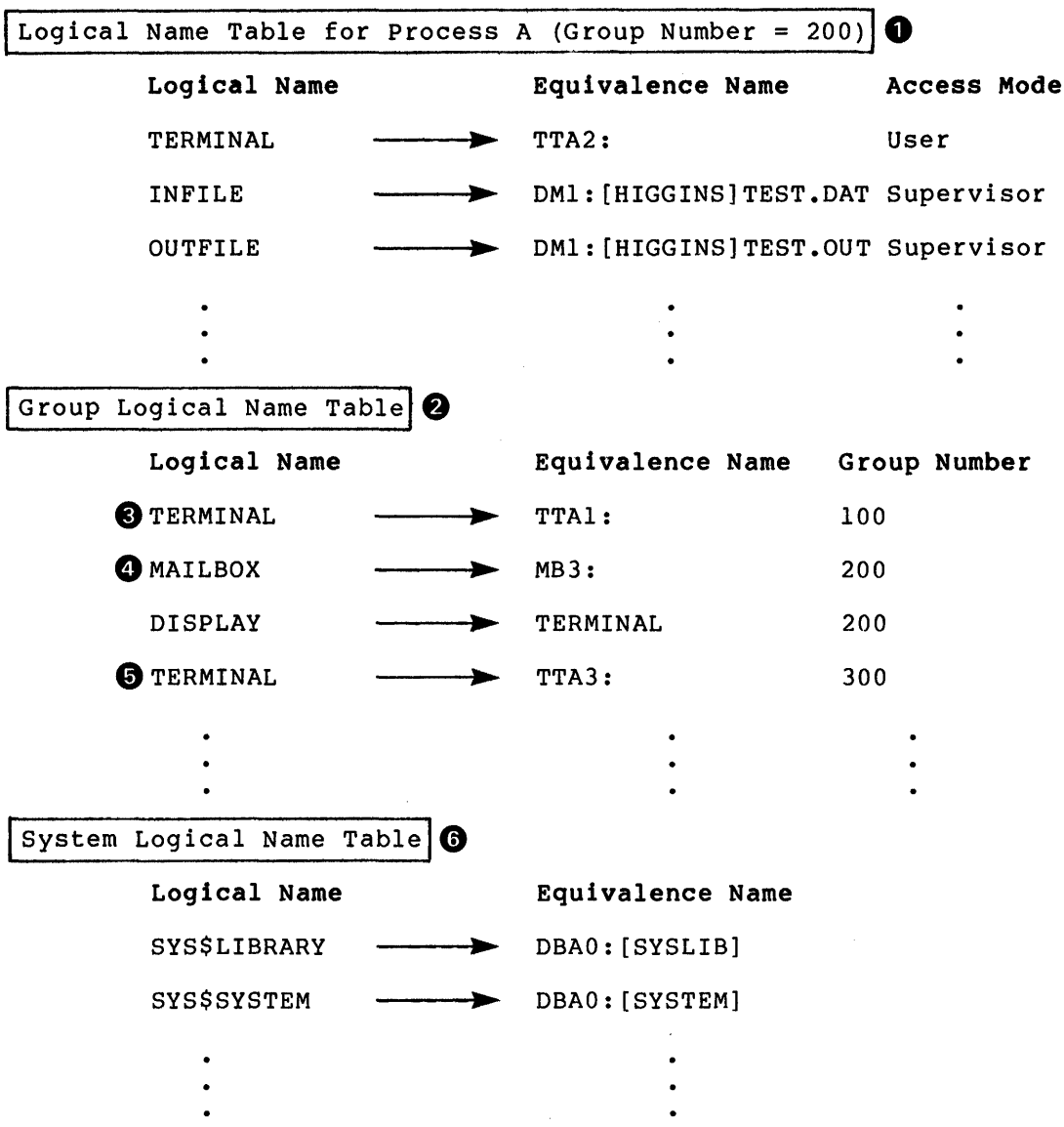


Figure 5-1 Logical Name Table Entries

Notes on Figure 5-1:

❶ This process logical name table equates the logical name TERMINAL to the specific terminal TTA2:. INFILE and OUTFILE are equated to disk file specifications: these logical names were created from supervisor mode.

❷ The group logical name table shows entries qualified by group numbers; only processes that have the indicated group number can access these entries.

❸ In Group 100, the logical name TERMINAL is equated to the terminal TTA1:. Individual processes in Group 100 that want to refer to the logical name TERMINAL do not have to individually assign it an equivalence name.

❹ Group 200 has entries for logical names MAILBOX and DISPLAY. Other processes in group 200 can use these logical names for input or output operations.

❺ In Group 300, the logical name TERMINAL is equated to the physical device name TTA3:. Note that there are two entries for TERMINAL in the group logical name table. These are discrete entries, since they are qualified by the number of the group to which they belong.

❻ The system logical name table contains the default physical device names for all processes in the system. SYS$LIBRARY and SYS$SYSTEM provide logical names for all users to refer to the device(s) containing system files.

5.2.1 Logical Name Table Numbers

Each logical name table has a number associated with it. To place an entry in a logical name table, specify a logical name table number with the TBLFLG argument to the $CRELOG system service. The logical name table numbers are as follows:

Table	Number
Process	2
Group	1
System	0

The TBLFLG argument defaults to a value of 0, that is, the system logical name table.

5.2.2 Duplication of Logical Names

The process logical name table can contain entries for the same logical name at different access modes. The group logical name table can contain entries for the same logical name, as long as the group numbers are different.

In all other cases, there can be only one entry for a particular logical name in a logical name table. For example, if the logical name TERMINAL is equated to TTA2: in the process table as shown in the figure, and the process subsequently equates the logical name TERMINAL to TTA3:, the equivalence of TERMINAL to TTA2: is replaced by the new equivalence name. The successful return status code SS$_SUPERSEDE indicates that a new entry replaced an old one.

Any number of logical names can have the same equivalence name.

5.3 LOGICAL NAME TRANSLATION

When you refer to a logical name for a physical device in an I/O service, the service performs logical name translation automatically. In many cases, a program must perform the logical name translation to obtain the equivalence name for a logical name. The Translate Logical Name ($TRNLOG) system service searches the logical name tables for a specified logical name and returns the equivalence name.

By default, the process, group, and system tables are all searched, in that order, and the first match found is returned. Thus, if identical logical names exist in the process and group tables, the process table entry is found first, and the group table is not searched. When the process logical name table is searched, the entries are searched in order of access mode, with user mode entries matched first, supervisor second, and so on.

The following example shows a call to the $TRNLOG system service to translate the logical name TERMINAL.

```
TLOGDESC: .ASCID /TERMINAL/        ;DESCRIPTOR FOR INPUT LOGNAM
TEQLDESC:                          ;BUFFER DESCRIPTOR FOR EQLNAME
        .LONG 64                   ;LENGTH
        .LONG TEQLDESC+8           ;ADDRESS OF BUFFER
        .BLKB 64                   ;BUFFER OF 64 BYTES
TLEN:   .BLKW 1                    ;RECEIVE EQLNAM LENGTH HERE
          .
          .
          .
        $TRNLOG_S LOGNAM=TLOGDESC,RSLLEN=TLEN,RSLBUF=TEQLDESC
```

If the logical name table entries are as shown in Figure 5-1, this call to the $TRNLOG system service results in the translation of the logical name TERMINAL. The equivalence name string TTA2: is placed in the output buffer described by TEQLDESC. The length of the equivalence name string is written into the word at TLEN.

Note that the call to $TRNLOG might be coded as follows:

```
$TRNLOG_S LOGNAM=TLOGDESC,RSLLEN=TEQLDESC,RSLBUF=TEQLDESC
```

In this case the output equivalence name string length is written into the first word of the character string descriptor. This descriptor can then be used as input to another system service.

5.3.1 Bypassing Logical Name Tables

To disable the search of a particular logical name table, you can code the optional argument DSBMSK to the $TRNLOG system service. This argument is a mask that disables the search of one or more logical name tables. The format of the mask is described in the discussion of the $TRNLOG system service in Part II.

5.3.2 Logical Name and Equivalence Name Format Conventions

The operating system uses special conventions for logical name/equivalence name assignments and translation. These conventions are generally transparent to user programs; however, you should be aware of the programming considerations involved.

If a logical name string is preceded with an underscore character (_), $TRNLOG will not translate the logical name. Instead, it returns the status code SS$_NOTRAN, strips the underscore from the logical name string, then writes the string into the result buffer. This convention permits bypassing logical name translation in I/O services when physical device name strings are specified.

At login, the system creates default logical name table entries for process permanent files. The equivalence names for these entries (for example, SYS$INPUT and SYS$OUTPUT,) are preceded with a 4-byte header that contains the following:

Byte(s)	Contents
0	^X1B (Escape character)
1	^X00
2-3	RMS Internal File Identifier (IFI)

This header is followed by the equivalence name string. If any of your program applications must translate system-assigned logical names, the program must be prepared to check for the existence of this header and then to use only the desired part of the equivalence string.

For an example of how to do this, see Figure 6-2 in Section 6.7, "Complete Terminal I/O Example."

5.4 RECURSIVE TRANSLATION

When a translate request is made for a logical name string, the $TRNLOG system service searches the logical name tables only once. If you structure one or more logical name tables such that logical name equivalencies are several levels deep (that is, such that an equivalence name is entered in the table as a logical name with another equivalence name, and so on), you may require recursive logical name translation. Note that Figure 5-1 earlier in this chapter illustrates recursive entries: the logical name DISPLAY is equated to the string TERMINAL in the group table, and the name TERMINAL is equated to the device name string TTA2: in the process table. The $TRNLOG system service must be used twice to complete the translation of the logical name DISPLAY.

You can code a program loop so that the output string from the $TRNLOG service is reused as the input string, and check for the status code SS$_NOTRAN following the call to the service. SS$_NOTRAN indicates that no logical name was found, and that the input string has been written into the output buffer.

5.5 DELETING LOGICAL NAMES

The Delete Logical Name ($DELLOG) system service deletes entries from a logical name table. When you code a call to the $DELLOG system service, you can specify a single logical name to delete, or you can specify that you want to delete all logical names from a particular table. For example, the following call deletes all names from the process logical name table that were entered in the table from user mode:

```
$DELLOG_S TBLFLG=#2
```

Logical names that were placed in the process logical name table from an image running in user mode are automatically deleted at image exit. Entries made from the command stream are placed in the table by the command interpreter; these are supervisor mode entries and are not deleted at image exit.

CHAPTER 6

INPUT/OUTPUT SERVICES

There are two basic methods you can use to perform input/output operations under VAX/VMS:

- VAX-11 Record Management Services (RMS)
- I/O system services

VAX-11 RMS provides a set of routines for general purpose, device-independent functions such as data storage, retrieval, and modification.

The I/O system services permit you to use the I/O resources of the operating system directly in a device-dependent manner. I/O services also provide some specialized functions not available in RMS. Using I/O services requires more knowledge on your part, but can result in more efficient input/output operations.

This chapter provides general information on how to use the I/O services, including:

- Assigning channels
- Queuing I/O requests
- Allocating devices
- Using mailboxes

Examples are provided to show you how to use the I/O services for simple functions, for example, terminal input and output operations. If you plan to write device-dependent I/O routines, see the VAX/VMS I/O User's Guide.

Other methods of performing I/O with VAX/VMS include the following, which are documented in other manuals:

- Writing your own device driver. See the VAX/VMS Guide to Writing a Device Driver
- Connecting to a device interrupt vector. See the VAX/VMS Real-Time User's Guide

6.1 ASSIGNING CHANNELS

Before any input or output operation can be done to a physical device, a channel must be assigned to the device to provide a path between the process and the device. The Assign I/O Channel ($ASSIGN) system service establishes this path.

When you code a call to the $ASSIGN service, you must supply the name of the device, which may be a physical device name or a logical name, and the address of a word to receive the channel number. The service returns a channel number, and you use this channel number when you code an input or an output request.

For example, the following lines assign an I/O channel to the device TTA2. The channel number is returned in the word at TTCHAN.

```
TTNAME: .ASCID /TTA2:/          ;TERMINAL DESCRIPTOR
TTCHAN: .BLKW   1               ;TERMINAL CHANNEL NUMBER
          .
          .
          .
        $ASSIGN_S DEVNAM=TTNAME,CHAN=TTCHAN
```

To assign a channel to the current default input or output device, you must first translate the logical name SYS$INPUT or SYS$OUTPUT with the Translate Logical Name ($TRNLOG) system service. Then, specify the equivalence name returned as the DEVNAM argument to the $ASSIGN system service. This technique requires you to interpret header information preceding the equivalence name string for these devices. For an example of this technique, see Figure 6-2 later in this chapter.

For more details on how $ASSIGN and other I/O services handle logical names, see Section 6.10, "Logical Names and Physical Device Names."

6.2 QUEUING I/O REQUESTS

All input and output operations in VAX/VMS are initiated with the Queue I/O Request ($QIO) system service. $QIO queues the request and returns; while the operating system processes the request, the program that issued the request can continue execution.

Required arguments to the $QIO service include the channel number assigned to the device on which the I/O is to be done, and a function code (expressed symbolically) that indicates the specific operation to be performed. Depending on the function code, one through six additional parameters may be required.

For example, the IO$_WRITEVBLK and IO$_READVBLK function codes are device-independent codes used to read and write single records or virtual blocks. These function codes are suitable for simple terminal I/O. They require parameters indicating the address of an input or output buffer and the buffer length. A call to $QIO to write a line to a terminal might appear as:

```
$QIO_S  CHAN=TTCHAN,FUNC=#IO$_WRITEVBLK, -
        P1=BUFADDR,P2=BUFLEN
```

Function codes are defined for all supported device types, and most of the codes are device dependent, that is, they perform functions that are specific to a particular device. The $IODEF macro defines symbolic names for these function codes, which are summarized in Appendix A, "System Symbolic Definition Macros." For details on all function codes and an explanation of the parameters required by each, see the VAX/VMS I/O User's Guide.

6.3 SYNCHRONIZING I/O COMPLETION

The $QIO system service returns control to the calling program as soon as the I/O request is queued; the status code returned in R0 indicates whether or not the request was queued successfully. To ensure proper synchronization of the I/O operation with respect to the program, the program must:

1. Test for the completion of the Queue I/O operation

2. Test whether the I/O operation itself completed successfully

Optional arguments to the $QIO service provide techniques for synchronizing I/O completion. There are three methods you can use to test for the completion of an I/O request:

- Specify the number of an event flag to be set when the I/O completes
- Specify the address of an AST routine to be executed when the I/O completes
- Specify the address of an I/O status block in which the system can place the return status when the I/O completes

Examples of using these three techniques are shown in Figure 6-1.

Example 1: Event Flags (1)

```
(2) $QIO_S  EFN=#1,...                ;ISSUE 1ST I/O REQUEST
    BSBW  ERROR                       ;QUEUED SUCCESSFULLY?
    $QIO_S EFN=#2,...                 ;ISSUE 2ND I/O REQUEST
    BSBW  ERROR                       ;QUEUED SUCCESSFULLY?
(3) $WFLAND_S EFN=#0,MASK=#^B110      ;WAIT TILL BOTH DONE
```

Notes on Example 1:

(1) When you code an event flag number as an argument, $QIO clears the event flag when it queues the I/O request. When the I/O completes, the flag is set.

(2) In this example, the program issues two Queue I/O requests. A different event flag is specified for each request.

(3) The Wait for Logical AND of Event Flags ($WFLAND) system service places the process in a wait state until both I/O operations are complete. The EFN argument indicates that the event flags are both in cluster 0; the MASK argument indicates the flags that are to be waited for.

Figure 6-1 Synchronizing I/O Completion

Example 2: An AST Routine ❶

```
      ❷ $QIO_S  ...,ASTADR=TTAST,ASTPRM=#1,... ;I/O WITH AST
        BSBW  ERROR                          ;QUEUED SUCCESSFULLY?
          .                                  ;CONTINUE
          .
          .
TTAST:  .WORD 0 ❸                            ;AST SERVICE ROUTINE ENTRY MASK
          .                                  ;HANDLE I/O COMPLETION
          .
          .
        RET                                  ;END OF SERVICE ROUTINE
```

Notes on Example 2:

❶ When you code the ASTADR argument to the $QIO system service, the system interrupts the process when the I/O completes and passes control to the specified AST service routine.

❷ The $QIO system service call specifies the address of the AST routine, TTAST, and a parameter to pass as an argument to the AST service routine. When $QIO returns control, the process continues execution.

❸ When the I/O completes, the AST routine TTAST is called, and it responds to the I/O completion.

When this routine is finished executing, control returns to the process at the point at which it was interrupted.

Figure 6-1 (Cont.) Synchronizing I/O Completion

Example 3: The I/O Status Block ❶

```
TTIOSB: .BLKQ 1 ❷                              ;I/O STATUS BLOCK
          .
          .
          .
        ❸ $QIO_S  ...,IOSB=TTIOSB,...          ;ISSUE I/O REQUEST
          BSBW  ERROR                          ;QUEUED SUCCESSFULLY?
                                               ;CONTINUE
          .
          .
          .
10$:      TSTW  TTIOSB ❹                             ;IS I/O DONE YET?
          BEQL  10$                            ;NO, LOOP TIL DONE
          CMPW  TTIOSB,#SS$_NORMAL             ;I/O SUCCESSFUL?
          BNEQ  IO_ERR                         ;NO, ERROR
                                               ;YES, HANDLE IT
          .
          .
          .
```

Notes on Example 3:

❶ An I/O status block is a quadword structure that the system uses to post the status of an I/O operation. The quadword area must be defined in your program.

❷ TTIOSB defines the I/O status block for this I/O operation. The IOSB argument in the $QIO system service refers to this quadword.

❸ $QIO clears the quadword when it queues the I/O request. When the request is successfully queued, the program continues execution.

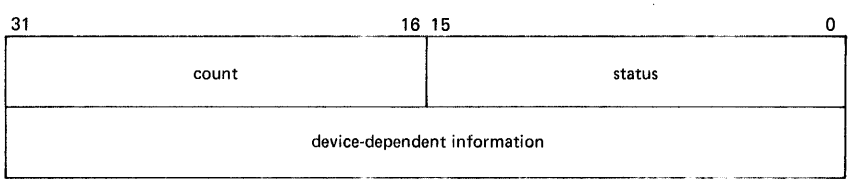
❹ The process polls the I/O status block. If the low-order word still contains 0, the I/O operation has not yet completed. In this example, the program loops until the request is complete.

Figure 6-1 (Cont.) Synchronizing I/O Completion

6.4 I/O COMPLETION STATUS

When an I/O operation completes, the system posts the completion status in the I/O status block, if one is specified. The completion status indicates whether the operation actually completed successfully, the number of bytes that were transferred, and additional device-dependent return information.

The format of the information written in the IOSB is:



The first word contains a system status code indicating the success or failure of the operation. The status codes used are the same as for all returns from system services; for example, SS$_NORMAL indicates successful completion.

The second word contains the number of bytes actually transferred in the I/O operation.

The second longword contains device-dependent return information.

To ensure successful I/O completion and the integrity of data transfers, the IOSB should be checked following I/O requests, particularly for device-dependent I/O functions. For complete details on how to use the I/O status block, see the VAX/VMS I/O User's Guide.

6.5 SIMPLIFIED FORMS OF THE $QIO MACRO ($QIOW, $INPUT, $OUTPUT)

The $QIOW macro combines the functions of the $QIO and the Wait for Single Event Flag ($WAITFR) system services. $QIOW has the same arguments as the $QIO macro. It queues the I/O request, and then places the program in a wait state until the I/O is complete.

The $INPUT and $OUTPUT macros are a subset of the $QIOW macro: they use only the function codes to read and write virtual blocks or records (IO$_READVBLK and IO$_WRITEVBLK, respectively). These macros provide an efficient and easy way to specify I/O for terminals, mailboxes, line printers, and interprocess network transfers.

When you code a $INPUT or $OUTPUT macro, you must specify the channel on which the I/O is to be performed and the length and address of the input or output buffer. Optionally, you can specify an event flag to be set when the I/O is complete and the address of an I/O status block. For example:

```
$INPUT CHAN=TTCHAN,LENGTH=INLEN,BUFFER=INBUF,EFN=#1,IOSB=TTIOSB
```

or

```
$OUTPUT CHAN=TTCHAN,LENGTH=OUTLEN,BUFFER=OUTBUF,EFN=#2,IOSB=TTIOSB
```

6.6 DEASSIGNING I/O CHANNELS

When a process no longer needs access to an I/O device, it should release the channel assigned to the device by issuing the Deassign I/O Channel ($DASSGN) system service. For example:

```
$DASSGN_S CHAN=TTCHAN
```

This service call releases the terminal channel assignment acquired in the $ASSIGN example shown earlier. The system automatically deassigns channels for a process when the image that assigned the channel exits.

6.7 COMPLETE TERMINAL I/O EXAMPLE

Figure 6-2 shows a complete sequence of input and output operations using the $INPUT and $OUTPUT macros to read and write lines to the current default SYS$INPUT device. Note that if the program containing these lines is executed interactively, the input/output is to the current terminal.

```
TTNAME: .ASCID /SYS$INPUT/ ❶              ;DESCRIPTOR FOR TERMINAL NAME

TTCHAN: .BLKW   1                         ;RECEIVE CHANNEL NUMBER HERE

TTIOSB: .BLKW   1 ❷                       ;FIRST WORD OF IOSB, STATUS
TTIOLEN:
        .BLKW   1                         ;SECOND WORD, GET LENGTH
        .BLKL   1                         ;SECOND LONGWORD OF IOSB

OUTLEN: .BLKL   1                         ;LENGTH OF STRING TO OUTPUT
INBUF:  .BLKB   80 ❸                      ;BUFFER TO READ INPUT

DEVDESC:                                  ;DESCRIPTOR FOR LOGICAL NAME TRANSLATION
NLEN:   .LONG   63                        ;LENGTH OF BUFFER
NADDR:  .LONG   NAME                      ;ADDRESS OF BUFFER
NAME:   .BLKB   63                        ;ALLOCATE 63-BYTE BUFFER TO HOLD
                                          ;EQUIVALENCE NAME OF "SYS$INPUT"
          .
          .
          .
      ❹ $TRNLOG_S LOGNAM=TTNAME,RSLLEN=NLEN,RSLBUF=DEVDESC
        CMPB    NAME,#^X1B                ;DOES NAME BEGIN WITH ESCAPE? (IF SO,
                                          ;   IT'S A PROCESS PERMANENT FILE.)
        BNEQ    10$                       ;NO, SKIP
        SUBL    #4,NLEN                   ;OTHERWISE, SUBTRACT 4 FROM LENGTH
        ADDL    #4,NADDR                  ;ADD 4 TO ADDRESS

10$:  ❺ $ASSIGN_S DEVNAM=DEVDESC,CHAN=TTCHAN ;ASSIGN CHANNEL
        BSBW    ERROR

      ❻ $INPUT  CHAN=TTCHAN,LENGTH=#80,BUFFER=INBUF,IOSB=TTIOSB
        BSBW    ERROR
      ❼ CMPW    TTIOSB,#SS$_NORMAL      ;I/O SUCCESSFUL?
        BNEQ    IO_ERR                  ;ERROR IF NOT...
      ❽ MOVZWL  TTIOLEN,OUTLEN          ;GET LENGTH OUT OF IOSB

      ❾ $OUTPUT CHAN=TTCHAN,LENGTH=OUTLEN,BUFFER=INBUF,IOSB=TTIOSB
        BSBW    ERROR
        CMPW    TTIOSB,#SS$_NORMAL      ;SUCCESSFUL?
        BNEQ    IO_ERR                  ;BRANCH IF NOT

      ❿ $DASSGN_S CHAN=TTCHAN           ;DONE, DEASSIGN CHANNEL
        BSBW    ERROR
```

Figure 6-2 Example of Terminal Input and Output

Notes on Figure 6-2:

❶ TTNAME is a character string descriptor for the logical device SYS$INPUT and TTCHAN is a word to receive the channel number assigned to it.

❷ The IOSB for the I/O operations is structured so that the program can easily check for the completion status (in the first word) and the length of the input string returned (in the second word).

❸ The string will be read into the buffer INBUF; the longword OUTLEN will contain the length of the string for the output operation.

❹ The Translate Logical Name ($TRNLOG) system service translates the logical name SYS$INPUT. On return from $TRNLOG, the equivalence name is checked for a 4-byte header beginning with an escape character. (This header is present for all process permanent files; see Section 5.3.2, "Logical Name and Equivalence Name Format Conventions.")

If this header is present, the program modifies the descriptor for the device name returned, so it can be used as input to $ASSIGN.

❺ $ASSIGN assigns a channel and writes the channel number at TTCHAN.

❻ If the $ASSIGN service completes successfully, the $INPUT macro reads a line from the terminal, and requests that the completion status be posted in the I/O status block defined at TTIOSB.

❼ The process waits until the I/O is complete, then checks the first word in the I/O status block for a successful return. If not successful, the program takes an error path.

❽ Next, the length of the string read is moved into the longword at OUTLEN. This is necessary because the $OUTPUT macro requires a longword argument, but the length field of the I/O status block is only a word long. The $OUTPUT macro writes the line just read to the terminal.

❾ The program performs error checks: first, it ensures that the $OUTPUT macro successfully queued the I/O request; then, when the request is completed, it ensures that the I/O was successful.

❿ When all I/O operations on the channel are finished, the channel is deassigned.

6.8 CANCELING I/O REQUESTS

If a process must cancel an I/O request that has been queued but not yet completed, it can issue the Cancel I/O On Channel ($CANCEL) system service. All pending I/O requests issued by the process on that channel are canceled.

For example, the $CANCEL system service can be called as follows:

```
$CANCEL_S CHAN=TTCHAN
```

In this example, the $CANCEL system service initiates the cancellation of all pending I/O requests to the channel whose number is located at TTCHAN.

The $CANCEL system service returns after initiating the cancellation of the I/O requests. If the call to $QIO specified an event flag, AST service routine, or I/O status block, the system sets the flag, delivers the AST, or posts the I/O status block as appropriate when the cancellation is actually completed.

6.9 DEVICE ALLOCATION

Many I/O devices are shareable; that is, more than one process can access the device at a time. Each process, by issuing a $ASSIGN service, is given a channel to the device for I/O operations.

In some cases, a process may need exclusive use of a device so that data is not affected by other processes. To reserve a device for exclusive use you must allocate it.

Device allocation is normally accomplished from the command stream, with the ALLOCATE command. A process can also allocate a device by calling the Allocate Device ($ALLOC) system service. When a device has been allocated by a process, only the process that allocated the device and any subprocesses it creates can assign channels to the device.

When you code the $ALLOC system service, you must provide a device name. The device name specified can be:

- A physical device name, for example, the tape drive MTB3:
- A logical name, for example, TAPE
- A generic device name, for example, MT:

If you specify a physical device name, $ALLOC attempts to allocate the specified device.

If you specify a logical name, $ALLOC translates the logical name and attempts to allocate the physical device name equated to the logical name.

If you specify a generic device name, that is, if you specify a device type but do not specify a controller and/or unit number, $ALLOC attempts to allocate any device available of the specified type. More information on the allocation of devices by generic names is provided in Section 6.10.1.

When you specify logical names or generic device names, you must provide fields for the $ALLOC system service to return the name and

the length of the physical device that is actually allocated, so you can provide this name as input to the $ASSIGN system service.

Figure 6-3 illustrates the allocation of a tape device specified by the logical name TAPE.

```
LOGDEV: .ASCID /TAPE/                          ;DESCRIPTOR FOR LOGICAL NAME
DEVDESC:                                       ;DESCRIPTOR FOR PHYSICAL NAME
        .LONG  64                              ;LENGTH OF BUFFER
        .LONG   DEVDESC+8                      ;ADDRESS OF BUFFER
        .BLKB   64                             ;GET PHYSICAL NAME RETURNED
TAPECHAN:
        .BLKW   1                              ;CHANNEL FOR TAPE I/O
          .
          .
    (1) $ALLOC_S DEVNAM=LOGDEV,PHYLEN=DEVDESC,PHYBUF=DEVDESC
        BSBW    ERROR
    (2) $ASSIGN_S DEVNAM=DEVDESC,CHAN=TAPECHAN ;ASSIGN CHANNEL
        BSBW    ERROR
          .                                    ;CONTINUE WITH I/O
          .
    (3) $DASSGN_S CHAN=TAPECHAN                ;DEASSIGN CHANNEL
        BSBW    ERROR
        $DALLOC_S DEVNAM=DEVDESC               ;DEALLOCATE TAPE
```

Figure 6-3 Device Allocation and Channel Assignment

Notes on Figure 6-3:

(1) The $ALLOC system service call requests allocation of a device corresponding to the logical name TAPE, defined by the character string descriptor LOGDEV. The argument DEVDESC refers to the buffer provided to receive the physical device name of the device actually allocated and the length of the name string. $ALLOC translates the logical name TAPE, and returns the equivalence name string of the device actually allocated into the buffer at DEVDESC. It writes the length of the string in the first word of DEVDESC.

(2) The $ASSIGN command uses the character string returned by the $ALLOC system service as the input device name argument, and requests that the channel number be written into TAPECHAN.

(3) When I/O operations are completed, the $DASSGN system service deassigns the channel and the $DALLOC system service deallocates the device. The channel must be deassigned before the device can be deallocated.

6.9.1 Implicit Allocation

Devices that cannot be shared by more than one process, for example, terminals and line printers, do not have to be explicitly allocated. Since they are nonshareable, they are implicitly allocated by the $ASSIGN system service when $ASSIGN is called to assign a channel to the device.

6.9.2 Deallocation

When the program has finished using an allocated device, it should release the device with the Deallocate Device ($DALLOC) system service, to make it available for other processes as in this example:

```
$DALLOC_S DEVNAM=DEVDESC
```

The system automatically deallocates devices allocated by an image at image exit.

6.10 LOGICAL NAMES AND PHYSICAL DEVICE NAMES

When a device name is specified as input to an I/O system service, it can be a physical device name or a logical name. When an underscore character (_) precedes a device name string, it indicates that the string is a physical device name string. For example:

```
TTNAME:  .ASCID  /_TTB3:/
```

Any string that does not begin with an underscore is considered a logical name, even though it may be a physical device name. The $ASSIGN, $DASSGN, $ALLOC, and $DALLOC system services call the Translate Logical Name ($TRNLOG) system service to search the logical name tables. The $TRNLOG service searches the process, group, and system tables, in that order, and if it locates an entry for the specified logical name, the I/O request is performed for the device specified in the equivalence name string. The search is not recursive; that is, if the result of the translation is another logical name, the $TRNLOG service does not further translate the result (see Section 5.4, "Recursive Translation").

If $TRNLOG does not locate an entry for the logical name, the I/O service treats the name that is specified as a physical device name. When you code the name of an actual physical device in a call to one of these services, code the underscore character to bypass the logical name translation.

When the $ALLOC system service returns the device name of the physical device that has been allocated, the device name string returned is prefaced with an underscore character. When this name is used for the subsequent $ASSIGN system service, the $ASSIGN service does not attempt to translate the device name.

If you use logical names in I/O service calls, you must be sure to establish a valid device name equivalence before program execution. You can do this by issuing an ASSIGN command from the command stream, or by having the program establish the equivalence name before the I/O service call with the Create Logical Name ($CRELOG) system service.

For details on how to create and use logical names, see Chapter 5, "Logical Name Services."

6.10.1 Device Name Defaults

If, after logical name translation, a device name string in an I/O system service call does not fully specify the device name (that is, device, controller, and unit), the service either provides default values for nonspecified fields, or provides values based on device availability.

The following rules apply:

- The $ASSIGN, $DASSGN, and $DALLOC system services apply default values as shown in Table 6-1.
- The $ALLOC system service treats the device name as a generic device name and attempts to find a device that satisfies the components of the device name that are specified, as shown in Table 6-1.

Table 6-1
Default Device Names for I/O Services

Final Device Name Specification	Device Name Defaults for $ASSIGN, $DASSGN, and $DALLOC	Generic Device Names Used by $ALLOC
DD:	DDA0: (unit 0 on controller A)	DDcn: (any available device of the specified type)
DDC:	DDC0: (unit 0 on controller specified)	DDCn: (any available unit on the specified controller)
DDN:	DDAN: (unit specified on controller A)	DDcN: (device of specified type and unit on any available controller)
DDAN:	DDAN:	DDAN:

Key:

DD: is the device type specified
C: is the controller specified
c: is any controller
N: is the unit number specified
n: is any unit number

6.11 OBTAINING INFORMATION ABOUT PHYSICAL DEVICES

In cases where a generic (that is, nonspecific) device name is used in an I/O service, the program may need to find out what device has actually been used. The Get I/O Channel Information ($GETCHN) system service provides specific information about the physical device to which a channel has been assigned. The Get I/O Device Information ($GETDEV) system service returns information about a device that is identified by its device name. The information returned includes the unit number of the device, as well as additional device characteristics.

When you code the $GETCHN or $GETDEV service, you must provide the address of a buffer or buffers into which the system writes the information. The format of the buffer and additional details about these services are given in Part II. Details on the device-specific information these services return is given in the VAX/VMS I/O User's Guide.

6.12 FORMATTING OUTPUT STRINGS

When you are preparing output strings for a program, you may need to insert variable information into a string prior to output, or you may need to convert a numeric value to an ASCII string. The Formatted ASCII Output ($FAO) system service performs these functions.

Input to the $FAO service consists of:

- A control string that contains the fixed text portion of the output and formatting directives. The directives indicate the position within the string where substitutions are to be made, and describe the data type and length of the input values that are to be substituted or converted.
- An output buffer to contain the string after conversions and substitutions have been made.
- An optional argument indicating a word to receive the final length of the formatted output string.
- Parameters that provide arguments for the formatting directives.

Figure 6-4 shows a call to the $FAO system service to format an output string for a $OUTPUT macro. Accompanying notes briefly discuss the input and output requirements of FAO. Complete details on how to use FAO, with additional examples, are provided in the description of the $FAO system service in Part II.

```
❶ FAOSTR: .ASCID /FILE !AS DOES NOT EXIST/ ;DESCRIPTOR FOR
                                          ;FAO CONTROL STRING
❷ FAODESC:                                ;DESCRIPTOR FOR FAO OUTPUT
          .LONG 80                        ;LENGTH OF BUFFER
          .LONG FAOBUF                    ;ADDRESS OF BUFFER
  FAOBUF: .BLKB 80                        ;BUFFER FOR FAO OUTPUT

  FAOLEN: .LONG 0                         ;RECEIVE LENGTH OF FAO OUTPUT STRING

❸ FILESPEC: .ASCID /DMA1:MYFILE.DAT/  ;DESCRIPTOR FOR FAO PARAMETER
            .
            .
            .
        ❹ $FAO_S CTRSTR=FAOSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                 P1=#FILESPEC         ;PARAMETER FOR FAO
          BSBW  ERROR
        ❺ $OUTPUT ...,BUFFER=FAOBUF,LENGTH=FAOLEN
          BSBW  ERROR
```

Figure 6-4 Example of Using Formatted ASCII Output Program

Notes on Figure 6-4:

❶ FAOSTR provides the FAO control string. !AS is an example of an FAO directive: it requires an input parameter that specifies the address of a character string descriptor. When FAO is called to format this control string, !AS will be substituted with the string whose address is specified.

❷ FAODESC is a character string descriptor for the output buffer; $FAO will write the string into the buffer, and will write the length of the final formatted string in the low-order word of FAOLEN. (A longword is reserved so that it can be used for an input argument to the $OUTPUT macro.)

❸ FILESPEC is a character string descriptor defining an input string for the FAO directive !AS.

❹ The call to $FAO specifies the control string, the output buffer and length fields, and the parameter P1, which is the address of the string descriptor for the string to be substituted.

❺ When $FAO completes successfully, $OUTPUT writes the output string:

```
FILE DMA1:MYFILE.DAT DOES NOT EXIST
```

6.13 MAILBOXES

Mailboxes are virtual devices that can be used for communication between processes. Actual data transfer is accomplished by using RMS or I/O services. When the create Mailbox and Assign Channel ($CREMBX) service creates a mailbox, it also assigns a channel to it for use by the creating process. Other processes can then assign channels to the mailbox using either the $CREMBX or $ASSIGN system service. (If the mailbox is located in memory shared by multiple processors, the first process on each processor to create or assign a channel to a mailbox must use the $CREMBX service.)

The Create Mailbox and Assign Channel ($CREMBX) system service creates the mailbox. The $CREMBX system service identifies a mailbox by a user-specified logical name and assigns it an equivalence name. The equivalence name is a physical device name in the format MBn: where n is a unit number.

When another process assigns a channel to the mailbox with the $CREMBX or $ASSIGN system service, it can identify the mailbox by its logical name. The service automatically translates the logical name. The process can obtain the MBn: name by translating the logical name (with the $TRNLOG system service), or it can call the Get I/O Channel Information ($GETCHN) system service to obtain the unit number and the physical device name.

Mailboxes are either temporary or permanent. The user privileges TMPMBX and PRMMBX are required to create temporary and permanent mailboxes, respectively.

For a temporary mailbox, the $CREMBX service enters the logical name and equivalence name in the group logical name table of the process that created it. The system deletes a temporary mailbox when no more channels are assigned to it.

For a permanent mailbox, the $CREMBX service enters the logical name and equivalence name in the system logical name table. Permanent mailboxes continue to exist until they are specifically marked for deletion with the Delete Mailbox ($DELMBX) system service.

A mailbox located in memory shared by multiple processors is also deleted when all of the following occur:

- A processor is rebooted
- The multiport memory is not reinitialized
- No other processor has any processes with channels assigned to the mailbox.

Figure 6-5 shows an example of processes communicating by means of a mailbox. The accompanying notes explain some of the arguments that the $CREMBX system service requires.

Process ORION

```
MBLOGNAM:  .ASCID /GROUP100_MAILBOX/  ;DESCRIPTOR FOR MAILBOX LOG. NAME
MBUFFER:   .BLKB 128                  ;INPUT BUFFER FOR MAILBOX READS
MBUFLEN:   .LONG 128                  ;BUFFER LENGTH (128 BYTES)
MBXCHAN:   .BLKW 1                    ;MAILBOX CHANNEL NUMBER

MBXIOSB:   .BLKW 1                    ;IOSB FIRST WORD (STATUS)
MBLEN:     .BLKW 1                    ;IOSB 2ND WORD (LENGTH)
           .BLKL 1                    ;REMAINDER OF IOSB

OUTLEN:    .BLKL 1                    ;LONGWORD TO GET LENGTH

             .
             .
.ENTRY   ORION, ^M<R2,R3,R4>          ;ENTRY MASK
     (1) $CREMBX_S PRMFLG=#0,CHAN=MBXCHAN,MAXMSG=MBUFLEN-
             BUFQUO=#384,PROMSK=#^X0000,LOGNAM=MBLOGNAM
         BSBW  ERROR
     (2) $QIO_S  CHAN=MBXCHAN,FUNC=#IO$_READVBLK,IOSB=MBXIOSB,-
             ASTADR=MBXAST,P1=MBUFFER,P2=MBUFLEN
         BSBW  ERROR
           .
           .
         RET
MBXAST:  .WORD 0 (3)                  ;AST ROUTINE ENTRY MASK
         CMPW  MBXIOSB,#SS$_NORMAL  ;I/O SUCCESSFUL?
         BNEQ  ASTERR                 ;BRANCH IF NOT
         MOVZWL  MBLEN,OUTLEN         ;MAKE LENGTH A LONGWORD
         $OUTPUT ...,BUFFER=MBUFFER,LENGTH=OUTLEN,...
         BSBW  ERROR
           .
           .
         RET
```

Process CYGNUS

```
MAILBOX: .ASCID /GROUP100_MAILBOX/  ;DESCRIPTOR FOR MAILBOX LOG. NAME
MAILCHAN:                           ;MAILBOX CHANNEL NUMBER
         .BLKW 1
OUTBUF:  .BLKB 128                  ;BUFFER FOR OUTPUT MSG DATA
OUTLEN:  .BLKL 1                    ;WILL CONTAIN LENGTH OF MSG
           .
           .
.ENTRY   CYGNUS, ^M<R2,R3,R4>       ;ENTRY MASK
     (4) $ASSIGN_S DEVNAM=MAILBOX,CHAN=MAILCHAN ;ASSIGN CHANNEL
         BSBW  ERROR
         $OUTPUT CHAN=MAILCHAN,BUFFER=OUTBUF,LENGTH=OUTLEN,...
         BSBW  ERROR
           .
           .
         RET
```

Figure 6-5 Mailbox Creation and I/O

Notes on Figure 6-5:

❶ Process ORION creates the mailbox and receives the channel number at MBXCHAN.

This PRMFLG argument indicates that the mailbox is a temporary mailbox. The logical name is entered in the group logical name table.

The MAXMSG argument limits the size of messages that the mailbox can receive. Note that the size indicated in this example is the same size as the buffer (MBUFFER) provided for the $QIO request. A buffer for mailbox I/O must be at least as large as the size specified in the MAXMSG argument.

When a process creates a temporary mailbox, the amount of system memory that is allocated for buffering messages is subtracted from the process's buffer quota. Use the BUFQUO argument to specify how much of the process quota you want to be used for mailbox message buffering.

Mailboxes are protected devices. By specifying a protection mask with the PROMSK argument, you can restrict access to the mailbox. (In this example, all bits in the mask are clear, indicating unlimited read and write access.)

❷ After creating the mailbox, Process ORION issues a $QIO system service, requesting that it be notified when I/O completes (that is, when the mailbox receives a message) by means of an AST interrupt. The process can continue executing, but the AST service routine at MBXAST will interrupt and begin executing when a message has been received.

❸ When a message is sent to the mailbox (by CYGNUS), the AST is delivered and ORION responds to the message. ORION gets the length of the message from the first word of the I/O status block at MBXIOSB and places it in the longword OUTLEN so it can pass the length to $OUTPUT.

❹ Process CYGNUS assigns a channel to the mailbox, specifying the logical name the process ORION gave the mailbox. The $OUTPUT form of the $QIOW system service writes a message from the output buffer provided at OUTBUF.

Note that on a write operation to a mailbox, the I/O is not complete until the message is read, unless you specify the IO$M_NOW function modifier. Therefore, if $QIOW (without the IO$M_NOW function modifier) or $OUTPUT is used to write the message, the process will not continue executing until another process reads the message.

6.13.1 Mailbox Name Format

The logical name string assigned to a mailbox determines whether it is located in memory that is used by a single processor or in memory that is shared by multiple processors. The LOGNAM argument to the $CREMBX service specifies a descriptor that points to a character string with the following format:

```
[shared-memory-name:]mailbox-name
```

shared-memory-name

Locates the mailbox within the named memory that is shared by multiple processors. The name of this memory was specified at system generation time. For example, the string SHRMEM$1:CHKPNT identifies a mailbox named CHKPNT located in the shared memory named SHRMEM$1.

If this part of the string is not included, the mailbox is not located in memory that is shared by multiple processors.

mailbox-name

The name assigned to the mailbox (1 to 15 characters in length).

If you wish, you can include both the shared-memory-name and the mailbox-name for a mailbox in memory shared by multiple processors. However, if you want to use existing programs without recompiling or relinking, you can specify just a mailbox-name and have the system translate it to a complete specification. The system attempts to perform logical name translation of the string specified by the LOGNAM argument in the following manner:

1. MBX$ is prefixed to the string (to the part before the colon if both parts are present), and the result is subjected to logical name translation. If the translation does not succeed, the string (without the MBX$ prefix) is made a logical name with an equivalence name MBn: ("n" is a number assigned by the system).

2. The part of the string after the colon (if any) is appended to the translated name.

3. If the result contains a logical name, steps 1 and 2 are repeated (up to 9 more times, if necessary) until translation does not succeed.

For example, assume that you have made the following logical name assignment:

```
$ DEFINE MBX$CHKPNT SHRMEM$1:CHKPNT
```

Assume that your program also contains the following statements:

```
MBXDESC:  .ASCID  /CHKPNT/  ;DESCRIPTOR FOR MAILBOX LOGICAL NAME
                .
                .

          $CREMBX_$  LOGNAME=MBXDESC,...
```

The following logical name translation takes place:

1. MBX$ is prefixed to CHKPNT.

2. MBX$CHKPNT is translated to SHRMEM$1:CHKPNT.

Since no further translation is successful, the logical name CHKPNT is created with the equivalence name MBn: ("n" is a number assigned by the system).

There is one exception to the translation method described in this section. If the name string starts with an underscore (_), the VAX/VMS system strips the underscore and considers the resultant string to be the actual name (that is, no further translation is performed).

6.13.2 System Mailboxes

The system uses mailboxes for communication among system processes. All system mailbox messages contain, in the first word of the message, a constant that identifies the sender of the message. These constants have symbolic names (defined in the $MSGDEF macro) in the format:

```
MSG$_sender
```

The remainder of the message contains variable information, depending on the system component that is sending the message.

The format of the variable information for each message type is documented with the system function that uses the mailbox.

6.13.3 Mailboxes for Process Termination Messages

When a process creates another process, it can specify the unit number of a mailbox as an argument to the Create Process ($CREPRC) system service. When the created process is deleted, the system sends a message to the specified termination mailbox. An example of how to create and use a termination mailbox is provided in Section 7.7.2, "Termination Mailboxes."

A mailbox in memory shared by multiple processors cannot be used as a process termination mailbox.

6.13.4 Mailboxes for System Processes

Certain I/O services are used internally by system processes to communicate various kinds of information. These services are:

- Send Message to Accounting Manager ($SNDACC)
- Send Message to Operator ($SNDOPR)
- Send Message to Symbiont Manager ($SNDSMB)

Details on the formats of the messages and the information they provide are given in the individual discussions of these services in Part II.

CHAPTER 7

PROCESS CONTROL SERVICES

A process is the primary execution agent in VAX/VMS. When you log into the system, the system creates a process for the execution of program images. You can create another process to execute an image by issuing the RUN command using any of the special qualifiers that pertain to process creation. You can also code a program that creates another process to execute a particular image.

Process control services allow you to create processes and to control a process or group of processes. Included in this chapter are discussions of:

- Subprocesses and detached processes
- The execution context of a process
- Process creation
- Interprocess control and communication
- Process hibernation and suspension
- Image exit and exit handlers
- Process deletion and termination messages

7.1 SUBPROCESSES AND DETACHED PROCESSES

A process is either a subprocess or a detached process. A subprocess receives a portion of its creator's resource quotas and must terminate before the creator. A detached process is fully independent; for example, the process the system creates for you when you log in is a detached process.

The Create Process ($CREPRC) system service creates both subprocesses and detached processes. The ability to create subprocesses is controlled by the PRCLM quota. The ability to create detached processes is controlled by the DETACH privilege.

7.2 THE EXECUTION CONTEXT OF A PROCESS

The execution context of a process defines a process to the system. It includes:

- The image that the process is executing
- The input and output streams for the image executing in a process
- Disk and directory defaults for the process
- System resource quotas and user privileges available to a process

When the system creates a detached process as the result of a login, it uses the system authorization file to determine the process's execution context.

For example, when you log into the system:

- The process created for you executes the image known as LOGINOUT.
- The terminal you are using is established as the input, output, and error stream for images that the process executes.
- Your disk and directory defaults are taken from the user authorization file.
- The resource quotas and privileges you have been granted by the system manager are associated with the created process.

When you code the $CREPRC system service to create a process, you define the context by specifying arguments to the service.

7.3 PROCESS CREATION

The following subsections (7.3.1 to 7.3.5) show examples of process creation and describe how the arguments you code to the $CREPRC system service define the context of the process.

7.3.1 Defining an Image for a Subprocess to Execute

When you code the $CREPRC system service, use the IMAGE argument to provide the process with the name of an image (program) to execute. For example, the following lines create a subprocess to execute the image named LIBRA.EXE.

```
PROGNAME: .ASCID /LIBRA/              ;DESCRIPTOR FOR IMAGE TO EXECUTE
          .
          .
          .
          $CREPRC_S IMAGE=PROGNAME    ;CREATE PROCESS TO EXECUTE LIBRA
```

In this example, only a file name is specified; the service uses current disk and directory defaults, performs logical name translation, uses the default file type of EXE, and locates the most recent version of the image file. When the subprocess completes execution of the image, the subprocess is deleted. Process deletion is described in Section 7.7.

7.3.2 Input, Output, and Error Devices for Subprocesses

When you code the $CREPRC system service you can provide equivalence names for the logical names SYS$INPUT, SYS$OUTPUT, and SYS$ERROR. These logical name/equivalence name pairs are placed in the process logical name table for the created process.

Figure 7-1 shows an example of defining input, output, and error devices for a subprocess. The notes indicate how these devices are used.

```
INSTREAM:   .ASCID /SUB_MAIL_BOX/       ;DESCRIPTOR FOR INPUT STREAM
OUTSTREAM:  .ASCID /COMPUTE_OUT/        ;DESCRIPTOR FOR OUTPUT STREAM
PROGNAME:   .ASCID /COMPUTE.EXE/        ;DESCRIPTOR FOR IMAGE NAME

        .
        .
                                  (1)
$CREPRC_S IMAGE=PROGNAME,INPUT=INSTREAM, - ;CREATE PROCESS
          OUTPUT=OUTSTREAM,ERROR=OUTSTREAM
                (2)                (3)
```

Figure 7-1 Defining Input and Output Streams for a Subprocess

Notes on Figure 7-1:

(1) The INPUT argument equates the equivalence name SUB_MAIL_BOX to the logical name SYS$INPUT. This logical name may represent a mailbox that the calling process previously created with the Create Mailbox and Assign Channel ($CREMBX) system service. Any input the subprocess reads from the logical device SYS$INPUT will be read from the mailbox.

(2) The OUTPUT argument equates the equivalence name COMPUTE_OUT to the logical name SYS$OUTPUT. All messages the program writes to the logical device SYS$OUTPUT will be written to this file.

(3) The ERROR argument equates the equivalence name COMPUTE_OUT to the logical name SYS$ERROR. All system-generated error messages will be written into this file. Since this is the same file as that used for program output, the file effectively contains a complete record of all output produced during the execution of the program image.

The $CREPRC system service does not provide default equivalence names for the logical names SYS$INPUT, SYS$OUTPUT, and SYS$ERROR; if none are specified, entries in the group or system logical name tables, if any, may provide equivalences. If, while the subprocess executes, it reads or writes to one of these logical devices and no equivalence name exists, an error condition results.

In a program that creates a subprocess, you can cause the subprocess to share the input, output, or error devices of the creating process. The following steps are required:

- Use the Translate Logical Name ($TRNLOG) system service to obtain the current equivalence name for the logical name SYS$INPUT, SYS$OUTPUT, or SYS$ERROR.

- Check whether the equivalence name returned contains system header information (a 4-byte field beginning with an escape character); if the logical name table entry was created by the command interpreter, it will contain this header. If

there is a header, adjust the length of the string returned and the address of the string returned by modifying these fields in the character string descriptor of the resultant name string.

- Specify the address of this descriptor when you code the INPUT, OUTPUT, or ERROR arguments to the $CREPRC system service.

This procedure is illustrated in the following example.

```
NDESC:                                  ;DESCRIPTOR FOR RESULT
NLEN:   .LONG   63                      ;LENGTH OF STRING RETURNED
NADDR:  .LONG   NAME                    ;ADDRESS OF STRING
NAME:   .BLKB   63                      ;DEVICE NAME STRING RETURNED

INPUT:  .ASCID /SYS$INPUT/              ;LOGICAL DEVICE NAME DESCRIPTOR
          .
          .
          .
        $TRNLOG_S LOGNAM=INPUT,RSLLEN=NLEN,RSLBUF=NDESC
        BSBW    ERROR                   ;BRANCH IF ERROR
        CMPB    NAME,#^X1B              ;FIRST BYTE AN ESCAPE?
        BNEQ    10$                     ;NO, DON'T ADJUST
        SUBL    #4,NLEN                 ;SUBTRACT 4 FROM LENGTH
        ADDL    #4,NADDR                ;ADD 4 TO ADDRESS
10$:    $CREPRC_S ...,INPUT=NDESC,OUTPUT=NDESC,...
```

When the subprocess executes, the logical names SYS$INPUT and SYS$OUTPUT are equated to the device name of the creating process's logical input device.

The subprocess can then use RMS to open the file for reading and/or writing; or the subprocess can use the Assign I/O Channel ($ASSIGN) system service to assign an I/O channel to this device for input/output operations by specifying the device name as the logical name SYS$OUTPUT. For example:

```
OUTPUT: .ASCID /SYS$OUTPUT/             ;LOGICAL NAME DESCRIPTOR
OUTCHAN: .BLKW  1                       ;CHANNEL NUMBER OF OUTPUT DEVICE
          .
          .
          .
        $ASSIGN_S DEVNAM=OUTPUT,CHAN=OUTCHAN
```

Logical name translation is described in more detail in Chapter 5, "Logical Name Services." For more information on channel assignment for I/O operations, see Chapter 6, "Input/Output Services."

7.3.3 Disk and Directory Defaults for Created Processes

When you use the $CREPRC system service to create a process to execute an image, the system locates the image file within the context of the created process. A subprocess inherits the current default device and directory of its creator. A detached process uses the default device and directory specified for its creator in the system user authorization file.

If a created process runs an image that is not in its default directory, you must identify the directory and perhaps also the device in the file specification of the image to be run. Similarly, if a created process uses an input, output, or error stream that is not its

current default (SYS$INPUT, SYS$OUTPUT, or SYS$ERROR), you must provide a sufficiently complete file specification.

There is no way to define an alternative default device and/or directory at process creation. The created process can, however, define an equivalence for the logical device SYS$DISK by calling the Create Logical Name ($CRELOG) system service. If the process is a subprocess, you can define an equivalence name in the group logical name table. The created process can also set its own default directory by calling the RMS Default Directory control routine. For details on how to call this routine, see the VAX-11 Record Management Services Reference Manual.

7.3.4 Controlling Resources of Created Processes

Ordinarily, when you create a subprocess you need only assign it an image to execute and, optionally, SYS$INPUT, SYS$OUTPUT, and SYS$ERROR devices. The system provides default values for the process's privileges, resource quotas, execution modes, and priority. In some cases, however, you may want to specifically define these values. The arguments to the $CREPRC system service that control these characteristics are listed below, with considerations for their use. For details, see the argument descriptions of $CREPRC in Part II.

- PRVADR - this argument defines the privilege list for the created process. Normally, a subprocess will have its creator's current privileges, and a detached process will have the privileges specified for its creator in the system user authorization file. In some circumstances, you may need to create a process that has a special privilege, but you must have the user privilege SETPRV to provide a subprocess with a privilege you do not have.

  Symbols associated with privileges are defined by the $PRVDEF macro. Each symbol begins with PRV$V_ and identifies the bit number that must be set to specify a given privilege. The following example shows the data definition for a mask specifying the GRPNAM and GROUP privileges.

```
PRVMSK: .LONG   <1@PRV$V_GRPNAM>!<1@PRV$V_GROUP> ;GRPNAM AND GROUP
                .LONG   0               ;QUADWORD MASK REQUIRED.  NO BITS SET IN
                                        ;HIGH-ORDER LONGWORD FOR THESE PRIVILEGES.
```

- QUOTA - this argument defines the quota list for a subprocess Since a subprocess receives a portion of its creator's quotas for timer queue entries, I/O buffers, and so on, you may want to control how much of each quota you want assigned to the subprocess. If you do not code this argument, the system defines default quotas for the subprocess; however, if your process has only the default quotas, you must code this argument to prevent the subprocess from exhausting all the process's deductible quotas.

- STSFLG - the status flag is a set of bits that control some execution characteristics of the created process, including resource wait mode and process swap mode.

- BASPRI - this argument sets the base execution priority for the created process. If not specified, it defaults to 2 for VAX-11 MACRO and VAX-11 BLISS-32 and 0 for other languages. If you want a subprocess to have a higher priority than its creator, you must have the user privilege ALTPRI to raise the priority level.

7.3.5 Detached Processes

The creation of a detached process is primarily a system function; the DETACH privilege controls the ability to create a detached process. The UIC argument to the $CREPRC system service defines whether a process is a subprocess or a detached process; it provides the created process with a user identification code (UIC). If you omit the UIC argument, the $CREPRC system service creates a subprocess that executes with your UIC.

7.4 INTERPROCESS CONTROL AND COMMUNICATION

Processes can be wholly independent, or they can be cooperative. You may develop an application that requires the concurrent execution of many programs. The following subsections discuss the things you might consider when you develop such applications.

7.4.1 Restrictions on Process Creation and Control

There are three levels of process control privilege:

1. The creator of a subprocess can always issue control functions for that subprocess.

2. The GROUP privilege is required to issue process control functions for other processes executing in the same group.

3. The WORLD privilege is required to issue process control functions for any process in the system.

Additional privileges are required to perform some specific functions, for example, to set a process's base priority to a higher level than that of the requestor.

7.4.2 Process Identification

In the examples shown in the preceding sections, the subprocesses are not identified. Once created, the subprocesses execute according to the image name or the input stream specified and are deleted when they complete execution.

However, if you want to control the execution of a subprocess, you must identify it. You must also identify detached processes that execute in the same group if they communicate with each other or issue control functions affecting each other.

There are two levels of process identification:

1. Process identification number (PID). The system assigns this unique 32-bit number to a process when it is created. If you provide the PIDADR argument to the $CREPRC system service, the system returns the process identification number at the location specified. You can then use the process identification number in subsequent process control services.

2. Process name. A process name is a 1- through 15-character text name string. Each process name must be unique within its group (processes in different groups can have the same name). You can assign a name to a process by coding the PRCNAM argument when you create it. You can then use this name to refer to the process in other system service calls.

For example, you might code a $CREPRC system service as follows:

```
ORION:  .ASCID /ORION/          ;DESCRIPTOR FOR PROCESS NAME
ORIONID:
        .LONG   0               ;PROCESS ID RETURNED
          .
          .
          .
        $CREPRC_S PRCNAM=ORION,PIDADR=ORIONID,...
```

The service returns the process identification in the longword at ORIONID. You can now use either the process name (ORION) or the process identification (ORIONID) to refer to this process in other system service calls.

A process can set or change its own name with the Set Process Name ($SETPRN) system service. For example, a process can set its name to CYGNUS as follows:

```
CYGNUS: .ASCID /CYGNUS/         ;DESCRIPTOR FOR PROCESS NAME
          .
          .
          .
        $SETPRN_S PRCNAM=CYGNUS
```

Most of the process control services accept either the PRCNAM or PIDADR arguments, or both. However, you are encouraged to identify a process by its process identification for the following reasons:

- The service executes faster because it does not have to search a table of process names.
- You must use the process identification for a process not in your group (see Section 7.4.2.1).

When the PIDADR argument is coded and the specified address contains a 0, the services return the process identification. Thus, you can obtain the process identification for a process by issuing any control function, as long as you know the process name.

If neither argument is specified, the service is performed for the calling process. For a summary of the possible combinations of these arguments and an explanation of how the services interpret them, see Table 7-1.

Table 7-1
Process Identification

Is A Process Name Specified?	Is A Process ID Address Specified?	Process ID Address Contains:	Resultant Action by Services
no	no	--	The process identification of the calling process is used. The process identification is not returned.
no	yes	zero	The process identification of the calling process is used and returned.
no	yes	process id	The process identification is used and returned.
yes	no	--	The process name is used. The process identification is not returned.
yes	yes	zero	The process name is used and the process identification is returned.
yes	yes	process id	The process identification is used and returned.

7.4.2.1 **Process Naming within Groups:** Process names are always qualified by their group number. The system maintains a table of all process names; and when a PRCNAM argument is specified in a process control service, the service searches for the process name specified and for a match on the group number. This search fails if the specified process name does not have the same group number. The search fails even if the calling process has world control privilege. To execute a process control service for a process that is not in the caller's group, the requesting process must use a process identification.

7.4.2.2 **Obtaining Information about Processes:** The Get Job/Process Information ($GETJPI) system service allows a process to obtain information about itself or another process. For complete details about the $GETJPI system service, see the service description in Part II.

7.4.2.3 **Techniques for Interprocess Communication:** There are several ways that processes can communicate:

- Common event flag clusters
- Logical name tables
- Mailboxes
- Global sections

Common Event Flag Clusters: Processes executing within the same group can use common event flag clusters to signal the occurrence or completion of particular activities. For details on event flags, event flag clusters, and an example of cooperating processes in the same group using a common event flag, see Chapter 3, "Event Flag Services."

Logical Name Tables: Processes executing in the same group can use the group logical name table to provide member processes with equivalence names for logical names. At least one member of the group must have the user privilege to place names in the group logical name table. For details on logical names and logical name tables, see Chapter 5, "Logical Name Services."

Mailboxes: Mailboxes can be used as virtual input/output devices to pass information, messages, or data among processes. For details on how to create and use mailboxes, with an example of cooperating processes using a mailbox, see Chapter 6, "Input/Output Services." Mailboxes may also be used to provide a creating process with a way to determine when and under what condition a created subprocess was deleted. See Section 7.7.2 for an example of a termination mailbox.

Global Sections: Global sections are disk files containing shareable code or data. Through the use of memory management services, these files can be mapped to the virtual address space of more than one process. In the case of a data file, cooperating processes can synchronize reading and writing the data in physical memory; as the data is updated, system paging results in the updated data being written directly back into the disk file. Global sections are described in more detail in Section 10.6, "Sections."

7.5 PROCESS HIBERNATION AND SUSPENSION

There are two ways to temporarily halt the execution of a process: hibernation, performed by the Hibernate ($HIBER) system service, and suspension, performed by the Suspend Process ($SUSPND) system service. The process can continue execution normally only after a corresponding Wake ($WAKE) system service if it is hibernating, or after a Resume Process ($RESUME) system service if it is suspended.

Process hibernation and suspension are compared in Table 7-2.

Table 7-2
Process Hibernation and Suspension

Hibernation	Suspension
Can only cause self to hibernate	Can suspend self or another process, depending on privilege
Reversed by $WAKE system service	Reversed by $RESUME system service
Interruptible; can receive ASTs	Noninterruptible; cannot receive ASTs
Can wake self	Cannot cause self to resume
Can schedule wakeup at an absolute time or at a fixed time interval	Cannot schedule resumption
Hibernate/wake complete quickly; require little system overhead	Resumption takes longer; $SUSPEND requires system dynamic memory

7.5.1 Process Hibernation

The hibernate/wake mechanism provides an efficient way to prepare an image for execution and then place it in a wait state until it is needed. When the wake request is issued, the image is reactivated with little delay or system overhead.

For example, if you create a subprocess that must execute the same function repeatedly and must execute immediately when it is needed, you could use the $HIBER and $WAKE system services as shown in Figure 7-2.

There is a variation of the $WAKE system service that schedules a wakeup for a hibernating process at a fixed time or at an elapsed (delta) time interval. This is the Schedule Wakeup ($SCHDWK) system service. Using the $SCHDWK service, a process can schedule a wakeup for itself before issuing a $HIBER call. For an example of how to use the $SCHDWK system service, see Chapter 8, "Timer and Time Conversion Services."

```
Process GEMINI

ORION: .ASCID /ORION/                    ;DESCRIPTOR FOR SUBPROCESS NAME
FASTCOMP: .ASCID /COMPUTE.EXE/           ;DESCRIPTOR FOR IMAGE NAME
          .
          .
      (1) $CREPRC_S PRCNAM=ORION,IMAGE=FASTCOMP,... ;CREATE ORION
          BSBW    ERROR                   ;CONTINUE
            .
            .
      (3) $WAKE_S PRCNAM=ORION            ;WAKE ORION
          BSBW    ERROR
            .
            .
          $WAKE_S PRCNAM=ORION            ;WAKE ORION AGAIN
          BSBW    ERROR
            .
            .

Process ORION

COMPUTE:: (2)
          .WORD   0                       ;ENTRY MASK
10$:      $HIBER_S                        ;SLEEP

          BSBW    ERROR
            .                             ;PERFORM...
            .
          BRW     10$                     ;BACK TO SLEEP
```

Figure 7-2 Process Hibernation

Notes on Figure 7-2:

(1) Process GEMINI creates the process ORION, specifying the descriptor for the image named COMPUTE.

(2) The image COMPUTE is initialized, and ORION issues the $HIBER system service.

(3) At an appropriate time, GEMINI issues a $WAKE request for ORION. ORION continues execution following the $HIBER service call. When it finishes its job, ORION loops back to repeat the $HIBER call and to wait for another wakeup.

Hibernating processes can be interrupted by Asynchronous System Traps (ASTs), as long as AST delivery is enabled. The process can issue a $WAKE for itself in the AST service routine, and continue execution following the execution of the AST service routine. For a description of ASTs, and how to use them, see Chapter 4, "AST (Asynchronous System Trap) Services."

7.5.2 Alternate Methods of Hibernation

Two additional techniques you can use to cause a process to hibernate are:

- Code the STSFLG argument for the $CREPRC system service, setting the bit that requests $CREPRC to place the created process in a state of hibernation as soon as it is initialized.
- Specify the /DELAY, /SCHEDULE, or /INTERVAL qualifiers of the RUN command when you execute the image from the command stream.

When you use the first method, the creating process can control when to wake the created process. When you use the RUN command, the qualifiers listed above control when the process will be awakened.

If the image to be executed does not itself call the $HIBER system service, the image is placed in a state of hibernation whenever it issues a RET instruction. Each time it is reawakened, it begins executing at its entry point. If the image does call $HIBER, then it begins executing at either the point following the call to $HIBER or at its entry point (if it issues a RET instruction) each time it is awakened.

If wakeup requests are scheduled at time intervals, the image can be terminated with the Delete Process ($DELPRC) or Force Exit ($FORCEX) system services, or from the command level with the STOP command. The $DELPRC and $FORCEX system services are described later in this chapter. The RUN and STOP commands are described in the VAX/VMS Command Language User's Guide.

These techniques allow you to code programs that can be executed a single time, on request, or cyclically, depending on a particular set of circumstances. Note that the program must ensure the integrity of data areas that are modified during its execution, as well as the status of opened files.

7.5.3 Suspension

Using the Suspend Process ($SUSPND) system service, a process can place itself or another process into a wait state similar to hibernation. Suspension, however, is a more pronounced state of hibernation. A suspended process cannot be interrupted by ASTs, and can resume execution only after another process issues a Resume Process ($RESUME) system service for it. If ASTs were queued for the process while it was suspended, they are delivered when the process resumes execution.

7.6 IMAGE EXIT

When the image executing in a process completes normally, the operating system performs a variety of image rundown functions. If the image was executed by the command interpreter, image rundown prepares the process for the execution of another image. If the image was not executed by the command interpreter -- for example, if it was executed by a subprocess -- the rundown readies the process for deletion.

These exit activities are also initiated when an image completes abnormally, as a result of any of the following:

- Specific error conditions caused by improper specifications when a process was created. For example, if an invalid device name is specified for SYS$INPUT, SYS$OUTPUT, or SYS$ERROR logical names, or if an invalid or nonexistent image name is specified, the error condition is noted within the context of the created process.

- An exception occurring during execution of the image. When an exception occurs, any user-specified condition handlers receive control to handle the exception. If not, a system-declared condition handler receives control, and it initiates exit activities for the image. Condition-handling is described in Chapter 9, "Condition-Handling Services."

- A Force Exit ($FORCEX) system service issued on behalf of the process by another process.

7.6.1 Image Rundown Activities

The operating system performs image rundown functions that release system resources that a process obtained while executing in user mode. These activities are listed below.

- Exit handlers declared from user mode, if any, are called, and the exit control blocks are released. (Exit handlers are described in Section 7.6.3.)

- Common event flag clusters are disassociated.

- User mode ASTs that are queued but have not been delivered are deleted, and ASTs are enabled for user mode.

- I/O channels are deassigned and any outstanding I/O requests on the channels are canceled.

- Any interrupt vectors connected with the image are disconnected.

- All devices allocated to the process at user mode are deallocated (devices allocated from the command stream in supervisor mode are not deallocated).

- Timer-scheduled requests, including wakeup requests, are canceled.

- Logical names in the process logical name table entered in user mode are deleted (logical names entered from the command stream in supervisor mode are not deleted).

- Exception vectors declared in user mode, compatibility mode handlers, and change mode to user handlers are reset.

- System service failure exception mode is disabled.

- Memory pages occupied by the image are deleted and the process's working set size limit is readjusted to its default value.

7.6.2 The $EXIT System Service

To initiate the rundown activities described above, the system calls the Exit ($EXIT) system service on behalf of the process. In some cases, a process can call $EXIT to terminate the image itself, for example, if an unrecoverable error occurs.

The $EXIT system service accepts a status code as an argument. If you use $EXIT to terminate image execution, you can use this status code argument to pass information about the completion of the image. If an image does not call $EXIT, the current value in R0 is passed as the status code when the system calls $EXIT.

This status code is used as follows:

- The command interpreter uses the status code to display an error message when it receives control following image rundown.
- If the image has declared an exit handler, the status code is written in the address specified in the exit control block.
- If the process was created by another process, and the creator has specified a mailbox to receive a termination message, the status code is written in the termination message when the process is deleted.

The use of exit handlers and termination messages requires additional coding considerations. These considerations are discussed in greater detail below.

7.6.3 Exit Handlers

Exit handlers are routines that can perform image-specific cleanup or rundown operations. For example, if an image uses system memory to buffer data, an exit handler can ensure that the data is not lost when the image exits as the result of an error condition.

To establish an exit handling routine, you must set up an exit control block and specify the address of the control block on the Declare Exit Handler ($DCLEXH) system service. Exit handlers are called using standard calling conventions; you can provide arguments to the exit handler in the exit control block. The first argument in the control block argument list must specify the address of a longword for the system to write the status code from $EXIT.

If an image declares more than one exit handler, the control blocks are linked together on a last-in, first-out basis. After an exit handler has been called and returns control, the control block is removed from the list. Exit control blocks can also be removed prior to image exit with the Cancel Exit Handler ($CANEXH) system service.

Exit handlers can also be declared from system routines executing in supervisor or executive modes. These exit handlers are also linked together, and receive control after exit handlers declared from user mode have been executed.

Figure 7-3 shows an example of an exit handling routine.

```
EXITBLOCK: (1)                                  ;EXIT CONTROL BLOCK
        .LONG     0                             ;SYSTEM USES THIS FOR POINTER
        .ADDRESS  EXITRTN                       ;ADDRESS OF EXIT HANDLER
        .LONG     1                             ;NUMBER OF ARGS FOR HANDLER
        .ADDRESS  STATUS                        ;ADDRESS TO RECEIVE STATUS CODE
STATUS: .BLKL     1                             ;STATUS CODE FROM $EXIT
          .
          .
.ENTRY  PEGASUS, ^M<R2,R3>                      ;ENTRY MASK FOR PEGASUS
        $DCLEXH_S DESBLK=EXITBLOCK (2)          ;DECLARE EXIT HANDLER
        BSBW      ERROR
          .
          .
        RET                                     ;END OF MAIN ROUTINE
EXITRTN:                                        ;EXIT HANDLER
     (3) .WORD    ^M<R2>                        ;ENTRY MASK
        CMPL      STATUS,#SS$_NORMAL            ;NORMAL EXIT?
        BEQL      10$                           ;YES, FINISH
          .                                     ;NO, CLEAN UP
          .
10$:    RET                                     ;FINISHED
```

Figure 7-3 Example of an Exit Handler

Notes on Figure 7-3:

(1) EXITBLOCK is the exit control block for the exit handler EXITRTN. The third longword indicates the number of arguments to be passed. In this example, only one argument is passed, the address of a longword for the system to store the return status code. This argument must be provided in an exit control block.

(2) The $DCLEXH system service call designates the address of the exit control block, thus declaring EXITRTN as an exit handler.

(3) EXITRTN checks the status code. If this is a normal exit, EXITRTN returns control. Otherwise, it handles the error condition.

7.6.4 Forced Exit

The Force Exit ($FORCEX) system service provides a way for a process to initiate image rundown for another process. For example, the following call to $FORCEX causes the image executing in the process CYGNUS to exit:

```
CYGNUS:   .ASCID  /CYGNUS/          ;PROCESS NAME DESCRIPTOR
            .
            .
            .
          $FORCEX_S PRCNAM=CYGNUS
```

The $FORCEX system service uses the AST mechanism to cause the image to exit. If the process CYGNUS has disabled AST delivery, the image cannot be forced to exit until CYGNUS reenables the delivery of ASTs. AST delivery, and how it is disabled and reenabled, is described in Chapter 4.

7.7 PROCESS DELETION

Process deletion completely removes a process from the system. Deletion occurs as a result of any of the following conditions:

- The command stream contains a LOGOUT command or an end-of-file.
- An image specified by $CREPRC exits.
- A process issues a STOP command or executes an image that calls the Delete Process ($DELPRC) system service.

When the system is called to delete a process as a result of any of the above conditions, it first locates all subprocesses, searching hierarchically. Then, beginning with the lowest process in the hierarchy and completing with the topmost process, each of the following procedures is performed:

- The image executing in the process is run down. System resources are released and, if this is a subprocess, quotas are returned to the creator of the process. The image rundown that occurs during process deletion is the same as that described in Section 7.6.1. When a process is deleted, however, the rundown releases all system resources, including those acquired from access modes other than user mode.
- Resource quotas are released to the creating process, if the process being deleted is a subprocess.
- If the creating process specified a termination mailbox, a message indicating that the process is being deleted is sent to the mailbox. For detached processes created by the system, the termination message is sent to the system job controller.
- The control region of the process's virtual address space is deleted. (The control region consists of memory allocated and used by the system on behalf of the process.)
- All system-maintained information about the process is deleted.

Figure 7-4 illustrates the flow of events from image exit through process deletion.

7.7.1 The Delete Process System Service

A process can delete itself or another process at any time, depending on the restrictions outlined in Section 7.4.1. The Delete Process ($DELPRC) system service deletes a process. For example, if a process has created a subprocess named CYGNUS, it can delete CYGNUS as shown below:

```
CYGNUS: .ASCID /CYGNUS/ ;DESCRIPTOR FOR PROCESS NAME
          .
          .
          .
        $DELPRC_S PRCNAM=CYGNUS
```

Since a subprocess is automatically deleted when the image it is executing terminates (or when the command stream for the command interpreter reaches end-of-file), you do not normally need to issue the $DELPRC system service explicitly.

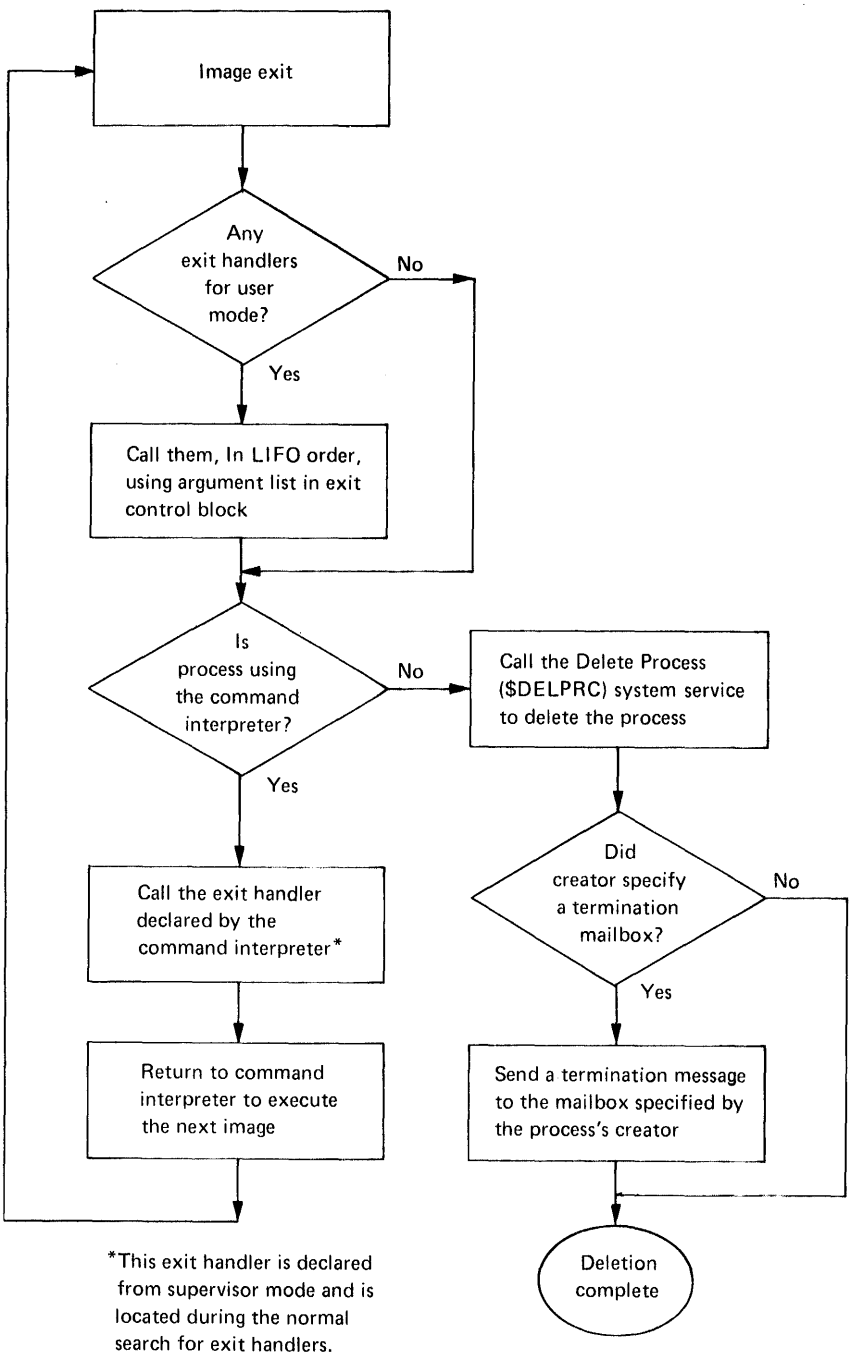


Figure 7-4 Image Exit and Process Deletion

As an alternative to deleting a process, you can use the Force Exit ($FORCEX) system service to force the exit of the image executing in a process. If the $FORCEX system service is used, any exit handlers that are declared for the image are executed during the image rundown. Thus, if the process is using the command interpreter, it is not deleted, but can run another image. Moreover, since the $FORCEX system service uses the AST mechanism, the exit cannot be performed if the process being forced to exit has disabled the delivery of ASTs.

7.7.2 Termination Mailboxes

A termination mailbox provides a process with a way of determining when, and under what conditions, a process that it has created is being deleted. The Create Process ($CREPRC) system service accepts the unit number of a mailbox as an argument. When the created process is deleted, the mailbox receives a termination message.

The first word of the termination message contains the symbolic constant, MSG$_DELPROC, which indicates that it is a termination message. The remainder of the message contains system accounting information used by the job controller, and is in fact identical to the first part of the accounting record sent to the system accounting log file. The complete format of the termination message is provided with the description of the $CREPRC system service in Part II.

The creating process can, if necessary, determine the process identification of the process being deleted from the I/O status block posted when the message is received in the mailbox. The second longword of the IOSB contains the process identification of the process that is being deleted.

A termination mailbox cannot be located in memory shared by multiple processors.

Figure 7-5 illustrates a complete sequence of process creation, with a termination mailbox. The Create Mailbox and Assign Channel ($CREMBX) and Queue I/O Request ($QIO) system services are described in greater detail in Chapter 6, "Input/Output Services."

```
EXCHAN:
        .BLKW   1                       ;TO HOLD CHANNEL NO. OF MAILBOX
EXITBUF:                                ;DESCRIPTOR FOR MAILBOX INFO
        .LONG   DIB$K_LENGTH            ;LENGTH OF BUFFER (SEE $GETCHN EXPLANATION)
        .LONG   BBUF                    ;ADDRESS OF BUFFER
BBUF:   .BLKB   DIB$K_LENGTH            ;BUFFER

EXITMSG:.BLKB   ACC$K_TERMLEN           ;BUFFER FOR MAILBOX MESSAGE
                                        ;(SEE $SNDACC EXPLANATION FOR ACC$K_TERMLEN)
MBXIOSB:.BLKW   1                       ;QUADWORD I/O STATUS BLOCK
MBLEN:  .BLKW   1                       ;LENGTH OF I/O
MBPID:  .BLKL   1                       ;RECEIVES PID OF PROCESS DELETED
LYRAPID:
        .LONG   0                       ;GET PID OF SUBPROCESS
LYREXE: .ASCID /LYRA.EXE/               ;NAME OF IMAGE FOR SUBPROCESS
          .
          .
          .
      1 $CREMBX_S CHAN=EXCHAN,MAXMSG=#120,PROMSK=#0,BUFQUO=#240
                                        ;CREATE MAILBOX
        BSBW    ERROR
      2 $GETCHN_S CHAN=EXCHAN,PRIBUF=EXITBUF
                                        ;GET MAILBOX INFO
        BSBW    ERROR
      3 $CREPRC_S IMAGE=LYREXE,PIDADR=LYRAPID, -
                  ,,,,-                 ;CREATE SUBPROCESS
                  MBXUNT=BBUF+DIB$W_UNIT ;SPECIFY TERMINATION MAILBOX
        BSBW    ERROR
      4 $QIO_S  CHAN=EXCHAN,FUNC=#IO$_READVBLK, -
                                        ;QIO (READ) TO MAILBOX
                  ASTADR=EXITAST,IOSB=MBXIOSB,P1=EXITMSG,P2=#ACC$K_TERMLEN
        BSBW    ERROR
          .                             ;CONTINUE EXECUTION
          .
          .
        RET
EXITAST:                                ;AST ROUTINE FOR TERMINATION MSG
      5 .WORD   0                       ;ENTRY MASK
        CMPW    MBXIOSB,#SS$_NORMAL ;I/O SUCCESSFUL?
        BNEQ    20$                     ;BRANCH IF NOT
        CMPW    EXITMSG+ACC$W_MSGTYP,#MSG$_DELPROC ;IS IT A TERMINATION MSG?
        BNEQ    20$                     ;NO, SOMETHING ELSE
        CMPL    LYRAPID,MBPID           ;IS IT LYRA?
        BNEQ    20$                     ;NO, SOMEBODY ELSE
        CMPL    EXITMSG+ACC$L_FINALSTS,#SS$_NORMAL ;DELETED NORMALLY?
        BEQL    10$                     ;YES, RETURN
          .                             ;NO, RESPOND TO ERROR IN LYRA
          .
          .
10$:    RET                             ;AST ROUTINE FINISHED
20$:      .                             ;HANDLE ALL OTHER CONDITIONS
          .
          .
```

Figure 7-5 Using a Termination Mailbox

Notes on Figure 7-5:

❶ The Create Mailbox and Assign Channel ($CREMBX) system service creates the mailbox, and returns the channel number at EXCHAN. Note that the maximum message size for a termination mailbox must be at least 84 (in this example it is 120).

❷ The Get I/O Channel Information ($GETCHN) system service returns information about the mailbox. The information returned in the buffer can be referred to by the symbolic offsets defined in the $DIBDEF macro. These symbolic offsets are listed under the explanation of the $GETCHN service in Part II.

❸ The Create Process ($CREPRC) system service creates a process to execute the image LYRA.EXE, and returns the process identification at LYRAPID. The MBXUNT argument refers to the unit number of the mailbox, obtained from the buffer BBUF by using the symbolic offset DIB$W_UNIT.

❹ The Queue I/O Request queues a read request to the mailbox, specifying an AST service routine to receive control when the mailbox receives a message and the address of a buffer to receive the message. The information in the message can be accessed by the symbolic offsets defined in the $ACCDEF macro. The process continues executing.

❺ When a message is received in the mailbox, the AST service routine, EXITAST, receives control. Since this mailbox can be used for other interprocess communication, the AST routine checks: 1) for successful completion of the I/O operation by examining the first word in the IOSB, 2) that the message received is a termination message by examining the message type field in the termination message at the offset ACC$W_MSGTYPE, 3) the process identification of the process that has been deleted by examining the second longword of the IOSB, and 4) the completion status of the process by examining the status field in the termination message at the offset ACC$L_FINALSTS.

In this example, the AST service routine performs special action when the subprocess is deleted. All other messages or error conditions cause a branch to the label 20$.

CHAPTER 8

TIMER AND TIME CONVERSION SERVICES

Many applications require the scheduling of program activities based on clock time. Under VAX/VMS, an image can schedule events for a specific time of day or after a specified time interval. Timer services can:

- Schedule the setting of an event flag or the queuing of an asynchronous system trap (AST) for the current process, or cancel a pending request that has not yet been honored
- Schedule a wakeup request for a hibernating process, or cancel a pending wakeup request that has not yet been honored
- Set or recalibrate the current system time, if the caller has the proper user privileges

The timer services require you to specify the time in a unique 64-bit format. To work with the time in different formats, you can use time conversion services to:

- Obtain the current date and time in an ASCII string or in system format
- Convert an ASCII string into the system time format
- Convert a system time value into an ASCII string
- Convert the time from system format to integer values

This chapter describes the system time format and the services that use it, with examples of scheduling program activities using the timer services.

8.1 THE SYSTEM TIME FORMAT

VAX/VMS maintains the current date and time (using a 24-hour clock) in 64-bit format. The time value is a binary number in 100-nanosecond units offset from the system base date and time, which is 00:00 o'clock, November 17, 1858 (the Smithsonian base date and time for the astronomical calendar). All time values passed to system services must also be in 64-bit format. A time value can be expressed as:

- An absolute time which is a specific date and time of day. Absolute times are always positive values.
- A delta time which is a future offset (number of hours, minutes, seconds, and so on) from the current time. Delta times are always expressed as negative values.

You can also specify the address of a time value as 0; in this case the system will always supply the current date and time by default.

8.2 THE CURRENT DATE AND TIME

The Convert Binary Time to ASCII String ($ASCTIM) system service converts a time in system format to an ASCII string and returns the string in a 23-byte buffer. If you want to obtain the current time in ASCII, code the $ASCTIM system service as follows:

```
ATIMENOW:                              ;DESCRIPTOR FOR ASCII TIME
        .LONG   23                     ;LENGTH OF BUFFER
        .LONG   ATIMENOW+8             ;ADDRESS OF BUFFER
        .BLKB   23                     ;23 BYTES RETURNED
          .
          .
          .
        $ASCTIM_S TIMBUF=ATIMENOW      ;GET CURRENT TIME
```

The string returned by the service has the format:

```
dd-mmm-yyyy hh:mm:ss.cc
```

where dd is the day of the month, mmm is the month (a 3-character alphabetic abbreviation), yyyy is the year, and hh:mm:ss.cc is the time in hours, minutes, seconds, and hundredths of seconds.

The current time can also be obtained in system format with the Get Time ($GETTIM) system service, which places the time in a quadword buffer. For example:

```
TIME:   .BLKQ   1                      ;BUFFER FOR TIME
          .
          .
          .
        $GETTIM_S TIMADR=TIME          ;GET TIME
```

This call to $GETTIM returns the current date and time in system format in the quadword buffer TIME.

8.3 OBTAINING AN ABSOLUTE TIME IN SYSTEM FORMAT

The converse of the $ASCTIM system service is the Convert ASCII String to Binary Time ($BINTIM) system service. You provide the service with the time in the ASCII format shown above, and the service converts the string to a time value in 64-bit format. You can then use this returned value as input to a timer scheduling service.

When you code the ASCII string buffer, you can omit any of the fields, and the service uses the current date or time value for the field. Thus, if you want a timer request to be date-independent, you could format the input buffer for the $BINTIM service as shown below. The two hyphens that are normally embedded in the date field must be included, and at least one blank must precede the time field.

```
ANOON:  .ASCID /-- 12:00:00.00/        ;DESCRIPTOR FOR ASCII 12 NOON
BNOON:  .BLKQ   1                      ;BUFFER FOR BINARY 12 NOON
          .
          .
          .
        $BINTIM_S TIMBUF=ANOON,TIMADR=BNOON ;CONVERT TIME
```

When the $BINTIM service completes, a 64-bit time value representing "noon today" is returned in the quadword at BNOON.

8.4 OBTAINING A DELTA TIME IN SYSTEM FORMAT

The $BINTIM system service also converts ASCII strings to delta time values to be used as input to timer services. The buffer for delta time ASCII strings has the format:

```
dddd hh:mm:ss.cc
```

The first field, indicating the number of days, must be specified as 0 if you are coding a "today" delta time.

The following example shows how to use the $BINTIM service to obtain a delta time in system format.

```
ATENMIN: .ASCID /0 00:10:00.00/      ;DESCRIPTOR FOR ASCII TEN MINUTES
BTENMIN: .BLKQ   1                   ;BUFFER FOR BINARY TEN MINUTES
          .
          .
          .
        $BINTIM_S TIMBUF=ATENMIN,TIMADR=BTENMIN ;CONVERT TIME
```

If you are a VAX-11 MACRO programmer, you can also specify approximate delta time values at assembly time, using two MACRO .LONG directives to represent a time value in terms of 100-nanosecond units. The arithmetic is based on the formula:

```
1 second = 10 million * 100 nanoseconds
```

For example, the following statement defines a delta time value of 5 seconds:

```
FIVESEC:  .LONG -10*1000*1000*5,-1 ;FIVE SECONDS
```

The value 10 million is expressed as 10*1000*1000 for readability. Note that the delta time value is negative.

If you use this notation, however, you are limited to the maximum number of 100-nanosecond units that can be expressed in a longword. In terms of time values, this is somewhat more than 7 minutes.

8.5 TIMER REQUESTS

Timer requests made with the Set Timer ($SETIMR) system service are queued, that is, they are ordered for processing according to their expiration times. The TQELM quota controls the number of entries a process can have pending in this timer queue.

When you code the $SETIMR system service, you can specify either an absolute time or a delta time value. Depending on how you want the request processed, you can specify either or both of the following:

- The number of an event flag to be set when the time expires. If you do not specify an event flag, the system sets event flag 0.
- The address of an AST service routine to be executed when the time expires.

Optionally, you can specify a request identification for the timer request. You can use this identification to cancel the request, if necessary. The request identification is passed to the AST service routine, if one is specified, as the AST parameter so that the AST service routine can identify the timer request.

Figure 8-1 shows examples of timer requests using event flags and ASTs. Event flags and event flag services are described in more detail in Chapter 3, "Event Flag Services." ASTs are described in more detail in Chapter 4, "AST (Asynchronous System Trap) Services."

Example 1: Setting an Event Flag

```
A30SEC: .ASCID  /0 00:00:30.00/ ;DESCRIPTOR FOR ASCII 30
                                ;   SECONDS, DELTA TIME
B30SEC: .BLKQ   1               ;QUADWORD TO HOLD CONVERTED
                                ;   (BINARY) DELTA TIME
          .
          .
          .
        $BINTIM_S  TIMBUF=A30SEC,TIMADR=B30SEC  ;CONVERT TO BINARY
        BSBW    ERROR
(1)     $SETIMR_S  EFN=#4,DAYTIM=B30SEC  ;SET TIME TO WAIT
        BSBW    ERROR
(2)     $WAITFR_S  EFN=#4                ;WAIT 30 SECONDS
        BSBW    ERROR
          .
          .
          .
```

Notes on Example 1:

(1) The call to $SETIMR requests that event flag 4 be set in 30 seconds (expressed in the quadword B30SEC).

(2) The Wait for Single Event Flag ($WAITFR) system service places the process in a wait state until the event flag is set. When the timer expires, the flag is set and the process continues execution.

Figure 8-1 Timer Requests

Example 2: Using an AST Service Routine

```
ANOON:  .ASCID  /-- 12:00:00.00/  ;DESCRIPTOR FOR ASCII 12 NOON
BNOON:  .BLKQ   1                 ;TO HOLD CONVERTED (BINARY) NOON
          .
          .
          .
      (1) $BINTIM_S  TIMBUF=ANOON,TIMADR=BNOON  ;CONVERT TO BINARY
        BSBW    ERROR
      (2) $SETIMR_S  DAYTIM=BNOON,ASTADR=ASTSERV,REQIDT=#12
                     ;SET TIMER FOR NOON, SPECIFY AST ROUTINE,
                     ;PASS REQUEST I.D. OF 12 AS AST PARAMETER.
        BSBW    ERROR
          .
          .
          .
        RET
ASTSERV:    (3)
        .WORD   0           ;ENTRY MASK FOR AST ROUTINE
        CMPL    #12,4(AP)   ;IS THIS A "NOON" AST REQUEST?
        BNEQ    10$         ;IF NOT, HANDLE OTHER TYPE(S)
          .                 ;HANDLE "NOON" AST REQUEST
          .
          .
        RET
10$:      .                 ;HANDLE OTHER TYPES OF REQUESTS
          .
          .
        RET
```

Notes on Example 2:

(1) The call to $BINTIM converts the ASCII string representing 12:00 noon to system format. The value returned in BNOON is used as input to the $SETIMR system service.

(2) The AST routine specified in the $SETIMR request will be called when the timer expires, that is, at 12:00 noon. The REQIDT argument identifies the timer request. (This argument is passed as the AST parameter and is stored at offset 4 in the argument list. See Section 4.4, "The AST Service Routine.") The process continues execution; when the timer expires, it is interrupted by the delivery of the AST. Note that if the current time of day is past noon, the timer expires immediately.

(3) This AST service routine checks the parameter passed by the REQIDT argument and checks, in this example, whether it must service the 12:00 noon timer request or another type of request (identified by a different REQIDT value). When the AST service routine completes, the process continues execution at the point of interruption.

Figure 8-1 (Cont.) Timer Requests

8.5.1 Canceling Timer Requests

Cancel Timer Request ($CANTIM) system service cancels timer requests that have not yet been processed. The entries are removed from the timer queue. Cancellation is based on the request identification given in the timer request. For example, to cancel the request illustrated in Example 2 of Figure 8-1, you would code:

```
$CANTIM_S REQIDT=#12
```

If you assign the same identification to more than one timer request, all requests with that identification are canceled. If you do not specify the REQIDT argument, all your requests are canceled.

8.6 SCHEDULED WAKEUPS

Example 1 in Figure 8-1 showed a process placing itself in a wait state for a period of time using the $SETIMR and $WAITFR services. Another way for a process to make itself inactive is by hibernating. A process hibernates by issuing the Hibernate ($HIBER) system service; hibernation is reversed by a wakeup request, which can be effected immediately with the $WAKE system service, or scheduled with the Schedule Wakeup ($SCHDWK) system service.

The following example shows a process scheduling a wakeup for itself prior to hibernating:

```
ATENSEC:.ASCID /0 00:00:10.00/  ;DESCRIPTOR FOR 10-SECOND WAIT TIME
BTENSEC:.BLKQ  1                 ;TO HOLD BINARY TEN-SECOND VALUE
          .
          .
          .
        $BINTIM_S TIMBUF=ATENSEC,TIMADR=BTENSEC ;CONVERT TIME
        $SCHDWK_S DAYTIM=BTENSEC                ;SCHEDULE WAKE
        $HIBER_S                                ;SLEEP TEN SECONDS
```

Hibernation and wakeup are described in more detail in Chapter 7, "Process Control Services." Note that a suitably privileged process can wake or schedule a wakeup for another process; thus, cooperating processes can synchronize activity using hibernation and scheduled wakeups. Moreover, when you code a $SCHDWK system service, you can specify that the wakeup request be repeated at fixed time intervals.

8.6.1 Canceling Scheduled Wakeups

Scheduled wakeup requests that are pending but have not yet been processed can be canceled with the Cancel Wakeup ($CANWAK) system service.

The following example shows the scheduling of wakeup requests for a process, CYGNUS, and the subsequent cancellation of the wakeups. The $SCHDWK system service in this example specifies a delta time of one minute and an interval time of one minute; the wakeup is repeated every minute until the requests are canceled.

```
CYGNUS:  .ASCID  /CYGNUS/          ;DESCRIPTOR FOR PROCESS NAME
ONE_MIN:.ASCID  /0 00:01:00.00/ ;DESCRIPTOR FOR 1 MIN (DELTA)
INTERVAL: .QUAD 1                  ;8 BYTES TO HOLD BINARY 1 MIN
            .
            .
            .
        $BINTIM_S  TIMBUF=ONE_MIN,TIMADR=INTERVAL ;CONVERT TO BINARY
            .
            .
            .
        $SCHDWK_S  PRCNAM=CYGNUS,DAYTIM=INTERVAL,REPTIM=INTERVAL
                               ;WAKE UP EVERY MINUTE
            .
            .
            .
        $CANWAK_S  PRCNAM=CYGNUS           ;CANCEL WAKE-UPS
            .
            .
            .
```

8.7 NUMERIC AND ASCII TIME

The Convert Binary Time to Numeric Time ($NUMTIM) system service converts a time in the system format into binary integer values. The service returns each of the components of the time (year, month, day, hour, and so on) into a separate word of a seven-word buffer. The $NUMTIM system service and the format of the information returned are described in Part II.

When you need the time formatted into ASCII for inclusion in an output string, you can use the $ASCTIM system service. The $ASCTIM service accepts as an argument the address of a quadword that contains the time in system format and returns the date and time in ASCII format.

If you want to include the date and time in a character string that contains additional data, you can format the output string with the Formatted ASCII Output ($FAO) system service. The $FAO system service converts binary values to ASCII representations, and substitutes the results in character strings according to directives supplied in an input control string. Among these directives are !%T and !%D, which convert a quadword time value to an ASCII string and substitute the result in an output string. For examples of how to do this, see the discussion of $FAO in Part II.

8.8 SETTING THE SYSTEM TIME

The Set System Time ($SETIME) service allows a user with the operator (OPER) and logical I/O (LOG_IO) privileges to set the current system time. You can specify a new system time (using the TIMADR argument), or you can recalibrate the current system time using the processor's hardware time-of-year clock (omitting the TIMADR argument). If you specify a time, it must be an absolute time value; a delta time (negative) value is invalid.

The system time is set whenever the system is booted. There is normally no need to change the system time between system boots; however, in certain circumstances you may wish to change the system time without rebooting. For example, you might specify a new system time to synchronize two processors, or to adjust for changes between standard time and daylight savings time. You might wish to

recalibrate the time to ensure that the system time matches the hardware clock time (the hardware clock is more accurate than the system clock).

The $SETIME service is called automatically by the SET TIME operator command.

Any change to the system time does not change the interval remaining for existing time requests. This is true for both absolute and delta time requests. The following example shows the effect of changing the system time on an existing timer request. In the example, a wakeup request scheduled for 08:30 is automatically changed to 09:30 when the system time is changed from 08:00 to 09:00.

```
WAKEUP: .ASCID  /-- 08:30:00.00/        ;8:30 TODAY
NEWTIM: .ASCID  /-- 09:00:00.00/        ;9 O'CLOCK TODAY
BINTIM: .BLKQ   1       ;TO HOLD CONVERTED BINARY TIMES
          .
          .
          .
; ASSUME CURRENT SYSTEM TIME IS 08:00:00
          .
          .
          .
        $BINTIM_S  TIMBUF=WAKEUP,-   ;CONVERT WAKEUP TIME TO BINARY
                   TIMADR=BINTIM
        BSBW       ERROR
        $SCHDWK_S  DAYTIM=BINTIM     ;SCHEDULE WAKEUP FOR 8:30
        BSBW       ERROR
        $BINTIM_S  TIMBUF=NEWTIM,-   ;CONVERT NEW SYSTEM TIME TO
                   TIMADR=BINTIM     ;    BINARY
        BSBW       ERROR
        $SETIME_S  TIMADR=BINTIM     ;CHANGE SYSTEM TIME TO 09:00
        BSBW       ERROR
        $HIBER_S                     ;HIBERNATE TILL 9:30 (30 MINUTES)
          .
          .
          .

;  SINCE THE INTERVAL BETWEEN THE CURRENT TIME AND THE WAKEUP
;  TIME WAS 30 MINUTES WHEN WE MADE THE $SETIME REQUEST,
;  CHANGING THE SYSTEM TIME TO 9:00 CAUSES THE WAKEUP TIME
;  TO BE CHANGED TO 9:30.
```

CHAPTER 9

CONDITION-HANDLING SERVICES

A condition handler is a procedure that is given control when an exception occurs. An exception is an event that is detected by the hardware or software and that interrupts the execution of an image. Examples of exceptions include arithmetic overflow or underflow and reserved opcode or operand faults.

If you determine that a program needs to be informed of particular exceptions so that it can take corrective action, you can code and specify a condition handler. This condition handler, which will receive control when any exception occurs, can test for specific exceptions.

If an exception occurs and you have not specified a condition handler, the default condition handler established by the command interpreter is given control. If the exception is a fatal error, the default condition handler issues a descriptive message and performs an exit on behalf of the image that incurred the exception.

This chapter describes how the condition-handling mechanism in VAX/VMS works and explains how to write a condition handler.

9.1 TYPES OF EXCEPTION

Exceptions can be generated by:

- Hardware
- Software
- System service failures

Hardware-generated exceptions always result in conditions that require special action if program execution is to continue.

Software-generated exceptions result in error or warning conditions. These conditions and their messages are documented in the VAX/VMS System Messages and Recovery Procedures Manual or, for certain software routines, in the manual associated with their routine. (For example, linker error messages appear in the VAX-11 Linker Reference Manual.)

System service failure exceptions occur when an error or severe error status is returned from a call to a system service. You can choose to handle error returns from system services by using the condition handling mechanism rather than other error checking methods. If you want to handle exceptions generated by service failures, you must

enable system service failure exception mode with the Set System Service Failure Mode ($SETSFM) system service. For example:

```
$SETSFM_S ENBFLG=#1
```

System service failure exception mode is initially disabled, and may be enabled or disabled at any time during the execution of an image. For additional information on system service failure exception mode, see Section 2.1.5.4 (MACRO programmers) or Section 2.2.2.3 (high-level language programmers).

Table 9-1 provides a summary of common conditions caused by exceptions.

Table 9-1
Summary of Exception Conditions

Condition Name/Type	Explanation	Additional Arguments
SS$_ACCVIO (Fault)	Access violation	1. Reason for access violation. This is a mask with the format: Bit 0 = type of access violation 0 = page table entry protection code did not permit intended access 1 = P0LR, P1LR, or SLR length violation Bit 1 = page table entry reference 0 = specified virtual address not accessible 1 = associated page table entry not accessible Bit 2 = intended access 0 = read 1 = modify 2. Virtual address to which access was attempted
SS$_ARTRES (Trap)	Reserved arithmetic trap	None
SS$_ASTFLT (Fault)	Stack invalid during attempt to deliver an AST	1. Stack pointer value when fault occurred 2. AST parameter of failed AST 3. Program counter (PC) at AST delivery interrupt 4. Processor status longword (PSL) at AST delivery interrupt1 5. Program counter (PC) to which AST would have been delivered1 6. Processor status longword (PSL) to which AST would have been delivered1
SS$_BREAK (Fault)	Breakpoint instruction encountered	None.
SS$_CMODSUPR (Trap)	Change mode to supervisor instruction encountered2	Change mode code. The possible values are -32768 through 32767.
SS$_CMODUSER (Trap)	Change mode to user instruction encountered2	Change mode code. The possible values are -32768 through 32767.

1 The PC and PSL normally included in the signal array are not included in this argument list. The stack pointer of the access mode receiving this exception is reset to its initial value.

2 If a change mode handler has been declared for user or supervisor modes with the Declare Change Mode or Compatibility Mode Handler ($DCLCMH) system service, that routine receives control when the associated trap occurs.

Table 9-1(Cont.)
Summary of Exceptional Conditions

Condition Name/Type	Explanation	Additional Arguments
SS$_COMPAT (Fault)	Compatibility mode exception. This exception condition can only occur when executing in compatibility mode.3	Type of compatibility exception. The possible values are: 0 = Reserved instruction execution 1 = BPT instruction executed 2 = IOT instruction executed 3 = EMT instruction executed 4 = TRAP instruction executed 5 = Illegal instruction executed 6 = Odd address fault 7 = TBIT trap
SS$_DECOVF (Trap)	Decimal overflow	None
SS$_FLTDIV (Trap)	Floating/decimal divide by zero	None
SS$_FLTDIV_F (Fault)	Floating divide by zero fault	None
SS$_FLTOVF (Trap)	Floating overflow	None
SS$_FLTOVF_F (Fault)	Floating overflow fault	None
SS$_FLTUND (Trap)	Floating underflow	None
SS$_FLTUND_F (Fault)	Floating underflow fault	None
SS$_INTDIV (Trap)	Integer divide by zero	None
SS$_INTOVF (Trap)	Integer overflow	None
SS$_OPCCUS (Fault)	Opcode reserved to customer fault	None
SS$_OPCDEC (Fault)	Opcode reserved to Digital fault	None
SS$_PAGRDERR (Fault)	Read error occurred during an attempt to read a faulted page from disk	1. Translation not valid reason. This is a mask with the format: Bit 0 = 0 Bit 1 = page table entry reference 0 = specified virtual address not valid 1 = associated page table entry not valid Bit 2 = intended access 0 = read 1 = modify
SS$_RADRMOD (Fault)	Attempt to use a reserved addressing mode	None
SS$_ROPRAND (Fault)	Attempt to use a reserved operand	None
SS$_SSFAIL (Fault)	System service failure (when system service failure exception mode is enabled)	Status return from system service (R0) (The same value is in R0 of the mechanism array)
SS$_SUBRNG	Subscript range trap	None
SS$_TBIT (Fault)	Trace bit is pending following an instruction	None

3 If a compatibility mode handler has been declared with the Declare Change Mode or Compatibility Mode Handler ($DCLCMH) system service, that routine receives control when this fault occurs.

9.1.1 Change Mode and Compatibility Mode Handlers

There are two types of hardware exception that can be handled in a special way, bypassing the normal condition-handling mechanism described in this chapter. These are:

- Traps caused by change mode to user or change mode to supervisor instructions
- Compatibility mode faults

You can use the Declare Change Mode or Compatibility Mode Handler ($DCLCMH) system service to establish procedures to receive control when one of these conditions occurs. The $DCLCMH system service is described in Part II.

9.2 HOW TO SPECIFY CONDITION HANDLERS

You can establish condition handlers to receive control in the event of an exception in two ways:

1. By specifying the address of the entry mask of a condition handler in the first longword of a procedure call frame
2. By establishing exception vectors with the Set Exception Vector ($SETEXV) system service

The first of these methods is the most common way to specify a condition handler for a particular image. It is also the most efficient way in terms of declaration. The VAX-11 MACRO programmer can use a single move address instruction to place the address of the condition handler in the longword pointed to by the current frame pointer (FP). For example:

```
MOVAL     HANDLER,(FP)
```

The high-level language programmer can call the common run-time library routine LIB$ESTABLISH (see the VAX-11 Run-Time Library Reference Manual); however, some languages provide access to condition-handling as part of the language.

Each procedure on the call stack can declare a condition handler.

The $SETEXV system service allows you to specify addresses for a primary exception vector, a secondary exception vector, and a last chance exception vector. Vectors may be specified for each access mode. The primary exception vector is reserved for the debugger.

An address of 0 in the first longword of a procedure call frame or in an exception vector indicates that no condition handler exists for that call frame or vector.

9.3 THE EXCEPTION DISPATCHER

When an exception occurs, control is passed to the operating system's exception dispatching routine. The exception dispatcher searches for a condition-handling routine using the following search order:

1. The primary exception vector for the access mode at which the program was executing when the exception occurred.

2. The secondary exception vector for the access mode at which the program was executing when the exception occurred.

3. The condition handler address specified in the procedure call stack of the access mode at which the program was executing when the exception occurred. Call frames on the stack are scanned backwards, using the saved frame pointer in each call frame to refer to the previous call frame.

4. The last chance exception vector for the access mode at which the program was executing when the exception occurred.

The search is terminated when the dispatcher finds a condition handler. If the dispatcher cannot find a user-specified condition handler, it calls the default condition handler established by the command interpreter, if the image was initiated by the command interpreter. The default handler issues a message and either continues program execution or performs an exit on behalf of the process, depending on whether the condition was a warning or an error condition, respectively.

The search can also be terminated when the dispatcher detects a saved frame pointer containing a 0 (that is, it reaches the end of the stack), or when an access violation occurs. In these cases, the system performs an exit for the process, with the return status code SS$_NOHANDLER indicating "absence of condition handler" (for a 0 frame pointer) or SS$_ACCVIO indicating "bad stack" (for an access violation).

Figure 9-1 illustrates the exception dispatcher's search of the call stack for a condition handler.

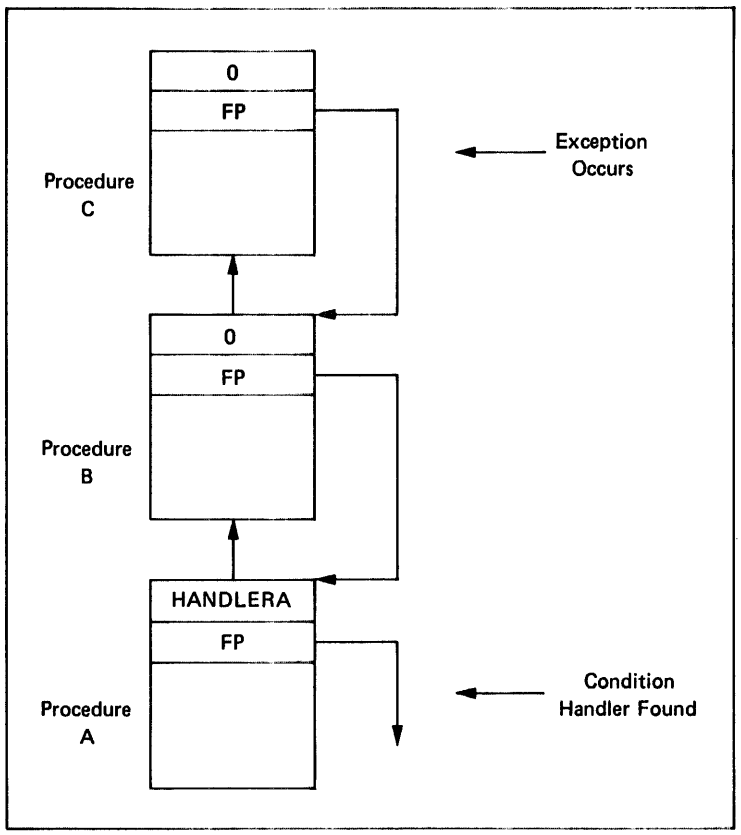


Figure 9-1 Search of Stack for Condition Handler

Notes on Figure 9-1:

1. The illustration of the call stack indicates the calling sequence: Procedure A called Procedure B, and Procedure B called Procedure C. Procedure A established a condition handler.

2. An exception occurs while Procedure C is executing. The exception dispatcher searches for a condition handler.

3. After checking for a condition handler declared in the exception vectors (assume that none has been specified for this process), the dispatcher looks at the first longword of Procedure C's call frame. A value of 0 indicates that no condition handler has been specified. The dispatcher locates the call frame for Procedure B by using the frame pointer (FP) in Procedure C's call frame. Again, it finds no condition handler, and locates Procedure A's call frame.

4. The dispatcher locates and gives control to HANDLERA.

9.4 THE ARGUMENT LIST PASSED TO A CONDITION HANDLER

When the dispatcher finds a condition handler, it passes control to it using a CALLG instruction. The argument list passed to the condition handler is constructed on the stack and consists of the addresses of two argument arrays, as illustrated in Figure 9-2; these arguments are described in detail in the next two subsections (9.4.1 and 9.4.2).

You can define symbolic names to refer to these arguments using the $CHFDEF macro instruction. The symbolic names are:

Symbolic Offset	Value
CHF$L_SIGARGLST	Address of signal array
CHF$L_MCHARGLST	Address of mechanism array
CHF$L_SIG_ARGS	Number of signal arguments
CHF$L_SIG_NAME	Condition name
CHF$L_SIG_ARG1	First signal-specific argument
CHF$L_MCH_ARGS	Number of mechanism arguments
CHF$L_MCH_FRAME	Establisher frame address
CHF$L_MCH_DEPTH	Frame depth of establisher
CHF$L_MCH_SAVR0	Saved register 0
CHF$L_MCH_SAVR1	Saved register 1

9.4.1 Signal Array Arguments

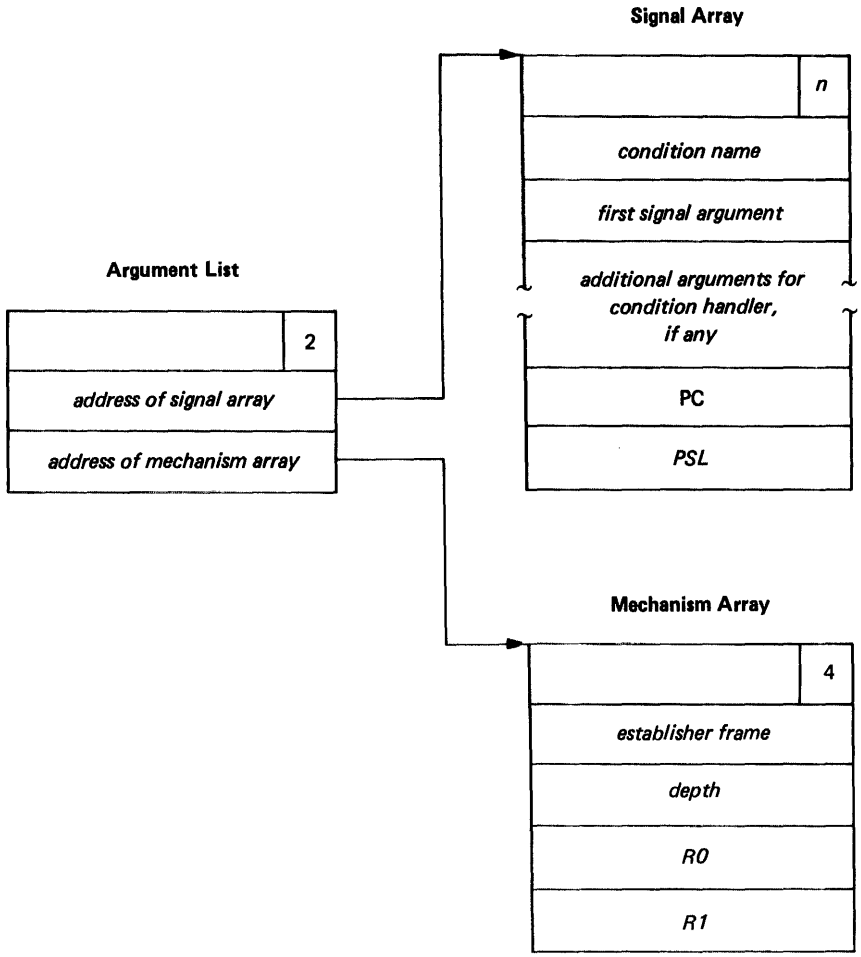
The signal array contains values describing the condition. These values are:

1. Condition name -- The symbolic value assigned to the specific condition. The possible conditions and their symbolic definitions are listed in Table 9-1.

2. Additional arguments -- Specific information relating to the condition. Table 9-1 also shows the additional arguments provided with each condition.

3. PC -- The program counter at the time of the exception. Depending on the type of exception (fault or trap), this can be the address of the instruction that caused the exception (for a fault), or of the following instruction (for a trap).

4. PSL -- The processor status longword at the time of the exception.



You can define symbolic names to refer to these arguments using the $CHFDEF macro instruction. The symbolic names are:

Symbolic Offset	Value
CHF$L_SIGARGLST	Address of signal array
CHF$L_MCHARGLST	Address of mechanism array
CHF$L_SIG_ARGS	Number of signal arguments
CHF$L_SIG_NAME	Condition name
CHF$L_SIG_ARG1	First signal-specific argument
CHF$L_MCH_ARGS	Number of mechanism arguments
CHF$L_MCH_FRAME	Establisher frame address
CHF$L_MCH_DEPTH	Frame depth of establisher
CHF$L_MCH_SAVR0	Saved register 0
CHF$L_MCH_SAVR1	Saved register 1

Figure 9-2 Argument List and Arrays Passed to Condition Handler

9.4.2 Mechanism Array Arguments

The mechanism array describes the context in which the exception occurred. The arguments supplied are:

1. Establisher frame -- The frame pointer (FP) register contents of the call frame that established the condition handler. This is the address of the longword containing the condition handler address. For example, if the call stack is as shown earlier in Figure 9-1, this argument points to the call frame for Procedure A.

   This value can be used to display local variables in the procedure that established the condition handler, if the variables are at known offsets from the FP of the procedure.

2. Depth -- The frame number of the procedure that established the condition handler, relative to the frame of the procedure that incurred the exception. The depth is determined as follows:

Depth	Meaning
-3	Condition handler was established in the last chance exception vector
-2	Condition handler was established in the primary exception vector
-1	Condition handler was established in the secondary exception vector
0	Condition handler was established by the frame that was active when the exception occurred
1	Condition handler was established by the caller of the frame that was active when the exception occurred
2	Condition handler was established by the caller of the caller of the frame that was active when the exception occurred
.	and so on.
.	
.	

   For example, if the call stack is as shown earlier in Figure 9-1, the depth argument passed to HANDLERA would have a value of 2.

   The condition handler can use this argument to determine whether it wants to handle the condition. For example, the handler may not want to handle the condition if the exception that caused the condition did not occur in the establisher frame.

3. R0 -- The contents of register 0 when the exception occurred.

4. R1 -- The contents of register 1 when the exception occurred.

9.5 COURSES OF ACTION FOR THE CONDITION HANDLER

After the condition-handling routine determines the nature of the exception, it can take one of the following courses of action:

1. Continue

   The condition handler may or may not be able to fix the problem but the program can continue execution. The handler places the return status value SS$_CONTINUE in R0 and issues a RET instruction to return control to the dispatcher. The exception dispatcher returns control to the procedure that incurred the exception, at the instruction that caused the exception. If the exception was a fault, the instruction that caused it is reexecuted; if the exception was a trap, control is returned at the instruction following the one that caused it. (In the case of a trap, the instruction causing the trap can sometimes be reexecuted by subtracting the length of the instruction from the PC in the signal array.)

2. Resignal

   The handler cannot fix the problem, or this condition is one that it does not handle. It places the return status value SS$_RESIGNAL in R0 and issues a RET instruction to return control to the exception dispatcher. The dispatcher resumes its search for a condition handler. If it finds another condition handler, it passes control to that routine.

3. Unwind

   The condition handler cannot fix the problem, and execution cannot continue using the current flow. The handler issues the Unwind Call Stack ($UNWIND) system service to unwind the call stack. Call frames may then be removed from the stack and the flow of execution modified, depending on the arguments to the $UNWIND service.

Examples of these three situations are shown in the next two sections.

9.6 EXAMPLE OF CONDITION-HANDLING ROUTINES CONTINUING AND RESIGNALING

Figure 9-3 shows two procedures, A and B, that have declared condition handlers. The notes describe the sequence of events that would occur if a call to a system service failed during the execution of Procedure B.

```
.ENTRY  PGMA,0                      ;ENTRY MASK FOR PROCEDURE A
      1 MOVAL   HANDLERA,(FP)       ;DECLARE CONDITION HANDLER
        $SETSFM_S ENBFLG=#1         ;ENABLE SSFAIL EXCEPTIONS
      2 CALLG   ARGLIST,PGMB        ;CALL PROCEDURE B
          .
          .
          .

HANDLERA:7
        .WORD   ^M<R2,R3,R4>        ;ENTRY MASK OF HANDLERA
        MOVL    CHF$L_SIGARGLST(AP),R4  ;GET ADDR OF SIGNAL ARGS
        CMPL    #SS$_SSFAIL,CHF$L_SIG_NAME(R4)
                                    ;SYSTEM SERVICE FAILURE?
        BNEQ    10$                 ;NO - RESIGNAL
      8   .                         ;HANDLE SSFAIL EXCEPTION
          .
          .
        MOVZWL  #SS$_CONTINUE,R0    ;SIGNAL TO CONTINUE
        RET                         ;RETURN TO EXCEPTION DISPATCHER
10$:    MOVZWL  #SS$_RESIGNAL,R0    ;SIGNAL TO RESIGNAL
        RET                         ;RETURN TO DISPATCHER

.ENTRY  PGMB,   ^M<R2,R3,R4>        ;ENTRY MASK OF PROCEDURE B
      3 MOVAL   HANDLERB,(FP)       ;DECLARE CONDITION HANDLER
          .
          .
          .       <-- System service failure occurs4
          .   9

HANDLERB:5
        .WORD   ^M<R2,R3,R4>        ;ENTRY MASK OF HANDLERB
        MOVL    CHF$L_SIGARGLST(AP),R4  ;GET ADDR OF SIGNAL ARGS
        CMPL    #SS$_BREAK,CHF$L_SIG_NAME(R4)  ;BREAKPOINT FAULT?
        BNEQ    10$                 ;NO, RESIGNAL
          .                         ;YES, HANDLE EXCEPTION
          .
          .
        MOVZWL  #SS$_CONTINUE,R0    ;SIGNAL TO CONTINUE
        RET                         ;RETURN TO EXCEPTION DISPATCHER
10$:6   MOVZWL  #SS$_RESIGNAL,R0    ;SIGNAL TO RESIGNAL
        RET                         ;RETURN TO DISPATCHER
```

Figure 9-3 Example of Condition Handling Routines

Notes on Figure 9-3:

1. Procedure A executes and establishes condition handler HANDLERA. HANDLERA is set up to respond to exceptions caused by failures in system service calls.

2. During its execution, Procedure A calls Procedure B.

3. Procedure B establishes condition handler HANDLERB. HANDLERB is set up to respond to breakpoint faults.

4. While Procedure B is executing, an exception occurs caused by a system service failure.

5. The exception dispatcher searches the exception vectors for a condition handler (assume there are none defined), and then searches the call stack. HANDLERB is called with the condition SS$_SSFAIL.

❻ Since HANDLERB only handles breakpoint faults, it places the return value SS$_RESIGNAL in R0 and returns control to the exception dispatcher.

❼ The exception dispatcher resumes its search for a condition handler and calls HANDLERA.

❽ HANDLERA handles the system service failure exception, corrects the condition, places the return value SS$_CONTINUE in R0, and returns control to the exception dispatcher.

❾ The dispatcher returns control to Procedure B, and execution of Procedure B resumes at the instruction following the system service failure.

9.7 UNWINDING THE CALL STACK

The third course of action a condition handler can take is to unwind the procedure call stack. The unwind operation is complex, and should only be used when control must be restored to an earlier procedure in the calling sequence. Moreover, use of the $UNWIND system service requires the calling condition handler to be aware of the calling sequence and of the exact point to which control is to return.

The $UNWIND system service accepts two optional arguments:

1. The depth to which the unwind is to occur. If the depth is 1, the call stack is unwound to the caller of the procedure that incurred the exception. If the depth is 2, the unwind is to the caller's caller, and so on.

2. The address of a location to receive control when the unwind is complete, that is, a return PC to replace the current PC in the call frame of the procedure that will receive control when all specified frames have been removed from the stack.

If no arguments are supplied to the $UNWIND service, the unwind is performed to the caller of the procedure that established the condition handler that is issuing the $UNWIND service. Control is returned to the address specified in the return PC for that procedure. Note that this is the default and normal case for unwinding.

Figure 9-4 illustrates an unwind situation and describes some of the possible results.

During the actual unwinding of the call stack, the unwind routine examines each frame in the call stack to see if a condition handler has been declared. If a handler has been declared, the unwind routine calls the handler with the status value SS$_UNWIND (indicating that the call stack is being unwound) in the condition name argument of the signal array. When a condition handler is called with this status value, it can perform any procedure-specific cleanup operations required. After the handler returns, the call frame is removed from the stack.

Thus, in Figure 9-4, HANDLERB may be called a second time, during the unwind operation. Note that HANDLERB does not have to be able to specifically interpret the SS$_UNWIND status value; the RET instruction merely returns control to the unwind procedure, which does not check any status values.

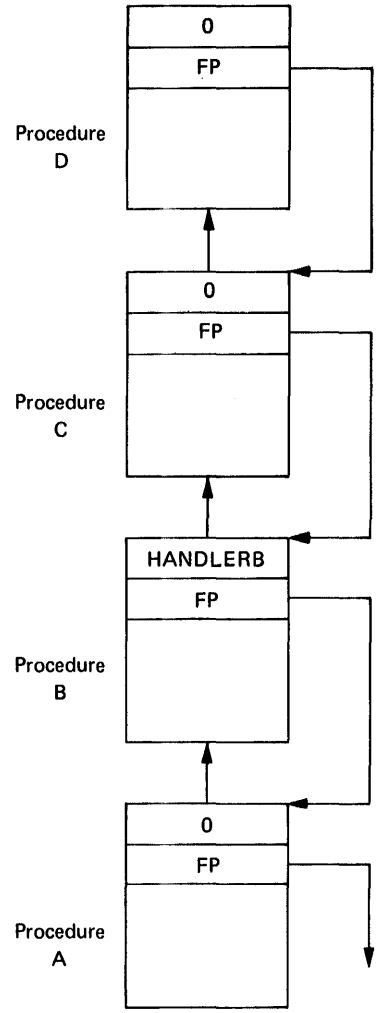


Figure 9-4 Unwinding the Call Stack

Notes on Figure 9-4:

1. The procedure call stack is as shown. Assume that no exception vectors are declared for the process and that the exception occurs during the execution of Procedure D.

2. Since neither Procedure D nor Procedure C has established a condition handler, HANDLERB receives control.

3. If HANDLERB issues the $UNWIND system service with no arguments, the call frames for B, C, and D are removed from the stack (along with the call frame for HANDLERB itself), and control returns to Procedure A. Procedure A receives control at the point following its call to Procedure B.

4. If HANDLERB issues the $UNWIND system service specifying a depth of 2, call frames for C and D are removed, and control returns to Procedure B.

9.8 MULTIPLE EXCEPTIONS

It is possible for a second exception to occur while a condition handler or a procedure that it has called is still executing. In this case, when the exception dispatcher searches for a condition handler, it skips the frames that were searched to locate the first handler.

The search for a second handler terminates in the same manner as the initial search, as described in Section 9.3.

If the $UNWIND system service is issued by the second active condition handler, the depth of the unwind is determined according to the same rules followed in the exception dispatcher's search of the stack: all frames that were searched for the first condition handler are skipped.

If an exception occurs during the execution of a handler established in the primary or secondary exception vector, that handler must handle the additional condition.

CHAPTER 10

MEMORY MANAGEMENT SERVICES

The VAX/VMS memory management routines map and control the relationship between physical memory and a process's virtual address space. These activities are, for the most part, transparent to you as a user and to your programs. However, you can in some cases make a program more efficient by explicitly controlling its virtual memory usage. Memory management services allow you to:

- Increase or decrease the virtual address space available in a process's program or control region
- Control the process's working set size and the exchange of pages between physical memory and the paging device
- Define disk files containing data or shareable images and map the file into the process's virtual address space

This chapter discusses the services that provide these capabilities. However, before you use any of these services, you should have an understanding of the VAX-11 memory structure and memory management routines. Where pertinent, virtual memory concepts related to the use of particular services are discussed in this chapter. For more background information, see the VAX/VMS Summary Description and Glossary.

10.1 INCREASING VIRTUAL ADDRESS SPACE

The virtual address space of a process is divided into two regions:

1. The program region (P0), which contains the image currently being executed.
2. The control region (P1), which contains the information maintained by the system on behalf of the process. It also contains the user stack, which expands toward the lower-addressed end of the control region.

Figure 10-1 illustrates the layout of a process's virtual memory. The initial size of a process's virtual address space depends on the size of the image being executed.

To facilitate memory protection and mapping, the virtual address space is subdivided into 512-byte units called pages. Using memory management services, a process can add a specified number of pages to the end of either the program region or the control region. Adding pages to the program region provides the process with additional space for image execution, for example, for the dynamic creation of tables or data areas. Adding pages to the control region increases the size

of the user stack. (The user stack can also be expanded when the image is linked, by the use of the STACK= option in a linker options file.)

The maximum size to which a process can increase its address space is controlled by an entry in the system authorization file for the user.

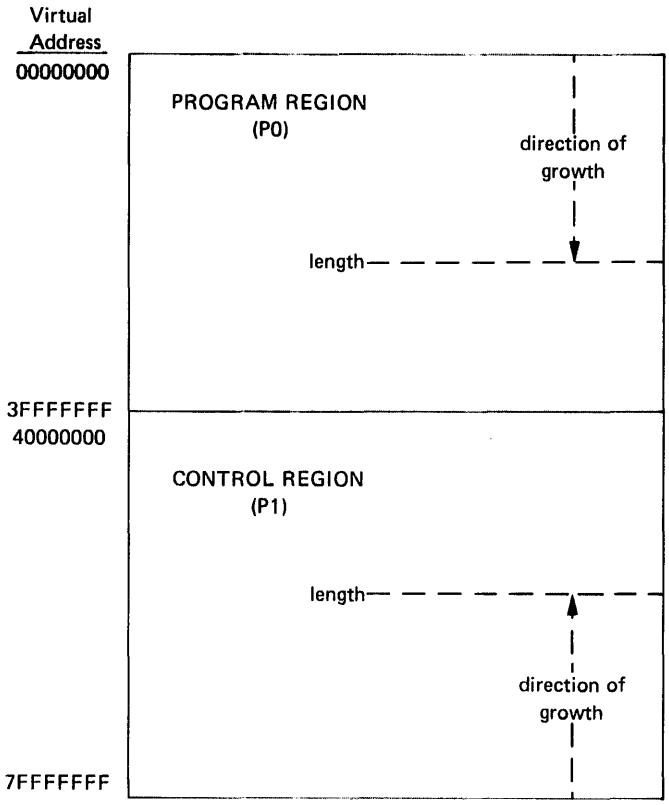


Figure 10-1 Layout of Process Virtual Address Space

10.2 INCREASING AND DECREASING VIRTUAL ADDRESS SPACE

The Expand Program/Control Region ($EXPREG) system service adds pages to the end of either the program or control region, and optionally returns the range of virtual addresses of the new pages. For example, if you want to add four pages to a process's program region, you can code a call to the $EXPREG system service as follows:

```
BEGSPACE:
        .BLKL   2    ;2 LONGWORDS TO HOLD START AND END OF NEW PAGES
          .
          .
          .
        $EXPREG_S PAGCNT=#4,RETADR=BEGSPACE,REGION=#0 ;GET 4 PAGES
```

To add the same number of pages to the control region, you would specify REGION=#1.

When pages that have been added at the end of a region are no longer needed, they can be deleted with the Contract Program/Control Region ($CNTREG) system service. As for the $EXPREG service, you code the number of pages you want deleted and the region:

```
$CNTREG_S PAGCNT=#4,REGION=#0
```

Note that the REGION argument for both the $EXPREG and $CNTREG services is optional; if not specified, the pages are added to or deleted from the program region by default.

The $EXPREG and $CNTREG services can only add or delete pages at the end of a particular region. When you need to add or delete pages that are not at the end of these regions, you can use the Create Virtual Address Space ($CRETVA) and Delete Virtual Address Space ($DELTVA) system services. For example, if you have used the $EXPREG service twice to add pages to the program region, and want to delete the first range of pages but not the second, you could use the $DELTVA system service as shown in the following sequence:

```
BEGSPACEA: .BLKL   2    ;2 LONGWORDS TO HOLD START + END OF 1ST AREA
BEGSPACEB: .BLKL   2    ;2 LONGWORDS TO HOLD START + END OF 2ND AREA
             .
             .
             .
           $EXPREG_S PAGCNT=#4,RETADR=BEGSPACEA,REGION=#0  ;FOUR PAGES
           BSBW    ERROR
             .
             .
             .
           $EXPREG_S PAGCNT=#3,RETADR=BEGSPACEB,REGION=#0  ;THREE MORE
           BSBW    ERROR
             .
             .
           $DELTVA_S INADR=BEGSPACEA ;DELETE FIRST 4 PAGES
           BSBW    ERROR
```

In the above example, the first call to $EXPREG adds four pages to the program region; the virtual addresses of the pages are returned in the 2-longword array at BEGSPACEA. The second call adds three pages, and returns the addresses at BEGSPACEB. The call to $DELTVA deletes the first four pages that were added.

10.2.1 Input Address Arrays and Return Address Arrays

When the $EXPREG system service adds pages to a region, it adds them in the normal direction of growth for the region. The return address array, if requested, indicates the order in which the pages were added:

- If the program region is expanded, the starting virtual address is lower than the ending virtual address.
- If the control region is expanded, the starting virtual address is higher than the ending virtual address.

Conversely, the direction of contraction with the $CNTREG system service is from a higher to a lower address in the program region and from a lower to a higher address in the control region.

The addresses returned indicate the first byte in the first page added or deleted and the last byte in the last page added or deleted.

When input address arrays are specified for the Create or Delete Virtual Address Space system services ($CRETVA and $DELTVA, respectively), these services add or delete pages beginning with the address specified in the first longword and ending with the address specified in the second longword.

The order in which the pages are added or deleted does not have to be in the normal direction of growth for the region. Moreover, since these services only add or delete whole pages, they ignore the low-order 9 bits of the specified virtual address (the low-order 9 bits contain the byte offset within the page). The virtual addresses returned do indicate the byte offsets.

Table 10-1 shows some sample virtual addresses that might be specified as input to $CRETVA or $DELTVA and shows the return address arrays, if all pages are successfully added or deleted.

Table 10-1
Sample Virtual Address Arrays

Input Array		Region	Output Array		Number of Pages
Start	End		Start	End	
1010	1670	P0	1000	17FF	4
1450	1451	P0	1400	15FF	1
1450	1450	P0	1400	15FF	1
7FFEC010	7FFEC010	P1	7FFEC1FF	7FFEC000	1
7FFEC010	7FFEBCA0	P1	7FFEC1FF	7FFEBC00	3

Note that if the input virtual addresses are the same, as in the fourth item in Table 10-1, a single page is added or deleted. The return address array indicates that the page was added or deleted in the normal direction of growth for the region.

10.3 PAGE OWNERSHIP AND PAGE PROTECTION

Each page in a process's virtual address space is owned by a particular access mode. The owner is the access mode that created the page. For example, pages in the program region initially provided for the execution of an image are owned by user mode. Pages that the image creates dynamically are also owned by user mode. Pages in the control region, except for the pages containing the user stack, are normally owned by more privileged access modes.

Only the owner of a page can delete the page or otherwise affect it. The owner of a page can also indicate, by means of a protection code, the type of access that each access mode will be allowed.

The Set Protection on Pages ($SETPRT) system service changes the protection assigned to a page or group of pages. The protection is expressed as a code that indicates the specific type of access (none, read-only, or read/write) for each of the four access modes (kernel, executive, supervisor, user). Only the owner access mode or a more privileged access mode can change the protection for a page.

When an image attempts to access a page that is protected against the access attempted, a hardware exception called an access violation occurs. When an image calls a system service, the service determines whether an access violation would occur when the image attempted to read or write a page it is not privileged to access. If so, the service returns the status code SS$_ACCVIO.

Since the memory management services add, delete, or modify a single page at a time, one or more pages can be successfully affected before an access violation is detected. If the RETADR argument is specified in the service call, the service returns the addresses of pages actually affected before the error. If no pages are affected, that is, if an access violation would occur on the first page specified, the service returns a -1 in both longwords of the return address array.

If the RETADR argument is not specified, no information is returned.

10.4 WORKING SET PAGING

When a process is executing an image, a subset of its pages resides in physical memory; these pages are called the process's working set. The working set includes pages in both the program region and the control region.

When the image refers to a page that is not in memory, a hardware fault occurs, and the page is brought into memory, replacing an existing page in the working set. If the page that is going to be replaced has been modified during the execution of the image, that page is written onto a secondary storage device called the paging device. When this page is needed again, it is brought back into memory, again replacing a current page from the working set. This exchange of pages between physical memory and secondary storage is called paging.

The paging of a process's working set is transparent to the process. However, if a program is very large, or if pages in the program image that are heavily used are being paged in and out frequently, the overhead required for paging may decrease the program's efficiency. Some system services allow a process, within limits, to counteract these potential problems:

- The Adjust Working Set Limit ($ADJWSL) system service increases or decreases the maximum number of pages that a process can have in its working set.
- The Purge Working Set ($PURGWS) system service removes one or more pages from the working set.
- The Lock Pages in Working Set ($LKWSET) system service makes one or more pages in the working set ineligible for paging.

The initial size of a process's working set is defined by the process's working set default (WSDEFAULT) quota. Since some programs may have larger memory requirements than others, a program can call the $ADJWSL system service to dynamically increase the process's working set limit. When the additional pages are no longer needed in the working set, the program can call the $ADJWSL service to decrease the working set limit. It can also call the $PURGWS system service to remove pages no longer in use from the working set.

When the system pages a process's working set, the pages in the working set are paged on a first-in, first-out basis. Under some circumstances, an image may not want certain pages to be paged out at all; in this case, the image can lock these pages in the working set. As long as the process's working set is in memory, these pages cannot be paged out until they are explicitly unlocked with the Unlock Pages in Working Set ($ULWSET) system service.

10.5 PROCESS SWAPPING

The operating system balances the needs of all the processes that are currently executing, providing each with the system resources it requires on an as-needed basis. The memory management routines balance the process's memory requirements. Thus, the sum of the working sets for all processes that are currently in physical memory is called the balance set.

When a process whose working set is in memory becomes inactive -- for example, to wait for an I/O request or to hibernate -- the entire working set may be removed from memory to provide space for another process's working set to be brought in for execution. This removal of a process's working set is called swapping. When a process is swapped out of the balance set, all of the pages of its working set (modified and unmodified pages) are swapped, including any pages that had been locked in the working set.

It is possible for a high-priority process to lock its entire working set in the balance set. While pages can still be paged in and out of the working set, the process remains in memory even when it is inactive. To lock itself in the balance set, the process issues the Set Process Swap Mode ($SETSWM) system service. For example:

```
$SETSWM_S SWPFLG=#1
```

This call to $SETSWM disables process swap mode. Swap mode can also be disabled by setting the appropriate bit in the STSFLG argument to the Create Process ($CREPRC) system service; however, you must have the PSWAPM privilege to alter process swap mode.

Another way that a process can lock pages in memory is with the Lock Pages in Memory ($LCKPAG) system service. When a page is locked in memory with this service, the page remains in memory even when the remainder of the process's working set is swapped out of the balance set. This system service has limited applicability, but may be useful in special circumstances, for example, for routines that perform I/O operations to slow devices or graphics devices.

Pages locked in memory can be unlocked with the Unlock Pages in Memory ($ULKPAG) system service. The user privilege PSWAPM is required to issue the $LCKPAG or $ULKPAG service.

10.6 SECTIONS

A section is a disk file or a portion of a disk file containing data or code that can be brought into memory and made available to a process for manipulation and execution. A section can also be one or more consecutive page frames in physical memory or I/O space instead of a disk file; such sections, which require you to specify page frame number mapping, are discussed in Section 10.6.13.

Sections are either private or global (shared):

- Private sections are accessible only by the process that creates them. A process can define a disk data file as a section, map it into its virtual address space, and manipulate it.

- Global sections can be shared by more than one process. One copy of the global section resides in physical memory, and each process sharing it refers to the same copy. A global section can contain shareable code or data that can be read, or read and written, by more than one process. Global sections are either temporary or permanent, and can be defined for use within a group or on a system-wide basis.

When modified pages in disk file sections are paged out of memory during image execution, they are written back into the section file, rather than into the paging file, as is the normal case with files. (However demand-zero or copy-on-reference sections are not written back into the section file.)

The use of disk file sections involves two distinct operations:

1. The creation of a section defines a disk file as a section and informs the system what portions of the file contain the section.

2. The mapping of a section makes the section available to a process and establishes the correspondence between virtual blocks in the file and specific addresses in the process's virtual address space.

The Create and Map Section ($CRMPSC) system service creates and/or maps a private section or a global section. Since a private section is used only by a single process, creation and mapping are simultaneous operations. In the case of a global section, one process can create a permanent global section and not map it; other processes can map to it. A process can also create and map a global section in one operation.

The following sections describe creating, mapping, and using disk file sections. In each case, considerations that are common to both private sections and global sections are described first, followed by additional notes and requirements for the use of global sections. Section 10.6.13 discusses special requirements for page frame sections.

10.6.1 Creating Sections

The steps involved in creating disk file sections are:

1. Opening or creating the disk file containing the section

2. Defining which virtual blocks in the file comprise the section

3. Defining the characteristics of the section

10.6.2 Opening the Disk File

Before a file can be used as a section, it must be opened using RMS.

The following example shows the file access block (FAB), OPEN macro, and channel specification on the $CRMPSC system service to open an existing file for reading:

```
SECFAB: $FAB    FNM=<SECTION.TST>,FOP=UFO ;FILE ACCESS BLOCK
          .
          .
          .
        $OPEN   FAB=SECFAB
        $CRMPSC_S CHAN=SECFAB+FAB$L_STV,...
```

The file options (FOP) parameter indicates that the file is to be opened for user I/O; this option is required so that RMS assigns the channel using the access mode of the caller. RMS returns the channel number on which the file is accessed in the offset FAB$L_STV; this channel number is specified as input to the $CRMPSC system service (CHAN argument). The same channel number can be used for multiple create and map section operations. For global sections associated with the same file, each process must open the file as shared by using the SHR parameter.

The file may be a new file that is to be created while it is in use as a section. In this case, use the $CREATE macro to open the file. If you are creating a new file, the file access block (FAB) for the file must specify an allocation quantity (ALQ parameter).

$CREATE can also be used to open an existing file; if the file does not exist, it will be created. The following example shows the required fields in the FAB for the conditional creation of a file:

```
GBLFAB: $FAB    FNM=<GLOBAL.TST>,ALQ=4,FAC=PUT,-
                FOP=<UFO,CIF,CBT>,SHR=PUT
          .
          .
          .
        $CREATE FAB=GBLFAB
```

When the $CREATE macro is invoked, it creates the file GLOBAL.TST if the file does not currently exist. The CBT (contiguous-best-try) option requests that if possible, the file be contiguous. Although it is not required that section files be contiguous, better performance can result if they are.

10.6.3 Defining the Section Extents

Once the file is successfully opened, the $CRMPSC system service can create a section from the entire file, or from only certain portions of it. The following arguments to $CRMPSC define the extents of the file that comprise the section:

- PAGCNT (page count). This argument is required; it indicates the number of virtual blocks in the file. These blocks correspond to pages in the section.

- VBN (virtual block number). This argument defines the number of the virtual block in the file that is the beginning of the section. It is an optional argument. If it is not specified, it defaults to 1; that is, the first virtual

block in the file is the beginning of the section. (If you have specified physical page frame number mapping, the VBN argument specifies the starting page frame number.)

10.6.4 Defining the Section Characteristics

The FLAGS argument to the $CRMPSC system service defines the following section characteristics:

- Whether it is a private section or a global section (the default is to create a private section)
- How the pages of the section are to be treated when they are copied into physical memory or when a process refers to them. The pages in a section can be:
  - -- Read/write or read-only
  - -- Created as demand-zero pages or as copy-on-reference pages, depending on how the processes are going to use the section and whether the file contains any data (see Section 10.6.8, "Section Paging").
- Whether the section is to be mapped to a disk file or to specific physical page frames (Section 10.6.13 discusses physical page frame sections).

10.6.5 Defining Global Section Characteristics

If the section is a global section, it must be assigned a character string name (GSDNAM argument) so that other processes can identify it when they map it. The format of this character string name is explained in the next subsection (10.6.5.1).

The FLAGS argument specifies the type of global section:

- Group temporary (the default)
- Group permanent
- System temporary
- System permanent

Group global sections can be shared only by processes executing with the same group number. The name of a group global section is implicitly qualified by the group number of the process that created it. When other processes map to it, their group numbers must match.

A temporary global section is automatically deleted when no processes are mapped to it, but a permanent global section remains in existence even when no processes are mapped to it. A permanent global section must be explicitly marked for deletion with the Delete Global Section ($DGBLSC) system service.

The user privileges PRMGBL and SYSGBL are required to create permanent group global sections, or system global sections (temporary or permanent), respectively.

A system global section is available to all processes in the system.

Optionally, a process creating a global section can specify a protection mask (PROT argument) restricting all access or a type of access (read, write, execute, delete) to other processes.

10.6.5.1 **Global Section Name** - The GSDNAM argument specifies a descriptor that points to a character string with the following format:

[shared-memory-name:]global-section-name

shared-memory-name

Identifies the global section to be created, mapped, or deleted as within the named memory that is shared by multiple processors. The name of this memory was specified at system generation time. For example, the string SHRMEM$1:GSDATA identifies a global section named GSDATA located in the shared memory named SHRMEM$1.

If this part of the string is not included and the section is being mapped or deleted, the system tries to find the specified global section first in local memory and then in shared memory units (in the order in which they were connected).

global-section-name

The name assigned to the global section. You may choose any valid name, from 1 to 15 characters; however, all processes mapping to the same global section must specify the same name.

If you wish, you can include both the shared-memory-name and the global-section-name for a global section in memory shared by multiple processors. However, if you want to use existing programs without recompiling or relinking, or if you want the program to work whether the section is in local memory or shared memory, you can specify just a global-section-name and have the system translate it to a complete specification. The system attempts to perform logical name translation of the string specified by the GSDNAM argument in the following manner:

1. GBL$ is prefixed to the string (to the part before the colon if both parts are present), and the result is subjected to logical name translation.

2. The part of the string after the colon (if any) is appended to the translated name.

3. If the result contains a logical name, steps 1 and 2 are repeated (up to 9 more times, if necessary) until translation does not succeed.

For example, assume that you have made the following logical name assignment:

```
$ DEFINE GBL$GSDATA SHRMEM$1:GSDATA
```

Your program contains the following statements:

```
NAMEDESC:  .ASCID  /GSDATA/  ;DESCRIPTOR FOR LOGICAL NAME OF SECTION
                .
                .
                .
           $CRMPSC_S  GSDNAM=NAMEDESC,...
```

The following logical name translation takes place:

1. GBL$ is prefixed to GSDATA.

2. GBL$GSDATA is translated to SHRMEM$1:GSDATA. (No further translation is successful. When logical name translation fails, the string is passed to the service.)

There are two exceptions to the logical name translation method discussed in this section:

- If the name string starts with an underscore (_), the VAX/VMS system strips the underscore and considers the resultant string to be the actual name (that is, no further translation is performed).

- If the global section has a name in the format "name_nnn," VAX/VMS first strips the underscore and the digits (nnn), then translates the resultant name according to the sequence discussed in this section, and finally reappends the underscore and digits. The system uses this method in conjunction with known images and shared files installed by the system manager.

10.6.6 Mapping Sections

When you code the $CRMPSC system service to create and/or map a section, you must provide the service with a range of virtual addresses (INADR argument) into which the section is to be mapped.

If you know specifically which pages the section should be mapped into, you provide these addresses in a 2-longword array. For example, to map a private section of 10 pages into virtual pages 10 through 19 of the program region, specify the input address array as follows:

```
MAPRANGE:
        .LONG ^X1400            ;ADDRESS (HEX) OF PAGE 10
        .LONG ^X2300            ;ADDRESS (HEX) OF PAGE 19
```

However, you do not need to know the explicit addresses to provide an input address range. If you simply want the section mapped into the first available virtual address range in the program (P0) or control (P1) region, you can specify the SEC$M_EXPREG flag bit in the FLAGS argument. In this case, the addresses specified by the INADR argument simply control whether the service finds the first available space in the program or control region. The value specified or defaulted for the PAGCNT argument determines the number of pages mapped. The following example shows part of the code to map a section at the current end of the program region.

```
MAPRANGE:
        .LONG ^X200             ;ANY PROGRAM (P0) REGION ADDRESS
        .LONG ^X200             ;ANY P0 ADDRESS (CAN BE SAME)
RETRANGE:
        .BLKL 2                 ;ADDRESS RANGE RETURNED HERE
          .
          .
          .
        $CRMPSC_S  INADR=MAPRANGE,RETADR=RETRANGE,-
                   FLAGS=<SEC$M_EXPREG>,...
          .
          .
          .
```

The addresses specified do not have to be currently in the process's virtual address space. The $CRMPSC system service creates the required virtual address space during the mapping of the section. If you code the RETADR argument, the service returns the range of addresses actually mapped.

Once a section has been successfully mapped, the image can refer to the pages using a base register or pointer and predefined symbolic offset names or labels defining offsets of an absolute program section or structure.

Figure 10-2 shows an example of creating and mapping a process section.

```
SECFAB: $FAB    FNM=<SECTION.TST>,FOP=UFO,FAC=PUT,SHR=<GET,PUT>

MAPRANGE:
        .LONG   ^X1400          ;FIRST PAGE
        .LONG   ^X2300          ;LAST PAGE
RETRANGE:
        .BLKL   1               ;FIRST PAGE MAPPED
ENDRANGE:
        .BLKL   1               ;LAST PAGE MAPPED
          .
          .
          .
(1)     $OPEN   FAB=SECFAB      ;OPEN SECTION FILE
        BSBW    ERROR

(2)     $CRMPSC_S INADR=MAPRANGE,-  ;INPUT ADDRESS ARRAY
                  RETADR=RETRANGE,-  ;OUTPUT ARRAY
                  PAGCNT=#4,-        ;MAP FOUR PAGES
(3)               FLAGS=#SEC$M_WRT,- ;READ/WRITE SECTION
                  CHAN=SECFAB+FAB$L_STV ;CHANNEL NUMBER
(4)     BSBW    ERROR
        MOVL    RETRANGE,R6     ;POINT TO START OF SECTION
```

Figure 10-2 Creating and Mapping a Private Section

Notes on Figure 10-2:

(1) The OPEN macro opens the section file defined in the file access block SECFAB. (The FOP parameter to the $FAB macro must specify the UFO option.)

(2) The $CRMPSC system services uses the addresses specified at MAPRANGE to specify an input range of addresses into which the section will be mapped. The PAGCNT argument requests that only four pages of the file be mapped.

(3) The FLAGS argument requests that the pages in the section be read/write. The symbolic flag definitions for this argument are defined in the $SECDEF macro. Note that the file access field (FAC parameter) in the FAB also indicates that the file is to be opened for writing.

(4) When $CRMPSC completes, the addresses of the four pages that were mapped are returned in the output address array at RETRANGE. The address of the beginning of the section is placed in register 6, which serves as a pointer to the section.

10.6.7 Mapping Global Sections

A process that creates a global section can map to it when it creates it. Then, other processes can map it by calling the Map Global Section ($MGBLSC) system service.

When a process maps a global section, it must specify the global section name assigned to the section when it was created, whether it is a group or system global section, and whether it desires read-only or read/write access. The process may also specify:

- A version identification (IDENT argument), indicating the version number of the global section (When multiple verisons exist) and whether more recent versons are acceptable to the process.

- A relative page number (RELPAG argument), specifying the page number, relative to the beginning of the section, to begin mapping the section. In this way, processes can use only portions of a section. Additionally, a process can map a piece of a section into a particular address range and subsequently map a different piece of the section into the same virtual addresses.

To specify that the global section being mapped is located in physical memory that is being shared by multiple processors, you can include the shared memory name in the GSDNAM argument character string (see Section 10.6.5.1). A demand-zero global section in memory shared by multiple processors must be mapped when it is created.

Cooperating processes can both issue a $CRMPSC system service to create and map the same global section. The first process to call the service actually creates the global section; subsequent attempts to create and map the section result only in mapping the section for the caller. The successful return status code SS$_CREATED indicates that the section did not already exist when the $CRMPSC system service was called. If the section did exist, the status code SS$_NORMAL is returned.

Figure 10-3 shows one process (ORION) creating a global section and a second process (CYGNUS) mapping the section.

Process ORION

```
FLGCLUSTER:     ;DESCRIPTOR FOR COMMON EVENT FLAG CLUSTER NAME
        .ASCID /FLAG_CLUSTER/
FLGSET = 65                     ;FLAG NUMBER TO ASSOCIATE AND SET
FLGWAIT = 66                    ;FLAG NUMBER TO WAIT FOR

GLOBALSEC:                      ;DESCRIPTOR FOR GLOBAL SECTION NAME
        .ASCID /GLOBAL_SECTION/

GBLFAB: $FAB    FNM=<GLOBAL.TST>,FOP=<UFO,CIF,CBT>,-
                ALQ=4,FAC=PUT
          .
          .
          .
❶       $ASCEFC_S EFN=#FLGSET,NAME=FLGCLUSTER
        BSBW    ERROR
❷       $CRMPSC_S GSDNAM=GLOBALSEC,- ;CREATE GLOBAL SECTION
                FLAGS=#SEC$M_WRT!SEC$M_GBL,...
        BSBW    ERROR
        $SETEF_S EFN=#FLGSET    ;SET COMMON EVENT FLAG
```

Process CYGNUS

```
CLUSTER:  .ASCID /FLAG_CLUSTER/ ;CLUSTER NAME DESCRIPTOR
FLGSET = 65
FLGWAIT = 66

SECTION:  .ASCID /GLOBAL_SECTION/ ;SECTION NAME DESCRIPTOR

          .
          .
          .
❸       $ASCEFC_S EFN=#FLGSET,NAME=CLUSTER
        BSBW    ERROR
        $WAITFR_S EFN=#FLGSET
        BSBW    ERROR
        $MGBLSC_S INADR=MAPRANGE,RETADR=RETRANGE,-
                FLAGS=#SEC$M_GBL,- ;GLOBAL SECTION
                GSDNAM=SECTION     ;SECTION NAME
        BSBW    ERROR
```

Figure 10-3 Creating and Mapping a Global Section

Notes on Figure 10-3:

❶ The processes ORION and CYGNUS are in the same group. Each process first associates with a common event flag cluster named FLAG_CLUSTER to use common event flags to synchronize their use of the section.

❷ ORION creates the global section named GLOBAL_SECTION, specifying flags that indicate that it is a global section (SEC$M_GBL) and that it is read/write. Input and output address arrays, the page count parameter and the channel number arguments are not shown; procedures for coding them are the same as shown earlier in Figure 10-2.

❸ The process CYGNUS associates with the common event flag cluster and waits for the flag defined as FLGSET. ORION sets this flag when it has completed creating the section. To map the section, CYGNUS specifies the input and output address arrays, the flag indicating that it is a global section, and the global section name. In this example, the number of pages mapped is the same as that specified by the creator of the section.

10.6.8 Section Paging

The first time that an image executing in a process refers to a page that was created during the mapping of a disk file section, the page is copied into physical memory. The address of the page in the process's virtual address space is mapped to the physical page. During the execution of the image, normal paging can occur; however, pages in sections are not written into the page file when they are paged out, as is the normal case. Rather, if they have been modified, they are written back into the section file on disk. The next time a page fault occurs for the page, the page is brought back from the section file.

However, if the pages in a section were defined as demand-zero pages or copy-on-reference pages when the section was created, the pages are treated differently:

- If the call to $CRMPSC requested that pages in the section be treated as demand-zero pages, these pages are initialized to zeros when they are first brought into physical memory. If the file is either a new file that is being created as a section or a file that is being completely rewritten, demand-zero pages provide a convenient way of initializing the pages. The pages are paged back into the section file.

- If the call to $CRMPSC requested that pages in the section be copy-on-reference pages, each process that maps to the section receives its own copy of the section, on a page-by-page basis from the file, as it refers to them. These pages are never written back into the section file, but are paged to the paging file as needed.

In the case of global sections, more than one process can be mapped to the same physical pages. If these pages need to be paged out or written back to the disk file defined as the section, these operations are done only when no processes are currently mapped to the pages.

10.6.9 Reading and Writing Data Sections

Read/write sections provide a way for a process or cooperating processes to manipulate data files in virtual memory.

The sharing of global sections may involve application-dependent synchronization techniques. For example, one process can create and map to a global section in read/write status; other processes can map to it in read-only status and interpret data written by the first process. Or, two or more processes can write to the section concurrently. (In this case, the application program must provide the necessary synchronization and protection.)

When a file that has been mapped as a section is written back to disk, its version number is not incremented but the revision number is. A full directory listing indicates the revision number of the file and the date and time that the file was last updated.

When the file has been updated, the process or processes can release, or unmap, the section. The section is then written back into the disk file defined as a section.

10.6.10 Releasing and Deleting Sections

A process unmaps a section by deleting the virtual addresses in its own virtual address space to which it has mapped the section. If a return address range was specified to receive the virtual addresses of the mapped pages, this address range can be used as input to the Delete Virtual Address Space ($DELTVA) system service. For example:

```
$DELTVA_S INADR=RETRANGE
```

When a process unmaps a private section, the section is deleted; that is, all control information maintained by the system is deleted. A temporary global section is deleted when all processes that have mapped to it have unmapped it. Permanent global sections are not deleted until they are specifically marked for deletion with the Delete Global Section ($DGBLSC) system service; they are then deleted when no more processes are mapped.

Note that deleting the pages occupied by a section does not delete the section file, but rather cancels the process's association with the file. Moreover, when a process deletes pages mapped to a read/write section and no other processes are mapped to it, all modified pages are written back into the section file.

When a section has been deleted, the channel assigned to it can be deassigned. The process that created the section can deassign the channel (with the Deassign I/O Channel system service). For example:

```
$DASSGN_S CHAN=GBLFAB+FAB$L_STV
```

10.6.11 Writing Back (Checkpointing) Sections

Since read/write sections are normally not updated on disk until the physical pages they occupy are paged out, or until all processes referring to the section have unmapped it, a process may want to ensure that all modified pages are successfully written back into the section file at regular intervals.

The Update Section File on Disk ($UPDSEC) system service writes the modified pages in a section into the disk file. This process of writing back modified pages in a section is sometimes called "checkpointing" the section. The $UPDSEC system service is described in Part II.

10.6.12 Image Sections

Global sections can contain shareable code. An image file that is going to be defined as a section must contain position-independent code.

The operating system uses global sections to implement shareable code as follows:

1. The object module containing code to be shared is linked to produce a shareable image. The shareable image is not, in itself, executable. It contains a series of sections, called image sections.

2. A user links private object modules with the shareable image to produce an executable image. Only image section descriptor records from the shareable image file are bound with the image sections from the user's code (unless /SHAREABLE=COPY was specified in a linker options file).

3. The system manager uses the INSTALL command to create a permanent global section from the shareable image file, making the image sections available for sharing.

4. When the user runs the executable image, the system automatically maps the global sections created by the INSTALL command into the virtual address space of the user's process.

For details on how to create and identify shareable images and how to link them with private object modules, see the VAX-11 Linker Reference Manual. For information on installing shareable images and making them available for sharing as global sections, see the VAX/VMS System Manager's Guide.

10.6.13 Page Frame Sections

A page frame section is one or more contiguous pages of physical memory or I/O space that have been mapped as a section. One use of page frame sections is to map to an I/O page, thus allowing a process to read device registers. A process mapped to an I/O page can also connect to a device interrupt vector.

A page frame section differs from a disk file section in that it is not associated with a particular disk file and is not paged. However, it is similar to a disk file section in most other respects: you create, map, and define the extent and characteristics of a page frame section in essentially the same manner as you do a disk file section.

To create a page frame section, you must specify page frame number mapping by setting the SEC$M_PFNMAP flag bit in the FLAGS argument to the Create and Map Section ($CRMPSC) service. The VBN argument is now used to specify the first page frame to be mapped instead of the first virtual block. You must have the user privilege PFNMAP to create or delete a page frame section, but not to map to an existing one.

Because this type of section is not associated with a disk file, the RELPAG, CHAN, and PFC arguments to the $CRMPSC service are not used in creating or mapping a page frame section. For the same reason, the SEC$M_CRF (copy on reference) and SEC$M_DZRO (demand-zero) bit settings in the FLAGS argument do not apply. Pages in page frame sections are not written back to any disk file (including the paging file).

Use caution in working with page frame sections. If you permit write access to the section, each process that writes to the section does so at its own risk. Serious errors can occur if a process writes incorrect data or writes to the wrong page, especially if the page is also mapped by the system or by another process. Thus, the security of a system can be violated or damaged by any user having the PFNMAP privilege.

PART II

SYSTEM SERVICE DESCRIPTIONS

This part of the manual describes each of the VAX/VMS system services. The services are presented in alphabetical order by their abbreviated names.

Each system service description consists of the following categories, as applicable. Certain services require detailed information beyond these categories. For these services, the additional information appears after the "Notes" section.

Macro Format

Shows the macro name, with all keyword arguments listed in positional order. Spaces between arguments are present for readability and are not part of the macro syntax.

High-Level Language Format

Shows the procedure name and a generalized format for calling the service from a high-level language, with all arguments listed in positional order. For more information about a specific language, see Section 2.3 in Part I. Spaces between arguments are present for readability and are not part of the statement syntax.

Arguments

Describes each of the arguments.

Return Status

Lists the possible return status codes from the service with an explanation of the return condition. The successful returns are listed first, in alphabetical order, followed by warning and severe error return status codes, also in alphabetical order. All status codes are severe errors, unless otherwise indicated.

Three severe errors may occur for all services and are not listed with each service description. These are:

SS$_ACCVIO

The argument list cannot be read by the caller (using the $service_G form), and the service is not called. The meaning of SS$_ACCVIO in this case is different from the meaning of the SS$_ACCVIO status listed for many individual services; in these latter cases, the service is called, but one or more specific arguments are addresses that cannot be read or written by the caller.

SS$_INSFARG

Not enough arguments were supplied to the service.

SS$_ILLSER

An illegal system service was called.

Privilege Restrictions

Notes any user privileges required to execute the service or to request a particular function of the service, or any access mode restrictions applied to the service.

Resources Required/Returned

Lists any system resources or process quotas used by the service, or returned to a process as a result of service execution.

Notes

Contains the "fine print" of the service description, as well as references to related services or additional information.

$ADJSTK

$ADJSTK - ADJUST OUTER MODE STACK POINTER

The Adjust Outer Mode Stack Pointer system service modifies the stack pointer for a less privileged access mode. This service is used by the operating system to modify a stack pointer for a less privileged access mode after placing arguments on the stack.

Macro Format

```
$ADJSTK  [acmode] ,[adjust] ,newadr
```

High-Level Language Format

```
SYS$ADJSTK([acmode] ,[adjust] ,newadr)
```

acmode

Access mode for which the stack pointer is to be adjusted. If not specified, this value defaults to 0, indicating kernel access mode.

adjust

Signed adjustment value. The contents of the longword addressed by the NEWADR argument are adjusted by the amount specified in the low-order 16 bits of this argument. The result is loaded into the stack pointer for the specified access mode.

If not specified, or specified as 0, the stack pointer is loaded with the address specified by the NEWADR argument.

newadr

Address of a longword to receive the updated value. If the longword contains a nonzero value, then that value is updated by the ADJUST argument value and the result is loaded into the stack pointer.

If the longword contains a 0, the current value of the stack pointer is updated by the ADJUST argument value.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The longword to store the updated stack pointer or a portion of the new stack segment cannot be written by the caller.

SS$_NOPRIV

The specified access mode is equal to or more privileged than the calling access mode.

Notes

Combinations of zero and nonzero values for the ADJUST argument and the NEWADR longword provide the following results:

If the ADJUST argument specifies:	And the longword addressed by NEWADR contains:	The stack pointer is:
0	0	not changed
0	an address	loaded with the address specified
a value	0	adjusted by the specified value
a value	an address	loaded with the specified address, adjusted by the specified value

In all cases, the updated stack pointer value is written into the longword addressed by NEWADR.

$ADJWSL

$ADJWSL - ADJUST WORKING SET LIMIT

The Adjust Working Set Limit system service changes the current limit of a process's working set size by a specified number of pages. This service allows a process to control the number of pages resident in physical memory for the execution of the current image.

Macro Format

```
$ADJWSL  [pagcnt] ,[wsetlm]
```

High-Level Language Format

```
SYS$ADJWSL([pagcnt] ,[wsetlm])
```

pagcnt

Number of pages to adjust the current maximum working set size. A positive value increases the maximum working set size; a negative value decreases it. If not specified, or specified as 0, the current working set size limit is returned in the address specified by the WSETLM argument, if that argument is coded.

wsetlm

Address of a longword to receive the new working set size limit, or, if the PAGCNT argument is not specified, to receive the current working set size limit.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The longword to receive the new working set size limit cannot be written by the caller.

Resources Required/Returned

The initial value of a process's working set size is controlled by the working set default quota (WSDEFAULT). The maximum value to which it may be increased is controlled by the working set limit quota (WSQUOTA).

Notes

If a program attempts to adjust the working set size beyond the system-defined upper and lower limits, no error condition is returned. The working set size is adjusted to the maximum or minimum size allowed; the caller can check the new working set size to verify the change.

For more details on memory management concepts and additional services that help a process control paging and swapping, see Chapter 10, "Memory Management Services."

$ALLOC - ALLOCATE DEVICE

The Allocate Device system service reserves a device for exclusive use by a process and its subprocesses. No other process can allocate the device or assign channels to it until the image that called $ALLOC exits or explicitly deallocates the device with the Deallocate Device ($DALLOC) system service.

Macro Format

```
$ALLOC  devnam ,[phylen] ,[phybuf] ,[acmode]
```

High-Level Language Format

```
SYS$ALLOC(devnam ,[phylen] ,[phybuf] ,[acmode])
```

devnam

Address of a character string descriptor pointing to the device name string. The string may be either a physical device name or a logical name. If the first character in the string is an underline character(_), the name is considered a physical device name. Otherwise, a single level of logical name translation is performed and the equivalence name, if any, is used. The final name, however, cannot contain a node name unless the name is that of the host system.

phylen

Address of a word to receive the length of the allocated device name string.

phybuf

Address of a character string descriptor pointing to the buffer to receive the physical device name string of the allocated device. The first character in the string returned is an underline character (_).

acmode

Access mode to be associated with the allocated device. The specified access mode is maximized with the access mode of the caller. Only equal or more privileged access modes can deallocate the device.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_BUFFEROVF

Service successfully completed. The physical name returned overflowed the buffer provided, and has been truncated.

SS$_ACCVIO

The device name string, string descriptor, or physical name buffer descriptor cannot be read by the caller; or the physical name buffer cannot be written by the caller.

SS$_DEVALLOC

Warning. The device is already allocated to another process, or an attempt to allocate an unmounted shareable device failed because other processes had channels assigned to the device.

SS$_DEVMOUNT

The specified device is currently mounted and cannot be allocated; or the device is a mailbox.

SS$_IVDEVNAM

No device name string was specified, or the device name string contains invalid characters.

SS$_IVLOGNAM

The device name string has a length of 0 or has more than 63 characters.

SS$_NONLOCAL

Warning. The device is on a remote node.

SS$_NOPRIV

An attempt was made to allocate a spooled device and the requesting process does not have the required privilege.

SS$_NOSUCHDEV

Warning. The specified device does not exist in the host system.

Privilege Restrictions

The user privilege ALLSPOOL is required to allocate a spooled device.

Notes

1. When a process calls the Assign I/O Channel ($ASSIGN) system service to assign a channel to a nonshareable, nonspooled device, such as a terminal or line printer, the device is implicitly allocated to the process.

2. This service can only be used to allocate devices that exist on the host system.

For an example of how to use this service and a description of the allocation of devices by generic device names, see Chapter 6, "Input/Output Services."

$ASCEFC - ASSOCIATE COMMON EVENT FLAG CLUSTER

The Associate Common Event Flag Cluster system service causes a named common event flag cluster to be associated with a process for the execution of the current image and assigned a process-local cluster number for use with other event flag services. If the named cluster does not exist but the process has suitable privilege, the service creates the cluster.

Macro Format

```
$ASCEFC  efn ,name ,[prot] ,[perm]
```

High-Level Language Format

```
SYS$ASCEFC(efn ,name ,[prot] ,[perm])
```

efn

Number of any event flag in the common cluster to be associated. The flag number must be in the range of 64 through 95 for cluster 2 and 96 through 127 for cluster 3.

name

Address of a character string descriptor pointing to the text name string for the cluster. (Section 3.7.1 explains the format of this string.) The name is implicitly qualified by the group number of the process issuing the associate request.

prot

Protection indicator controlling group access to the common event flag cluster. A value of 0 (the default) indicates that any process in the creator's group may access the cluster. A value of 1 indicates that access is restricted to processes executing with the creator's UIC.

perm

Permanent indicator. If perm is equal to 1, the common event cluster is marked permanent.

If perm is equal to 0, the cluster is temporary; this is the default value.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The cluster name string or string descriptor cannot be read by the caller.

SS$_EXPORTQUOTA

The process has exceeded the number of clusters that processes on this port of the multiport (shared) memory can associate with.

SS$_EXQUOTA

The process has exceeded its timer queue entry quota; this quota controls the creation of temporary common event flag clusters.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_ILLEFC

An illegal event flag number was specified. The cluster number must be in the range of event flags 64 through 127.

SS$_INTERLOCK

The bit map lock for allocating common event flag clusters from the specified shared memory is locked by another process.

SS$_IVLOGNAM

The cluster name string has a length of 0 or has more than 15 characters.

SS$_NOPRIV

The process does not have the privilege to create a permanent cluster, the process does not have the privilege to create a common event flag cluster in memory shared by multiple processors, or the protection applied to an existing cluster by its creator prohibits association.

SS$_NOSHMBLOCK

No shared memory control block for common event flag clusters is available.

SS$_SHMNOTCNCT

The shared memory named in the NAME string is not known to the system. This error can be caused by a spelling error in the string, an improperly assigned logical name, or the failure to identify the memory as shared at SYSGEN time.

Privilege Restrictions

The user privilege PRMCEB is required to create a permanent common event flag cluster.

The user privilege SHMEM is required to create a common event flag cluster in memory shared by multiple processors.

Resources Required/Returned

Creation of temporary common event flag clusters uses the process's quota for timer queue entries (TQELM); the creation of a permanent cluster does not effect the quota. The quota is restored to the creator of the cluster when all processes associated with the cluster have disassociated.

Notes

1. When a process associates with a common event flag cluster, that cluster's reference count is increased by 1. The reference count is decreased when a process disassociates the cluster either explicitly with the Disassociate Common Event Flag Cluster ($DACEFC) system service, or implicitly, at image exit.

   Temporary clusters are automatically deleted when their reference count goes to 0; permanent clusters must be explicitly marked for deletion with the Delete Common Event Flag Cluster ($DLCEFC) system service.

2. Since this service automatically creates the common event flag cluster if it does not already exist, cooperating processes need not be concerned with which process executes first to create the cluster. The first process to call $ASCEFC creates the cluster and the others associate with it regardless of the order in which they call the service.

   The initial state for all event flags in a newly-created common event flag cluster is 0.

3. If a process has already associated a cluster number with a named common event flag cluster and then issues another call to $ASCEFC with the same cluster number, the service disassociates the number from its first assignment before associating it with its second.

For an example of the $ASCEFC system service and descriptions of services that manipulate event flags, see Chapter 3, "Event Flag Services."

$ASCTIM

$ASCTIM - CONVERT BINARY TIME TO ASCII STRING

The Convert Binary Time to ASCII String system service converts an absolute or delta time from 64-bit system time format to an ASCII string. The formats of the strings returned are described in Note 3 on the next page.

Macro Format

```
$ASCTIM  [timlen] ,timbuf ,[timadr] ,[cvtflg]
```

High-Level Language Format

```
SYS$ASCTIM([timlen] ,timbuf ,[timadr] ,[cvtflg])
```

timlen

Address of a word to receive the length of the output string returned.

timbuf

Address of a character string descriptor pointing to the buffer to receive the converted string. The buffer length specified in the descriptor, together with the CVTFLG argument, controls what information is returned. See Note 4 on the next page.

timadr

Address of the 64-bit time value to be converted. If no address is specified or is specified as 0 (the default), the current date and time are returned. A positive time value represents an absolute time. A negative time value represents a delta time. If a delta time is specified, it must be less than 10,000 days.

cvtflg

Conversion indicator. A value of 1 causes only the hour, minute, second, and hundredth of second fields to be returned, depending on the length of the buffer. A value of 0 (the default) causes the full date and time to be returned, depending on the length of the buffer.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_IVTIME

The specified delta time is equal to or greater than 10,000 days.

Notes

1. The $ASCTIM service executes at the access mode of the caller and does not check whether address arguments are accessible before it executes. Therefore, an access violation causes an exception condition if the input time value cannot be read or the output buffer or buffer length cannot be written.

2. This service does not check the length of the argument list, and therefore cannot return the SS$_INSFARG (insufficient arguments) error status code. If the service does not receive enough arguments (for example, if you omit required commas in the call), you might not get the desired result.

3. The ASCII strings returned have the following formats:

   Absolute Time: dd-mmm-yyyy hh:mm:ss.cc

   Delta Time: dddd hh:mm:ss.cc

Field	Length (Bytes)	Contents	Range of values
dd	2	day of month	1 - 31
-	1	hyphen	
mmm	3	month	JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
-	1	hyphen	
yyyy	4	year	1858 - 9999
blank	1	blank	
hh	2	hour	00 - 23
:	1	colon	
mm	2	minutes	00 - 59
:	1	colon	
ss	2	seconds	00 - 59
.	1	period	
cc	2	hundredths of seconds	00 - 99
dddd	4	number of days	000 - 9999

4. Some possible combinations of buffer length specification and CVTFLG arguments, and their results, are shown below:

Time Value	Buffer Length Specified	CVTFLG Argument	Information Returned
Absolute	23	0	date and time
Absolute	11	0	date
Absolute	11	1	time
Delta	16	0	days and time
Delta	11	1	time

For an example of the $ASCTIM system service, see Chapter 8, "Timer and Time Conversion Services."

$ASSIGN

$ASSIGN - ASSIGN I/O CHANNEL

The Assign I/O Channel system service (1) provides a process with an I/O channel so that input/output operations can be performed on a device, or (2) establishes a logical link with a remote node on a network.

Macro Format

```
$ASSIGN  devnam ,chan ,[acmode] ,[mbxnam]
```

High-Level Language Format

```
SYS$ASSIGN(devnam ,chan ,[acmode] ,[mbxnam])
```

devnam

Address of a character string descriptor pointing to the device name string. The string may be either a physical device name or a logical name. If the first character in the string is an underline character (_), the name is considered a physical device name. Otherwise, a single level of logical name translation is performed and the equivalence name, if any, is used.

If the device name contains a double colon (::), the system assigns a channel to the device NET0: and performs an access function on the network.

chan

Address of a word to receive the channel number assigned.

acmode

Access mode to be associated with the channel. The specified access mode is maximized with the access mode of the caller. I/O operations on the channel can only be performed from equal and more privileged access modes.

mbxnam

Address of a character string descriptor pointing to the logical name string for the mailbox to be associated with the device, if any. The mailbox receives status information from the device driver, as described in Note 2, below.

An address of 0 implies no mailbox; this is the default value.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_REMOTE

Service successfully completed. A logical link is established with the target on a remote node.

SS$_ABORT

A physical line went down during a network correct operation.

SS$_ACCVIO

The device or mailbox name string or string descriptor cannot be read by the caller, or the channel number cannot be written by the caller.

SS$_DEVACTIVE

A mailbox name has been specified, but a mailbox is already associated with the device.

SS$_DEVALLOC

Warning. The device is allocated to another process.

SS$_DEVNOTMBX

A logical name has been specified for the associated mailbox, but the logical name refers to a device that is not a mailbox.

SS$_EXQUOTA

The target of the assignment is on a remote node and the process has insufficient buffer quota to allocate a network control block.

SS$_INSFMEM

The target of the assignment is on a remote node and there is insufficient system dynamic memory to complete the request.

SS$_IVDEVNAM

No device name was specified, or the device or mailbox name string contains invalid characters. If the device name is a target on a remote node, this status code indicates that the Network Connect Block has an invalid format.

SS$_IVLOGNAM

The device or mailbox name string has a length of 0 or has more than 63 characters.

SS$_NOIOCHAN

No I/O channel is available for assignment.

SS$_NOLINKS

No logical network links are available.

SS$_NOPRIV

The process does not have the privilege to perform network operations.

SS$_NOSUCHDEV

Warning. The specified device or mailbox does not exist.

SS$_NOSUCHNODE

The specified network node is nonexistent or unavailable.

SS$_REJECT

The network connect was rejected by the network software or by the partner at the remote node; or the target image exited before the connect confirm could be issued.

Privilege Restrictions

The NETMBX privilege is required to perform network operations.

Resources Required/Returned

System dynamic memory is required if the target device is on a remote system.

Notes

1. For details on how to use $ASSIGN in conjunction with network operations, see the DECnet-VAX User's Guide.

2. Only the owner of a device can associate a mailbox with the device (the owner is the process that has allocated the device, either implicitly or explicitly), and only one mailbox can be associated with a device at a time. If a mailbox is associated with a device, the device driver can send messages containing status information to the mailbox, as in the following cases:

   - If the device is a terminal, a message indicates dialup, hangup, or the reception of unsolicited input.
   - If the target is on a network, the message may indicate that the network is connected or initiated, or whether the line is down.
   - If the device is a line printer, the message indicates that the printer is offline.

   For details on the message format and the information returned, see the VAX/VMS I/O User's Guide.

   Mailboxes cannot be associated with devices that have file-oriented (DEV$M_FOR) or shareable (DEV$M_SHR) characteristics.

   A mailbox is disassociated from a device when the channel that associated it is deassigned.

3. Channels remain assigned until they are explicitly deassigned with the Deassign I/O Channel ($DASSGN) system service, or, if they are user-mode channels, until the image that assigned the channel exits.

4. The $ASSIGN service establishes a path to a device, but does not check whether the caller can actually perform input/output operations to the device. Privilege and protection restrictions may be applied by the device drivers. For details on how the system controls access to devices, see the VAX/VMS I/O User's Guide.

For examples of how to use $ASSIGN to assign channels for input/output operations, see Chapter 6, "Input/Output Services."

$BINTIM - CONVERT ASCII STRING TO BINARY TIME

The Convert ASCII String to Binary Time system service converts an ASCII string to an absolute or delta time value in the system 64-bit time format suitable for input to the Set Timer ($SETIMR) or Schedule Wakeup ($SCHDWK) system services.

Macro Format

```
$BINTIM  timbuf ,timadr
```

High-Level Language Format

```
SYS$BINTIM(timbuf ,timadr)
```

timbuf

Address of a character string descriptor pointing to the buffer containing the absolute or delta time to be converted. The required formats of the ASCII strings are described in the Notes, below.

If a delta time is specified, it must be less than 10,000 days.

timadr

Address of a quadword that is to receive the converted time in 64-bit format.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_IVTIME

The syntax of the specified ASCII string is invalid, or the time component is out of range.

Notes

1. The $BINTIM service executes at the access mode of the caller and does not check whether address arguments are accessible before it executes. Therefore, an access violation causes an exception condition if the input buffer or buffer descriptor cannot be read or the output buffer cannot be written.

2. This service does not check the length of the argument list, and therefore cannot return the SS$_INSFARG (insufficient arguments) error status code. If the service does not receive enough arguments (for example, if you omit required commas in the call), you might not get the desired result.

3. The required ASCII input strings have the format:

   Absolute Time: dd-mmm-yyyy hh:mm:ss.cc

   Delta Time: dddd hh:mm:ss.cc

Field	Length (Bytes)	Contents	Range of values
dd	2	day of month	1 - 31
-	1	hyphen	Required syntax
mmm	3	month	JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
-	1	hyphen	Required syntax
yyyy	4	year	1858 - 9999
blank	n	blank	Required syntax
hh	2	hour	00 - 23
:	1	colon	Required syntax
mm	2	minutes	00 - 59
:	1	colon	Required syntax
ss	2	seconds	00 - 59
.	1	period	Required syntax
cc	2	hundredths of seconds	00 - 99
dddd	4	number of days (in 24-hour units)	000 - 9999

4. The following syntax rules apply to the coding of the ASCII input string:

   - Any of the fields of the date and time can be omitted.

     For absolute time values, the $BINTIM service supplies the current system date and time for nonspecified fields. Trailing fields can be truncated. If leading fields are omitted, the punctuation (hyphens, blanks, colons, periods) must be specified. For example, the string

     ```
     -- 12:00:00.00
     ```

     results in an absolute time of 12:00 on the current day.

     For delta time values, the $BINTIM service defaults nonspecified fields to 0. Trailing fields can be truncated. If leading fields are omitted from the time value, the punctuation (blanks, colons, periods) must be specified. For example, the string

     ```
     0 ::10
     ```

     results in a delta time of 10 seconds.

   - For both absolute and delta time values, there can be any number of leading or trailing blanks, and any number of blanks between fields normally delimited by blanks. However, there can be no embedded blanks within either the date or time fields, and no trailing characters that are not blanks (blank = hex 20).

$BRDCST

$BRDCST - BROADCAST

The Broadcast system service writes a message to one or more terminals.

Macro Format

```
$BRDCST  msgbuf, [devnam]
```

High-Level Language Format

```
SYS$BRDCST(msgbuf, [devnam])
```

msgbuf

Addess of a character string descriptor pointing to the text of the message to be broadcast. The maximum length of the message is 250 bytes.

devnam

Address of a character string descriptor pointing to the name of the terminal that is to receive the message. The string may be either a physical device name or a logical name. If the first character in the string is an underscore character (_), the name is considered a physical device name. Otherwise, a single level of logical name translation is performed and the equivalence name, if any, is used.

If this argument is omitted, or specified as 0, then the message is broadcast to all terminals.

If the first longword in the descriptor contains a 0, the message is sent to all terminals that are currently allocated to processes.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The message buffer or buffer descriptor, or the device name string or string descriptor, cannot be read by the caller.

SS$_DEVOFFLINE

The specified terminal is offline, has disabled broadcast message reception, has enabled passall mode, or is not a terminal.

SS$_EXQUOTA

The process has exceeded its buffer space quota and has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the request and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_NOPRIV

The process does not have the privilege to broadcast messages.

SS$_NOSUCHDEV

Warning. The specified terminal does not exist, or it cannot receive the message.

Privilege Restrictions

The user privilege OPER is required to broadcast a message to more than one terminal or to broadcast a message to a terminal that is allocated to any other user.

Resources Required/Returned

This service requires system dynamic memory, and uses the process's buffered I/O byte count quota (BYTLM) to buffer the message while the service executes.

Notes

1. The service does not return control to the caller until all specified terminals have displayed the broadcast message.

2. The current state (reading or writing) of each specified terminal determines when the message is displayed:

   - If the terminal is reading, the read operation is suspended, the broadcast occurs, and then the line being read is redisplayed (a CTRL/R is performed).

   - If the terminal is writing, the message is broadcast when the current write is complete.

   However, the message is not displayed in any of the following cases: the terminal is in PASSALL mode, the current operation is a "read physical block" (IO$_READPBLK function code), or the current operation has "no echo" specified (IO$M_NOECHO function modifier) or "no format" specified (IO$M_NOFORMAT function modifier).

   After the message is displayed, each terminal is returned to the state it was in prior to receiving the message. The message is preceded and followed by a carriage return/line feed.

   A terminal cannot receive a broadcast message, however, if it has the /NOBROADCAST characteristic.

$CANCEL - CANCEL I/O ON CHANNEL

The Cancel I/O On Channel system service cancels all pending I/O requests on a specific channel. In general, this includes all I/O requests that are queued as well as the request currently in progress.

Macro Format

```
$CANCEL  chan
```

High-Level Language Format

```
SYS$CANCEL(chan)
```

chan

Number of the I/O channel on which I/O is to be canceled.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_EXQUOTA

The process has exceeded its quota for direct I/O and has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_INSFMEM

Insufficient system dynamic memory is available to cancel the I/O, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVCHAN

An invalid channel was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The specified channel is not assigned, or was assigned from a more privileged access mode.

Privilege Restrictions

I/O can be canceled only from an access mode equal to or more privileged than the access mode from which the original channel assignment was made.

Resources Required/Returned

The Cancel I/O on channel system service requires system dynamic memory and uses the process's direct I/O limit (DIOLM) quota.

Notes

1. When a request currently in progress is canceled, the driver is notified immediately. Actual cancellation may or may not occur immediately depending on the logical state of the driver. When cancellation does occur, the action taken for I/O in progress is similar to that taken for queued requests:

   a. The specified event flag is set.

   b. The first word of the I/O status block, if specified, is set to SS$_CANCEL if the I/O request is queued or to SS$_ABORT if the I/O is in progress.

   c. The AST, if specified, is queued.

   Proper synchronization between this service and the actual canceling of I/O requests requires the issuing process to wait for I/O completion in the normal manner and then note that the I/O has been canceled.

2. If the I/O operation is a virtual I/O operation involving a disk or tape ACP, the I/O cannot be canceled. In the case of a magnetic tape, however, cancellation may occur if the device driver is hung.

3. Outstanding I/O requests are automatically canceled at image exit.

For an example of the $CANCEL system service and additional information on system services that perform device-dependent I/O operations, see Chapter 6, "Input/Output Services."

$CANEXH

$CANEXH - CANCEL EXIT HANDLER

The Cancel Exit Handler system service deletes an exit control block from the list of control blocks for the calling access mode. Exit control blocks are declared by the Declare Exit Handler ($DCLEXH) system service, and are queued according to access mode in a last-in first-out order.

Macro Format

```
$CANEXH  [desblk]
```

High-Level Language Format

```
SYS$CANEXH([desblk])
```

desblk

Address of the control block describing the exit handler to be canceled. If not specified, or specified as 0, all exit control blocks are canceled for the current access mode.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The first longword of the exit control block or the first longword of a previous exit control block in the list cannot be read by the caller, or the first longword of the preceding control block cannot be written by the caller.

SS$_NOHANDLER

Warning. The exit handler specified does not exist.

$CANTIM

$CANTIM - CANCEL TIMER

The Cancel Timer Request system service cancels all or a selected subset of the Set Timer requests previously issued by the current image executing in a process. Cancellation is based on the request identification specified in the Set Timer ($SETIMR) system service. If more than one timer request was given the same request identification, they are all canceled.

Macro Format

```
$CANTIM  [reqidt] ,[acmode]
```

High-Level Language Format

```
SYS$CANTIM([reqidt] ,[acmode])
```

reqidt

Request identification of the timer request(s) to be canceled. A value of 0 (the default) indicates that all timer requests are to be canceled.

acmode

Access mode of the request(s) to be canceled. The access mode is maximized with the access mode of the caller. Only those timer requests issued from an access mode equal to or less privileged than the resultant access mode are canceled.

Return Status

SS$_NORMAL

Service successfully completed.

Privilege Restrictions

Timer requests can be canceled only from access modes equal to or more privileged than the access mode from which the requests were issued.

Resources Required/Returned

Canceled timer requests are restored to the process's quota for timer queue entries (TQELM quota).

Notes

Outstanding timer requests are automatically canceled at image exit.

For an example of the $CANTIM system service and additional information on timer scheduled requests, see Chapter 8, "Timer and Time Conversion Services."

$CANWAK

$CANWAK - CANCEL WAKEUP

The Cancel Wakeup system service removes all scheduled wakeup requests for a process from the timer queue, including those made by the caller or by other processes. Scheduled wakeup requests are made with the Schedule Wakeup ($SCHDWK) system service.

Macro Format

```
$CANWAK  [pidadr] ,[prcnam]
```

High-Level Language Format

```
SYS$CANWAK([pidadr] ,[prcnam])
```

pidadr

Address of a longword containing the process identification of the process for which wakeups are to be canceled.

prcnam

Address of a character string descriptor pointing to the process name string. The process name is implicitly qualified by the group number of the process issuing the cancel wakeup request.

If neither a process identification nor a process name is specified, scheduled wakeup requests for the caller are canceled. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_IVLOGNAM

The process name string has a length of 0 or has more than 15 characters.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to cancel wakeups for the specified process.

Privilege Restrictions

User privileges are required to cancel scheduled wakeup requests for:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Resources Required/Returned

Canceled wakeup requests are restored to the process's AST limit quota (ASTLM).

Notes

1. Pending wakeup requests issued by the current image are automatically canceled at image exit.
2. This service only cancels wakeup requests that have been scheduled; it does not cancel wakeup requests made with the Wake Process ($WAKE) system service.

For an example of the $CANWAK system service, see Chapter 8, "Timer and Time Conversion Services." For more information on process hibernation and waking, see Chapter 7, "Process Control Services."

$CLREF - CLEAR EVENT FLAG

The Clear Event Flag system service sets an event flag in a local or common event flag cluster to 0.

Macro Format

```
$CLREF  efn
```

High-Level Language Format

```
SYS$CLREF(efn)
```

efn

Number of the event flag to be cleared.

Return Status

SS$_WASCLR

Service successfully completed. The specified event flag was previously 0.

SS$_WASSET

Service successfully completed. The specified event flag was previously 1.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Notes

For an example of the $CLREF system service, see Chapter 3, "Event Flag Services."

$CMEXEC

$CMEXEC - CHANGE TO EXECUTIVE MODE

The Change to Executive Mode system service allows a process to change its access mode to executive, execute a specified routine, and then return to the access mode in effect before the call was issued.

Macro Format

```
$CMEXEC  routin ,[arglst]
```

High-Level Language Format

```
SYS$CMEXEC(routin ,[arglst])
```

routin

Address of the routine to be executed in executive mode.

arglst

Address of the argument list to be supplied to the routine, if any.

Return Status

SS$_NOPRIV

The process does not have the privilege to change mode to executive.

All other values returned are from the routine executed.

Privilege Restrictions

A process can call this service if it has the user privilege CMEXEC and is currently executing in either executive or kernel mode.

Notes

1. The $CMEXEC system service uses standard procedure calling conventions to pass control to the specified routine. If no argument list is specified, the argument pointer (AP) contains a 0, unless it is modified by the caller. (However, to conform to the VAX-11 procedure calling standard, you must not omit the ARGLIST argument.) The routine must exit with a RET instruction.

2. The specified routine should place a status value in R0 before returning.

$CMKRNL - CHANGE TO KERNEL MODE

The Change to Kernel Mode system service allows a process to change its access mode to kernel, execute a specified routine, and then return to the access mode in effect before the call was issued.

Macro Format

```
$CMKRNL  routin ,[arglst]
```

High-Level Language Format

```
SYS$CMKRNL(routin ,[arglst])
```

routin

Address of the routine to be executed in kernel mode.

arglst

Address of the argument list to be supplied to the routine, if any.

Return Status

SS$_NOPRIV

The process does not have the privilege to change mode to kernel.

All other values returned are from the routine executed.

Privilege Restrictions

A process can call this service if it has the user privilege CMKRNL and is currently executing in either executive or kernel mode.

Notes

1. The $CMKRNL system service uses standard procedure calling conventions to pass control to the specified routine. If no argument list is specified, the argument pointer (AP) contains a 0, unless it is modified by the caller. (However, to conform to the VAX-11 procedure calling standard, you must not omit the ARGLIST argument.) The routine must exit with a RET instruction.

2. The specified routine should place a status value in R0 before returning.

$CNTREG

$CNTREG - CONTRACT PROGRAM/CONTROL REGION

The Contract Program/Control Region system service deletes a specified number of pages from the current end of the program or control region of a process's virtual address space. The deleted pages become inaccessible; any references to them cause access violations.

Macro Format

```
$CNTREG  pagcnt ,[retadr] ,[acmode] ,[region]
```

High-Level Language Format

```
SYS$CNTREG(pagcnt ,[retadr] ,[acmode] ,[region])
```

pagcnt

Number of pages to be deleted from the current end of the program or control region.

retadr

Address of a 2-longword array to receive the virtual addresses of the starting page and ending page of the deleted area.

acmode

Access mode of the owner of the pages to be deleted. The specified access mode is maximized with the access mode of the caller.

region

Region indicator. A value of 0 (the default) indicates that the program region (P0 region) is to be contracted, and a value of 1 indicates that the control region (P1 region) is to be contracted.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The return address array cannot be written by the caller.

SS$_ILLPAGCNT

The specified page count was less than 1.

SS$_PAGOWNVIO

A page in the specified range is owned by a more privileged access mode.

Notes

1. If an error occurs while deleting pages, the return range, if requested, indicates the pages that were successfully deleted before the error occurred. If no pages were deleted, both longwords in the return address array contain a -1.

2. The $CNTREG system service can delete pages only from the current end of the process's program or control region. To delete a specific range of pages in either region, use the Delete Virtual Address Space ($DELTVA) system service.

For an example of the $CNTREG system service and additional details on page creation and deletion, see Section 10.2, "Increasing and Decreasing Virtual Address Space."

$CRELOG

$CRELOG - CREATE LOGICAL NAME

The Create Logical Name system service inserts a logical name and its equivalence name into the process, group, or system logical name table. If the logical name already exists in the respective table, the new definition supersedes the old.

Macro Format

```
$CRELOG  [tblflg] ,lognam ,eqlnam ,[acmode]
```

High-Level Language Format

```
SYS$CRELOG([tblflg] ,lognam ,eqlnam ,[acmode])
```

tblflg

Logical name table number. A value of 0 indicates the system table (this is the default value), 1 indicates the group table, and 2 indicates the process logical name table.

lognam

Address of a character string descriptor pointing to the logical name string.

eqlnam

Address of a character string descriptor pointing to the equivalence name string.

acmode

Access mode to be associated with the logical name table entry. Access modes only qualify names in the process logical name table. The specified access mode is maximized with the access mode of the caller.

Return Status

SS$_NORMAL

Service successfully completed. A new name was entered in the specified logical name table.

SS$_SUPERSEDE

Service successfully completed. A new equivalence name replaced a previous equivalence name in the specified logical name table.

SS$_ACCVIO

The logical name or equivalence name string or string descriptor cannot be read by the caller.

SS$_INSFMEM

Insufficient system dynamic memory is available to allocate a group or system logical name table entry or the process has exceeded its limit for process logical name table entries. The code is only returned if the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVLOGNAM

The logical name or equivalence name string has a length of 0, or has more than 63 characters.

SS$_IVLOGTAB

An invalid logical name table number was specified.

SS$_NOPRIV

The process does not have the privilege to place an entry in the specified logical name table.

Privilege Restrictions

The user privileges GRPNAM and SYSNAM are required to place entries in the group and system logical name tables, respectively.

Resources Required/Returned

1. Up to 5 pages of memory are available in the control region of a process's virtual address space to store names in the process logical name table.

2. Creation of logical names for the group and system logical name tables requires system dynamic memory.

Notes

Logical names can also be created from the command stream, with the ASSIGN, DEFINE, ALLOCATE, and MOUNT commands.

For examples of the $CRELOG system service and details on logical name translation and deletion, see Chapter 5, "Logical Name Services."

$CREMBX

$CREMBX - CREATE MAILBOX AND ASSIGN CHANNEL

The Create Mailbox and Assign Channel system service creates a virtual mailbox device named MBn: and assigns an I/O channel to it. The system provides the unit number, n, when it creates the mailbox. If a mailbox with the specified name already exists, the $CREMBX service assigns a channel to the existing mailbox.

Macro Format

```
$CREMBX  [prmflg] ,chan ,[maxmsg] ,[bufquo] ,[promsk]
         ,[acmode] ,[lognam]
```

High-Level Language Format

```
SYS$CREMBX([prmflg] ,chan ,[maxmsg] ,[bufquo] ,[promsk]
           ,[acmode] ,[lognam])
```

prmflg

Permanent indicator. A value of 1 indicates that a permanent mailbox is to be created. The logical name, if specified, is entered in the system logical name table. A value of 0 (the default) indicates a temporary mailbox. The logical name, if specified, is entered in the group logical name table.

chan

Address of a word to receive the channel number assigned.

maxmsg

Number indicating the maximum size of messages that can be sent to the mailbox. If not specified, or specified as 0, the system provides a default value.

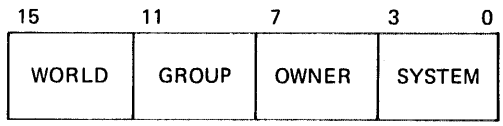
bufquo

Number of bytes of system dynamic memory that can be used to buffer messages sent to the mailbox. For a temporary mailbox, this value must be less than or equal to the process buffer quota. If not specified, or specified as 0, the system provides a default value.

promsk

Numeric value representing the protection mask for the mailbox.

The mask contains four 4-bit fields:



Bits, which are read from right to left in each field, indicate when they are cleared that read, write, execute and delete access, in that order, are granted to the particular category of user.

Only read access and write access are meaningful for mailbox protection.

If not specified, or specified as 0, read access and write access are granted to all users.

acmode

Access mode to be associated with the channel to which the mailbox is assigned. The access mode is maximized with the access mode of the caller.

lognam

Address of a character string descriptor pointing to the logical name string for the mailbox. (Section 6.13.1 explains the format of this string.) The logical name is entered into the group logical name table (if it is a temporary mailbox) or the system logical name table (if it is a permanent mailbox). In either case, the MBn: name is entered as the equivalence name (the first character in the equivalence name string is an underline character [_]). Processes can use the logical name to assign other I/O channels to the mailbox.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The logical name string or string descriptor cannot be read by the caller, or the channel number cannot be written by the caller.

SS$_EXPORTQUOTA

The process has exceeded the number of mailboxes that processes on this port of the multiport (shared) memory can create.

SS$_EXQUOTA

The process has exceeded its buffered I/O byte count quota.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service.

SS$_INTERLOCK

The bit map lock for allocating mailboxes from the specified shared memory is locked by another process.

SS$_IVLOGNAM

The logical name string has a length of 0 or has more than 63 characters.

SS$_NOIOCHAN

No I/O channel is available for assignment.

SS$_NOPRIV

The process does not have the privilege to create a temporary mailbox, a permanent mailbox, or a mailbox in memory that is shared by multiple processors.

SS$_NOSHMBLOCK

No shared memory mailbox control block is available to use to create a new mailbox.

SS$_SHMNOTCNCT

The shared memory named in the LOGNAM string is not known to the system. This error can be caused by a spelling error in the string, an improperly assigned logical name, or the failure to identify the memory as shared at SYSGEN time.

SS$_TOOMANYLNAM

Logical name translation of the LOGNAM string exceeded the allowed depth.

Privilege Restrictions

The user privileges TMPMBX and PRMMBX are required to create temporary and permanent mailboxes, respectively.

The user privilege SHMEM is required to create a mailbox in memory that is shared by multiple processors.

Resources Required/Returned

1. System dynamic memory is required for the allocation of a device data base for the mailbox and for an entry in the logical name table, if a logical name is specified.

2. When a temporary mailbox is created, the process's buffered I/O byte count (BYTLM) quota is reduced by the amount specified in the BUFQUO argument. The size of the mailbox unit control block and the logical name (if one is specified) are also subtracted from the quota. The quota is returned to the process when the mailbox is deleted.

Notes

1. After a mailbox is created, the creating process and other processes can assign additional channels to it by calling the Assign I/O Channel ($ASSIGN) system service. The system maintains a reference count of the number of channels assigned to a mailbox; the count is decreased whenever a channel is deassigned with the Deassign I/O Channel ($DASSGN) system service or when the image that assigned the channel exits. If it is a temporary mailbox, it is deleted when there are no more channels assigned. A permanent mailbox must be explicitly marked for deletion with the Delete Mailbox ($DELMBX) system service, and is then deleted when no more channels are assigned to it.

2. A mailbox is treated as a shareable device; it cannot, however, be mounted or allocated.

3. Mailboxes are assigned sequentially increasing unit numbers (from 1 to a maximum of 65,535) as they are created. When all unit numbers have been used, the system starts numbering again at unit 1.

4. A process can obtain the unit number of the created mailbox by calling the Get I/O Channel Information ($GETCHN) system service.

5. Default values for the maximum message size and the buffer quota (an appropriate multiple of the message size) are determined for a specific system during system generation. However, for termination mailboxes the maximum message size must be at least as large as the termination message (currently 84 bytes).

6. The reason $CREMBX simply assigns a channel if the mailbox already exists is to remove the need for cooperating processes to be concerned over which process must execute first to create the mailbox. If a temporary mailbox is being created, $CREMBX implicitly qualifies the mailbox name with the group number to check whether the mailbox already exists. In other words, there can be only one mailbox per group with the same name. For permanent mailboxes, there can be only one mailbox with a particular name. However, there can be a permanent mailbox and group mailboxes with the same name.

For an example of mailbox creation and input/output operations to it, see Section 6.13, "Mailboxes."

$CREPRC

$CREPRC - CREATE PROCESS

The Create Process system service allows a process to create another process. The created process can be either a subprocess or a detached process.

A detached process is a fully independent process. For example, the process that the system creates when a user logs in is a detached process. A subprocess, on the other hand, is related to its creator in a tree-like structure; it receives a portion of the creating process's resource quotas and must terminate before the creating process. The specification of the UIC argument controls whether the created process is a subprocess or a detached process.

Macro Format

```
$CREPRC  [pidadr] ,[image] ,[input] ,[output] ,[error]
        ,[prvadr] ,[quota] ,[prcnam] ,[baspri] ,[uic]
        ,[mbxunt] ,[stsflg]
```

High-Level Language Format

```
SYS$CREPRC([pidadr] ,[image] ,[input] ,[output] ,[error]
          ,[prvadr] ,[quota] ,[prcnam] ,[baspri] ,[uic]
          ,[mbxunt] ,[stsflg])
```

pidadr

Address of a longword to receive the process identification number assigned to the created process.

image

Address of a character string descriptor pointing to the file specification of the image to be activated in the created process. The image name can have a maximum of 63 characters.

input

Address of a character string descriptor pointing to the equivalence name string to be associated with the logical name SYS$INPUT in the logical name table for the created process. The equivalence name string can have a maximum of 63 characters.

output

Address of a character string descriptor pointing to the equivalence name string to be associated with the logical name SYS$OUTPUT in the logical name table for the created process. The equivalence name string can have a maximum of 63 characters.

error

Address of a character string descriptor pointing to the equivalence name string to be associated with the logical name SYS$ERROR in the logical name table for the created process. The equivalence name string can have a maximum of 63 characters.

prvadr

Address of a 64-bit mask defining privileges for the created process. The mask is formed by setting the bits corresponding to specific privileges (see Section 7.3.4 for an example). The $PRVDEF macro defines the following symbolic names for the bit settings:

Name	Privilege
PRV$V_ALLSPOOL	Allocate a spooled device
PRV$V_BUGCHK	Make bug check error log entries
PRV$V_BYPASS	Bypass UIC-based protection
PRV$V_CMEXEC	Change mode to executive
PRV$V_CMKRNL	Change mode to kernel
PRV$V_DETACH	Create detached processes
PRV$V_DIAGNOSE	Diagnose devices
PRV$V_EXQUOTA	Exceed quotas
PRV$V_GROUP	Group process control
PRV$V_GRPNAM	Place name in group logical name table
PRV$V_LOG_IO	Perform logical I/O operations
PRV$V_MOUNT	Issue mount volume QIO
PRV$V_NETMBX	Create a network device
PRV$V_NOACNT	Create processes for which no accounting is done
PRV$V_OPER	All operator privileges
PRV$V_PFNMAP	Map to section by physical page frame number
PRV$V_PHY_IO	Perform physical I/O operations
PRV$V_PRMCEB	Create permanent common event flag clusters
PRV$V_PRMGBL	Create permanent global sections
PRV$V_PRMMBX	Create permanent mailboxes
PRV$V_PSWAPM	Change process swap mode
PRV$V_SETPRI	Set any process priority
PRV$V_SETPRV	Set any process privileges
PRV$V_SHMEM	Allocate structures in memory shared by multiple processors
PRV$V_SYSGBL	Create system global sections
PRV$V_SYSNAM	Place name in system logical name table
PRV$V_SYSPRV	Access files and other resources as if you have a system UIC
PRV$V_TMPMBX	Create temporary mailboxes
PRV$V_VOLPRO	Override volume protection
PRV$V_WORLD	World process control

The user privilege SETPRV is required to grant a process any privileges other than one's own. If the caller does not have this privilege, the mask is minimized with the current privileges of the creating process, that is, any privileges the creator does not have are not granted but no error status code is returned.

quota

Address of a list of values assigning resource quotas to the created process. If no address is specified, or the address is specified as 0, the system supplies default values for the resource quotas.

The format of the quota list and considerations for specifying quota values are described later in this section, under the heading "Format of the Quota List." The specific quotas, their defaults, and their minimum values, are listed under the heading "Quota Descriptions."

prcnam

Address of a character string descriptor pointing to a 1- to 15-character process name string to be assigned to the created process. The process name is implicitly qualified by the group number of the caller, if a subprocess is created, or by the group number in the UIC argument, if a detached process is created.

baspri

Numeric value indicating the base priority to be assigned to the created process. The priority must be in the range of 0 to 31, where 31 is the highest priority level and 0 is the lowest. Normal priorities are in the range 0 through 15, and real-time priorities are in the range 16 through 31.

If not specified, the base priority for the created process is 2 for VAX-11 MACRO and VAX-11 BLISS-32 and 0 for other languages.

The user privilege SETPRI is required to set a priority higher than one's own. If the caller does not have this privilege, the specified base priority is compared with the caller's priority and the lower of the two values is used.

uic

Numeric value representing the user identification code (UIC) of the created process. This argument also indicates whether a process is a subprocess or a detached process.

If not specified, or specified as 0 (the default), it indicates that the created process is a subprocess; the subprocess has the same UIC as the creator.

If a nonzero value is specified, it indicates that the created process is a detached process. The specified value is interpreted as a 32-bit octal number, with two 16-bit fields:

bits 0-15 member number
bits 16-31 group number

The user privilege DETACH is required to create a detached process.

mbxunt

Unit number of a mailbox to receive a termination message when the created process is deleted. If not specified, or specified as 0 (the default), the system sends no termination message when it deletes the process. The format of the message is described in Note 2 below.

stsflg

32-bit status flag indicating options selected for the created process. The flag bits, when set, have the following meanings:

Bit	Meaning
0	Disable resource wait mode
1	Enable system service failure exception mode
2	Inhibit process swapping (PSWAPM privilege required)
3	Do not perform accounting (NOACNT privilege required)
4	Batch (non-interactive) process
5	Force process to hibernate before it executes the image
6	Provide detached process executing LOGINOUT.EXE with authorization file attributes of the creator; do not check authorization file
7	Process is a network connect object (NETMBX privilege required)
8-31	Reserved. These bits must be 0.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The caller cannot read a specified input string or string descriptor, the privilege list, or the quota list. Or, the caller cannot write the process identification.

SS$_DUPLNAM

The process name specified duplicates one already specified within that group.

SS$_EXQUOTA

1. The process has exceeded its quota for the creation of subprocesses.

2. A quota value specified for the creation of a subprocess exceeds the creator's corresponding quota; or, the quota is deductible and the remaining quota for the creator would be less than the minimum.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVLOGNAM

The specified process name has a length of 0 or has more than 15 characters.

SS$_IVQUOTAL

The quota list is not in the proper format.

SS$_IVSTSFLG

A reserved status flag was set.

SS$_NOPRIV

The caller has violated one of the privilege restrictions listed below.

SS$_NOSLOT

No process control block or swap slot is available. In other words, the maximum number of processes that can exist concurrently in the system has been reached.

Privilege Restrictions

User privileges are required to:

- Create detached processes (DETACH privilege)
- Set a created subprocess's base priority higher than one's own (ALTPRI privilege)
- Grant a process user privileges that the caller does not have (SETPRV privilege)
- Disable either process swap mode (PSWAPM privilege) or accounting functions (NOACNT privilege) for the created process
- Create a network connect object (NETMBX privilege)

Resources Required/Returned

1. The number of subprocesses that a process can create is controlled by the subprocess quota (PRCLM); the quota amount is returned when a subprocess is deleted.
2. The Create Process system service requires system dynamic memory.
3. When a subprocess is created, the value of any deductible quota is subtracted from the total value the creator has available; and when the subprocess is deleted, the unused portion of any deductible quota is added back to the total available to the creator. Any pooled quota value is shared by the creator and all its subprocesses. "Deductible" and "pooled" quotas are defined later in this section under the heading "Quota Descriptions." Information about how quotas are determined at process creation appears later under the heading "Quota Values."

Notes

1. Some error conditions are not detected until the created process executes. These conditions include an invalid or nonexistent image; invalid SYS$INPUT, SYS$OUTPUT, or SYS$ERROR logical name equivalences; and inadequate quotas or insufficient privilege to execute the requested image.

2. If a mailbox unit is specified, the mailbox is not used until the created process actually terminates. At that time, a $ASSIGN system service is issued for the mailbox in the context of the terminating process and an accounting message is sent to the mailbox. If the mailbox no longer exists, cannot be assigned, or is full, the error is treated as if no mailbox had been specified.

   The message is sent before the process rundown is initiated but after the process name has been set to null. Thus, a significant interval of time can occur between the sending of the termination message and the final deletion of the process.

   To receive the message, the caller must issue a read to the mailbox. When the I/O completes, the second longword of the I/O status block, if one is specified, contains the process identification of the deleted process.

   Symbolic names for offsets of fields within the accounting message are defined in the $ACCDEF macro. The offsets, their symbolic names, lengths, and the contents of each field are listed below.

Offset	Name	Length	Contents
0	ACC$W_MSGTYP	word	MSG$_DELPROC
2		word	not used
4	ACC$L_FINALSTS	longword	Exit status code
8	ACC$L_PID	longword	Process identification
12		longword	Not used
16	ACC$Q_TERMTIME	quadword	Current time in system format at process termination
24	ACC$T_ACCOUNT	8 bytes	Account name for process, blank filled
32	ACC$T_USERNAME	12 bytes	User name, blank filled
44	ACC$L_CPUTIM	longword	CPU time used by the process, in 10-millisecond units
48	ACC$L_PAGEFLTS	longword	Number of page faults incurred by the process in its lifetime
52	ACC$L_PGFLPEAK	longword	Peak paging file usage
56	ACC$L_WSPEAK	longword	Peak working set size
60	ACC$L_BIOCNT	longword	Count of buffered I/O operations performed by the process
64	ACC$L_DIOCNT	longword	Count of direct I/O operations performed by the process
68	ACC$L_VOLUMES	longword	Count of volumes mounted by the process
72	ACC$Q_LOGIN	quadword	Time in system format that process logged in
80	ACC$L_OWNER	longword	Process identification of owner

   The length of the termination message is equated to the constant ACC$K_TERMLEN.

3. All subprocesses created by a process must terminate before the creating process can be deleted. If subprocesses exist when their creator is deleted, they are automatically deleted.

For examples of subprocess creation, termination mailboxes, and system services that control the execution of processes, see Chapter 7, "Process Control Services."

Format of the Quota List

The system defines specific resources that are controlled by quotas. A quota limits the use of a particular system resource by a process.

The quota list addressed by the QUOTA argument of the $CREPRC system service consists of consecutive quota values contained in longwords, each preceded by a byte that indicates the quota type.

The $PQLDEF macro defines symbolic names for the quotas in the format:

```
PQL$_type
```

The quota list is terminated by the type code PQL$_LISTEND. For example, a quota list may be specified as:

```
QLIST:  .BYTE PQL$_PRCLM        ; LIMIT NUMBER OF SUBPROCESSES
        .LONG 2                 ; MAX = 2 SUBPROCESSES
        .BYTE PQL$_ASTLM        ; LIMIT NUMBER OF ASTS
        .LONG 6                 ; MAX = 6 OUTSTANDING ASTS
        .BYTE PQL$_LISTEND      ; END OF QUOTA LIST
```

Quota Descriptions

The individual quota types are described below. Each description also indicates the following characteristics of the quota:

- Minimum value. A process cannot be created if it does not have a quota equal to or greater than this minimum.
- Default value. If the quota list does not specify a value for a particular quota, the system assigns the process this default value.
- Deductible/Pooled/Nondeductible.

  Deductible quotas: When a subprocess is created, the value for a deductible quota is subtracted from the creator's current quota, and is returned to the creator when the subprocess is deleted. (Quotas are never deducted from the creator when a detached process is created.) There is currently only one deductible quota, the CPU time limit.

  Pooled quotas: These quotas are established when a detached process is created, and are shared by that process and all its descendent subprocesses. Charges against pooled quota values are subtracted from the current available totals as they are used, and are added back to the total when they are not being used.

  Non-deductible quotas: These quotas are established and maintained separately for each process and subprocess.

Note that the minimum and default values listed are not necessarily those provided at your installation; they are, however, the values recommended for general use.

The explanation under the heading "Quota Values," which appears later in this section, describes how these characteristics may affect quota assignments.

PQL$_ASTLM

AST limit. This quota restricts both the number of outstanding AST routines specified in system service calls that accept an AST address and the number of scheduled wakeup requests that can be issued.

Minimum: 2
Default: 6
Non-deductible

PQL$_BIOLM

Buffered I/O limit. This quota limits the number of outstanding system-buffered I/O operations. A buffered I/O operation is one which uses an intermediate buffer from the system pool rather than a buffer specified in a process's $QIO request.

Minimum: 2
Default: 6
Non-deductible

PQL$_BYTLM

Buffered I/O byte count quota. This quota limits the amount of system space that can be used to buffer I/O operations or to create temporary mailboxes.

Minimum: 1024
Default: 8192
Pooled

PQL$_CPULM

CPU time limit. This quota can be used to limit the total amount of CPU time used by a process. If the quota is specified as 0, there is no CPU time limit; the creating process, however, must have unlimited CPU time itself in order to grant the created process unlimited time.

If specified, the CPU time limit must be specified in units of 10 milliseconds. This quota is consumable; when the time limit has been used, the process is deleted. If a subprocess is given limited CPU time, the amount of time used is not returned to the creator when the subprocess is deleted.

Minimum: 0
Default: 0
Deductible

PQL$_DIOLM

Direct I/O quota. This quota limits the number of outstanding direct I/O operations. A direct I/O operation is one for which the system locks the pages containing the associated I/O buffer in memory for the duration of the I/O operation.

Minimum: 2
Default: 6
Non-deductible

PQL$_FILLM

Open file quota. This quota limits the number of files that a process can have open at one time.

Minimum: 2
Default: 10
Pooled

PQL$_PGFLQUOTA

Paging file quota. This quota limits the number of pages that can be used to provide secondary storage in the paging file for a process's execution.

Minimum: 256
Default: 2048
Pooled

PQL$_PRCLM

Subprocess quota. This quota limits the number of subprocesses a process can create.

Minimum: 0
Default: 8
Pooled

PQL$_TQELM

Timer queue entry quota. This quota limits both the number of timer queue requests a process can have outstanding and the creation of temporary common event flag clusters.

Minimum: 0
Default: 8
Pooled

PQL$_WSDEFAULT

Default working set size. This quota defines the number of pages in the default working set for any image executed by the process. The maximum size that can be specified for this quota is determined by the working set size quota.

Minimum: 10
Default: 100
Non-deductible

PQL$_WSQUOTA

Working set size quota. This quota limits the maximum size to which an image can expand its working set size with the Adjust Working Set Limit ($ADJWSL) system service.

Minimum: 10
Default: 120
Non-deductible

Quota Values

Values specified in the quota list are not necessarily the quotas that will actually be assigned to the created process. The $CREPRC system service performs the following steps to determine the quota values that will be assigned:

1. It constructs a default quota list for the process being created, assigning it the default values for all quotas.

2. It reads the specified quota list, if any, and updates the corresponding items in the default list. If the quota list contains multiple entries for a quota, only the last specification is used.

3. For each item in the updated quota list, it compares the quota value with the minimum value required for the quota and uses the larger value.

   If a subprocess is being created:

   1. The resulting value is compared with the current value of the corresponding quota of the creator. If the value exceeds the creator's quota, the status code SS$_EXQUOTA is returned and the subprocess is not created.

   2. If the quota is a deductible quota, it deducts the resulting value from the creator's quota and verifies that the creator will still have at least the minimum quota required. If not, the status code SS$_EXQUOTA is returned and the subprocess is not created.

   3. Pooled quota values are ignored.

   If a detached process is created, the resulting values are not compared with the creator's, nor are quotas deducted. Moreover, the service does not check that a specified quota value exceeds the maximum allowed by the system.

$CRETVA

$CRETVA - CREATE VIRTUAL ADDRESS SPACE

The Create Virtual Address Space system service adds a range of demand-zero allocation pages to a process's virtual address space for the execution of the current image.

Macro Format

```
$CRETVA  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$CRETVA(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be created. If the starting and ending virtual addresses are the same, a single page is created. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually created.

acmode

Access mode and protection for the new pages. The specified access mode is maximized with the caller's access mode. The protection of the pages is read/write for the resultant access mode and those more privileged.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The input address array cannot be read by the caller, or the return address array cannot be written by the caller.

SS$_EXQUOTA

The process has exceeded its paging file quota.

SS$_INSFWSL

The process's working set limit is not large enough to accommodate the increased size of the virtual address space.

SS$_NOPRIV

A page in the specified range is in the system address space.

SS$_PAGOWNVIO

A page in the specified range already exists and can not be deleted because it is owned by a more privileged access mode than that of the caller.

SS$_VASFULL

The process's virtual address space is full; no space is available in the page tables for the requested pages.

Resources Required/Returned

The processes paging file quota (PGFLQUOTA) and working set limit quota (WSQUOTA) must be sufficient to accommodate the increased size of the virtual address space.

Notes

1. Pages are created starting at the address contained in the first longword of the location addressed by the parameter INADR and ending with the second longword. The ending address can be lower than the starting address. The return address array indicates the byte addresses of the pages created.

2. If an error occurs while creating pages, the return array, if requested, indicates the pages that were successfully created before the error occurred. If no pages were created, both longwords of the return address array contain a -1.

3. If $CRETVA creates pages that already exist, the service deletes those pages if they are not owned by a more privileged access mode than that of the caller. Any such deleted pages are reinitialized as demand-zero pages.

The Expand Program/Control Region ($EXPREG) also adds pages to a process's virtual address space. For additional details on page creation and deletion, see Section 10.2, "Increasing and Decreasing Virtual Address Space."

$CRMPSC

$CRMPSC - CREATE AND MAP SECTION

The Create and Map Section system service creates and/or maps a section. A section can be a disk file section or a page frame section. A disk file section is data or code from a disk file that can be brought into memory and made available, either only to the process that creates it (private section) or to all processes that map to it (global section). A page frame section consists of one or more page frames in physical memory or I/O space; such sections are discussed in Section 10.6.13.

Creating a disk file section involves defining all or part of a disk file as a section. Mapping a disk file section involves making a correspondence between virtual blocks in the file and pages in the caller's virtual address space. If the $CRMPSC service specifies a global section that already exists, the service maps it.

Depending on the actual operation requested, certain arguments are required or optional. Table 1 summarizes how the $CRMPSC system service interprets the arguments passed to it, and under what circumstances it requires or ignores arguments.

Macro Format

```
$CRMPSC  [inadr] ,[retadr] ,[acmode] ,[flags] ,[gsdnam] ,[ident]
         ,[relpag] ,[chan] ,[pagcnt] ,[vbn] ,[prot] ,[pfc]
```

High-Level Language Format

```
SYS$CRMPSC([inadr] ,[retadr] ,[acmode] ,[flags] ,[gsdnam] ,[ident]
           ,[relpag] ,[chan] ,[pagcnt] ,[vbn] ,[prot] ,[pfc])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses in the process's virtual address space into which the section is to be mapped. If the starting and ending virtual addresses are the same, a single page is mapped (except when the SEC$M_EXPREG bit is set in the FLAGS argument). Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

If the SEC$M_EXPREG bit is set in the FLAGS argument, the addresses specified in the INADR argument simply determine whether the section is mapped in the program (P0) or control (P1) region.

If this argument is not specified, or specified as 0, the section is not mapped.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages into which the section was actually mapped.

acmode

Access mode to be the owner of the pages created during the mapping. The access mode is maximized with the access mode of the caller.

flags

Mask defining the section type and characteristics. This mask is the logical OR of the flag bits you wish to set. The $SECDEF macro defines symbolic names for the flag bits in the mask. Their meanings and the default values they override are:

Flag	Meaning	Default Attribute
SEC$M_GBL	Global section	Private section
SEC$M_CRF	Pages are copy-on-reference	Pages are shared
SEC$M_DZRO	Pages are demand-zero pages	Pages are not zeroed when copied
SEC$M_EXPREG	Map into first available space	Map into range specified by INADR argument
SEC$M_WRT	Read/write section	Read-only
SEC$M_PERM	Permanent	Temporary
SEC$M_PFNMAP	Page frame section	Disk file section
SEC$M_SYSGBL	System global section	Group global section

gsdnam

Address of a character string descriptor pointing to the text name string for the global section. (Section 10.6.5.1 explains the format of this text name string.) For group global sections, the global section name is implicitly qualified by the group number of the process creating the global section.

ident

Address of a quadword indicating the version number of a global section, and, for processes mapping to an existing global section, the criteria for matching the identification.

The version number is in the second longword. The version number contains two fields: a minor identification in the low-order 24 bits and a major identification in the high-order 8 bits. Values for these fields can be assigned by installation convention to differentiate versions of global sections. If no version number is specified when a section is created, processes that specify a version number when mapping cannot access the global section.

The first longword specifies, in its low-order 3 bits, the matching criteria. The valid values, symbolic names by which they can be specified, and their meanings are:

Value/Name	Match Criteria
0 SEC$K_MATALL	Match all versions of the section
1 SEC$K_MATEQU	Match only if major and minor identifications match
2 SEC$K_MATLEQ	Match if the major identifications are equal and the minor identification of the mapper is less than or equal to the minor identification of the global section

The match control field is ignored when a section is mapped at creation time. If no address is specified, or is specified as 0 (the default), the version number and match control fields default to 0.

relpag

Relative page number within the section of the first page in the section to be mapped. If this argument is not specified or is specified as 0 (the default), the global section is mapped beginning with the first virtual block in the file. This argument must be 0 for demand-zero sections in memory shared by multiple processors.

chan

Number of the channel on which the file has been accessed. The file must have been accessed with an RMS $OPEN macro; the file options parameter (FOP) in the FAB must indicate a user file open (UFO keyword). The access mode at which the channel was opened must be the same or less privileged than the access mode of the caller.

pagcnt

Number of pages in the section. The specified page count is compared with the number of pages in the section file; if they are different, the lower value is used. If the page count is not specified or is specified as 0 (the default), the size of the section file is used. However, for physical page frame sections, this argument must not be 0.

vbn

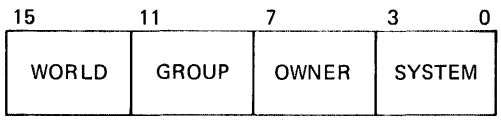
Virtual block number in the file that marks the beginning of the section. If this argument is not specified or is specified as 0 (the default), the section is created beginning with the first virtual block in the file.

If you specified page frame number mapping (by setting the SEC$M_PFNMAP flag), this argument specifies the page frame number where the section begins in memory.

prot

Numeric value representing the protection mask to be applied to the global section.

The mask contains four 4-bit fields:



Bits read from right to left in each field, when clear, indicate that read, write, execute, and delete access, in that order, are granted to the particular category of user.

Only read access and write access are meaningful for section protection.

If not specified, or specified as 0, read access and write access are granted to all users.

pfc

Page fault cluster size. If specified, the cluster size indicates how many pages are to be brought into memory when a page fault occurs for a single page. This argument is not used for physical page frame sections or for global sections in memory shared by multiple processors.

Table 1
Arguments for the $CRMPSC System Service

Argument	Create and Map Global Section	Map Global[1] Section	Create and Map Private Section
INADR	Optional[2]	Required	Required
RETADR	Optional	Optional	Optional
ACMODE	Optional	Optional	Optional
FLAGS			
SEC$M_GBL	Required	Ignored	---
SEC$M_CRF[3]	Optional	Not used	Optional
SEC$M_DZRO[3]	Optional	Not used	Optional
SEC$M_EXPREG	Optional	Optional	Optional
SEC$M_PERM	Optional[2]	Not used	Not used
SEC$M_PFNMAP	Optional	Not used	Not used
SEC$M_SYSGBL	Optional	Optional	Not used
SEC$M_WRT	Optional	Optional	Optional
GSDNAM	Required	Required	Not used
IDENT	Optional	Optional	Not used
RELPAG[3]	Optional	Optional	Not used
CHAN[3]	Required		Required
PAGCNT	Required		Required
VBN[3]	Optional		Optional
PROT	Optional		Not used
PFC[3]	Optional[4]		Optional

1. The Map Global Section ($MGBLSC) system service maps an existing global section.

2. INADR can be omitted only if you wish to create but not map a global section; however, in such a case you must make the section permanent, because temporary sections are automatically deleted when no processes are mapped to them. INADR cannot be omitted for demand-zero sections in memory shared by multiple processors.

3. For physical page frame sections: VBN specifies the starting page frame number; RELPAG, CHAN, and PFC are not used; the SEC$M_CRF and SEC$M_DZRO flag bit settings are invalid.

4. This argument is not used for global sections in memory shared by multiple processors.

Return Status

SS$_NORMAL

Service successfully completed. The specified global section already existed and has been mapped.

SS$_CREATED

Service successfully completed. The specified global section did not previously exist and has been created.

SS$_ACCVIO

The input address array or the global section name or name descriptor cannot be read, or the return address array cannot be written, by the caller.

SS$_ENDOFFILE

Warning. The starting virtual block number specified is beyond the logical end-of-file.

SS$_EXPORTQUOTA

The process has exceeded the number of global sections that processes on this port of the multiport (shared) memory can create.

SS$_GPTFULL

There is no more room in the system global page table to set up page table entries for the section.

SS$_GSDFULL

There is no more room in the system space allocated to maintain control information for global sections.

SS$_EXQUOTA

The process exceeded its paging file quota while creating copy-on-reference pages.

SS$_ILLPAGCNT

The page count value is negative, or is zero for a physical page frame section.

SS$_INSFMEM

Not enough pages are available in the specified shared memory to create the section.

SS$_INSFWSL

The process's working set limit is not large enough to accommodate the increased size of the address space.

SS$_INTERLOCK

The bit map lock for allocating global sections from the specified shared memory is locked by another process.

SS$_IVCHAN

An invalid channel number was specified, that is a channel number of 0 or a number larger than the number of channels available.

SS$_IVCHNLSEC

The channel number specified is currently active.

SS$_IVLOGNAM

The specified global section name has a length of 0, or has more than 15 characters.

SS$_IVSECFLG

An invalid flag has been specified: a reserved flag, a flag requiring a privilege you lack, or an invalid combination of flags.

SS$_IVSECIDCTL

The match control field of the global section identification is invalid.

SS$_NOTFILEDEV

The device is not a file-oriented, random-access, or directory device.

SS$_NOPRIV

The process does not have the privilege to create a system global section (SYSGBL) or a permanent group global section (PRMGBL).

The process does not have the privilege to create a section starting at a specific physical page frame number (PFNMAP).

The process does not have the privilege to create a global section in memory shared by multiple processors (SHMEM).

A page in the input address range is in the system address space.

The specified channel does not exist or was assigned from a more privileged access mode.

SS$_NOSHMBLOCK

No shared memory control block for global sections is available.

SS$_PAGOWNVIO

A page in the specified input address range is owned by a more privileged access mode.

SS$_SECTBLFUL

There are no entries available in the system global section table.

SS$_SHMNOTCNCT

The shared memory named in the GSDNAM string is not known to the system. This error can be caused by a spelling error in the string, an improperly assigned logical name, or the failure to identify the memory as shared at SYSGEN time.

SS$_TOOMANYLNAM

Logical name translation of the GSDNAM string exceeded the allowed depth.

SS$_VASFULL

The process's virtual address space is full; no space is available in the page tables for the pages created to contain the mapped global section.

Privilege Restrictions

The user privilege SYSGBL is required to create a system global section; the PRMGBL privilege is required to create a permanent global section.

The user privilege PFNMAP is required to create a section starting at a specific page frame number. However, the PFNMAP privilege is not required to map to an existing global section at a specific page frame number.

The user privilege SHMEM is required to create a global section in memory that is shared by multiple processors. However, the SHMEM privilege is not required to map to an existing global section in memory shared by multiple processors.

Resources Required/Returned

The process's working set limit quota (WSQUOTA) must be sufficient to accommodate the increased size of the virtual address space when mapping a section. If the section pages are copy-on-reference, the process must also have sufficient paging file quota (PGFLQUOTA).

Notes

1. When the $CRMPSC system service maps a section, it calls the Create Virtual Address Space ($CRETVA) system service to add the pages specified by the INADR argument or requested by the SEC$M_EXPREG flag bit setting to the process's virtual address space. The virtual addresses can be in the program (P0) region or the control (P1) region.

   The $CRMPSC system service returns the virtual addresses of the pages created in the RETADR argument, if specified. The section is mapped from a low address to a high address, regardless of whether the section is mapped in the program or control region.

2. If an error occurs during the mapping of a global section, the return address array, if specified, indicates the pages that were successfully mapped when the error occurred. If no pages were mapped, both longwords of the return address array contain -1.

   If the global section is permanent, it is not deleted if the mapping operation fails.

3. The SEC$M_PFNMAP flag setting identifies the memory for the section as starting at the page frame number specified in the VBN argument and extending for the number of pages specified in the PAGCNT argument. Setting the SEC$M_PFNMAP flag places these restrictions on the following arguments:

   RELPAG - Does not apply
   CHAN - Does not apply
   PAGCNT - Must be specified; cannot be zero
   VBN - Specifies first page frame to be mapped
   PFC - Does not apply

   Setting the SEC$M_PFNMAP flag also places restrictions on these other flag values:

   SEC$M_CRF - Must be 0
   SEC$M_DZRO - Must be 0.

For examples of the creation and mapping of private and global sections, see Section 10.6, "Sections."

$DACEFC

$DACEFC - DISASSOCIATE COMMON EVENT FLAG CLUSTER

The Disassociate Common Event Flag Cluster system service releases the calling process's association with a common event flag cluster.

Macro Format

```
$DACEFC  efn
```

High-Level Language Format

```
SYS$DACEFC(efn)
```

efn

Number of any event flag in the common cluster to be disassociated. The flag number must be in the range of 64 through 95 for cluster 2 and 96 through 127 for cluster 3.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ILLEFC

An illegal event flag number was specified. The number must be in the range of event flags 64 through 127.

SS$_INTERLOCK

The bit map lock for allocating common event flag clusters from the specified shared memory is locked by another process.

Notes

1. The count of processes associated with the cluster is decreased for each process that disassociates. When the image that associated with a cluster exits, the system performs an implicit disassociate for the cluster. When the count of processes associated with a temporary cluster or with a permanent cluster that is marked for deletion reaches zero, the cluster is automatically deleted.

2. If a process issues this service specifying an event flag cluster with which it is not associated, the service completes successfully.

For an example of the $DACEFC system service and a description of the creation and association of common event flag clusters, see Section 3.4, "Common Event Flag Clusters."

$DALLOC

$DALLOC - DEALLOCATE DEVICE

The Deallocate Device system service deallocates a previously allocated device. Exclusive use by the issuing process is relinquished and other processes can assign or allocate the device.

Macro Format

```
$DALLOC  [devnam] ,[acmode]
```

High-Level Language Format

```
SYS$DALLOC([devnam] ,[acmode])
```

devnam

Address of a character string descriptor pointing to the device name string. The string may be either a physical device name or a logical name. If the first character in the string is an underline character (_), the name is considered a physical device name. Otherwise, a single level of logical name translation is performed and the equivalence name, if any, is used. The final name, however, cannot contain a node name unless the name is that of the host system.

If no device name is specified, all devices allocated by the process from access modes equal to or less privileged than that specified are deallocated.

acmode

Access mode on behalf of which the deallocation is to be performed. The access mode is maximized with the access mode of the caller.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The device name string or string descriptor cannot be read by the caller.

SS$_DEVASSIGN

Warning. The device cannot be deallocated because the process still has channels assigned to it.

SS$_DEVNOTALLOC

Warning. The device is not allocated to the requesting process.

SS$_IVDEVNAM

No device name string was specified or the device name string contains invalid characters.

SS$_IVLOGNAM

The device name string has a length of 0 or has more than 63 characters.

SS$_NOPRIV

The device was allocated from a more privileged access mode.

SS$_NOSUCHDEV

Warning. The specified device does not exist in the host system.

Privilege Restrictions

An allocated device can be deallocated only from access modes equal to or more privileged than the access mode from which the original allocation was made.

Notes

1. A process cannot deallocate a device at any time. If, at the time of deallocation, the issuing process has one or more I/O channels assigned to the device, the device remains allocated.

2. The system automatically deallocates all devices that were allocated at user mode at image exit.

3. If an attempt is made to deallocate a mailbox, success is returned but no operation is performed.

For an example of how to use this service and additional notes on device allocation, see Section 6.9, "Device Allocation."

$DASSGN - DEASSIGN I/O CHANNEL

The Deassign I/O Channel system service releases an I/O channel acquired for input/output operations with the Assign I/O Channel ($ASSIGN) system service.

Macro Format

```
$DASSGN  chan
```

High-Level Language Format

```
SYS$DASSGN(chan)
```

chan

Number of the I/O channel to be deassigned.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_IVCHAN

An invalid channel number was specified; that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The specified channel is not assigned, or was assigned from a more privileged access mode.

Privilege Restrictions

An I/O channel can be deassigned only from an access mode equal to or more privileged than the access mode from which the original channel assignment was made.

Notes

1. When a channel is deassigned, any outstanding I/O requests on the channel are canceled. If a file is open on the specified channel, the file is closed.

2. If a mailbox was associated with the device when the channel was assigned, the linkage to the mailbox is cleared.

3. If the I/O channel was assigned for a network operation, the network link is disconnected. For more information on channel assignment and deassignment for network operations, see the DECnet-VAX User's Guide.

4. If the specified channel is the last channel assigned to a device that has been marked for dismounting, the device is dismounted.

5. I/O channels assigned from user mode are automatically deassigned at image exit.

For an example of the $DASSGN system service and additional information on channel assignment, see Section 6.1, "Assigning Channels."

$DCLAST

$DCLAST - DECLARE AST

The Declare AST system service queues an AST for the calling or for a less privileged access mode. For example, a routine executing in supervisor mode can declare an AST for either supervisor or user mode.

Macro Format

```
$DCLAST  astadr ,[astprm] ,[acmode]
```

High-Level Language Format

```
SYS$DCLAST(astadr ,[astprm] ,[acmode])
```

astadr

Address of the entry mask of the AST service routine.

astprm

Value to be passed to the AST routine as an argument, if any.

acmode

Access mode for which the AST is to be declared. This access mode is maximized with the access mode of the caller. The resultant mode is the access mode for which the AST is declared.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_EXQUOTA

The process has exceeded its AST limit quota.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

Resources Required/Returned

1. The Declare AST system service requires system dynamic memory.

2. This service uses the process's AST limit quota (ASTLM).

Notes

1. The $DCLAST system service does not validate the address of the AST service routine. If an illegal address, for example, an address of 0, is specified, an access violation occurs when the AST service routine is given control.

For an example of the $DCLAST system service and notes and coding conventions for AST service routines, see Chapter 4, "Asynchronous System Trap (AST) Services."

$DCLCMH - DECLARE CHANGE MODE OR COMPATIBILITY MODE HANDLER

Declare Change Mode or Compatibility Mode Handler ($DCLCMH) system service establishes the address of a routine to receive control when (1) a Change Mode to User or Change Mode to Supervisor instruction trap occurs, or (2) a compatibility mode fault occurs.

Macro Format

```
$DCLCMH  addres ,[prvhnd] ,[type]
```

High-Level Language Format

```
SYS$DCLCMH(addres ,[prvhnd] ,[type])
```

addres

Address of a routine to receive control when a change mode trap or a compatibility mode fault occurs. An address of 0 clears a previously declared handler.

prvhnd

Address of a longword to receive the address of a previously declared handler.

type

Type indicator. If specified as 0 (the default), a change mode handler is declared for the access mode at which the request is issued. If specified as 1, a compatibility mode handler is declared.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The longword to receive the address of the previous change mode handler cannot be written by the caller.

Notes

1. A change mode handler provides users with a dispatching mechanism similar to that used for system service calls. It allows a routine that executes in supervisor mode to be called from user mode. The change mode handler is declared from supervisor mode; when the process is then executing in user mode and issues a Change Mode to Supervisor instruction, the change mode handler receives control, and executes in supervisor mode.

2. Compatibility mode handlers are used by the operating system to bypass normal condition handling procedures when an image executing in compatibility mode incurs a compatibility mode exception.

3. When the change mode or compatibility mode handler receives control, the stack pointer points to the change mode code specified in the change mode instruction or the compatibility exception type code. On exit, the handler must remove the code from the stack, then relinquish control with an REI instruction.

4. A change mode handler can be declared only from user or supervisor modes.

$DCLEXH - DECLARE EXIT HANDLER

The Declare Exit Handler system service describes an exit handling routine to receive control when an image exits. Image exit normally occurs when the image currently executing in a process returns control to the operating system. Image exit may also occur when the Exit ($EXIT) or Force Exit ($FORCEX) system services are called.

Macro Format

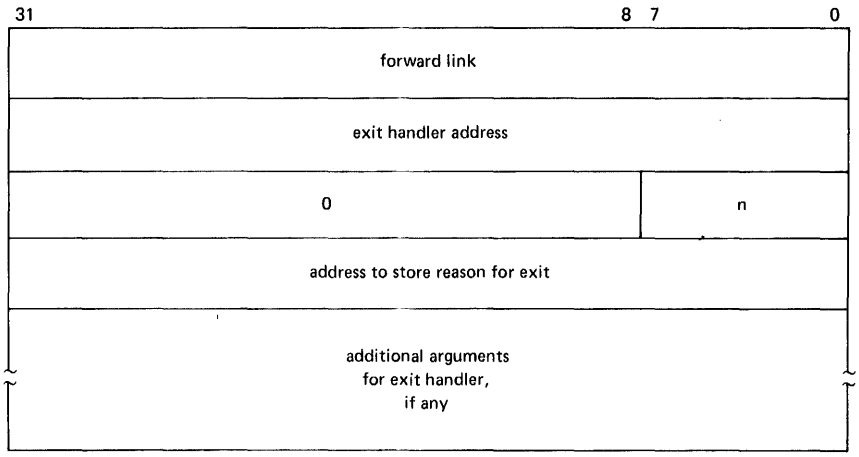
```
$DCLEXH  desblk
```

High-Level Language Format

```
SYS$DCLEXH(desblk)
```

desblk

Address of a control block describing the exit handler. The exit control block has the format:



The system fills in the first longword.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The first longword of the exit control block cannot be written by the caller.

SS$_NOHANDLER

Warning. No exit handler control block address was specified, or the address specified is 0.

Notes

1. Exit handlers are described by exit control blocks. The operating system maintains a separate list of these control blocks for user, supervisor, and executive modes. The $DCLEXH system service adds the description of an exit handler to the front of one of these lists. The actual list to which the exit control block is added is determined by the access mode of the caller.

   This service can only be called from user, supervisor, and executive modes.

2. At image exit, the exit handlers declared from user mode are called first; they are called in the reverse order from which they were declared.

   Each exit handler is executed only once; it must be redeclared before it can be executed again. The exit handling routine is called as a normal procedure with the argument list specified in the 3rd through nth longwords of the exit control block. The first argument is the address of a longword to receive a system status code indicating the reason for exit; the system always fills in this longword before calling the exit handler.

3. The Cancel Exit Handler ($CANEXH) removes an exit control block from the list.

For an example of an exit control block and a description of the action the system takes when an image exits, see Section 7.6, "Image Exit."

$DELLOG - DELETE LOGICAL NAME

The Delete Logical Name system service deletes a logical name and its equivalence name from the process, group, or system logical name table.

Macro Format

```
$DELLOG  [tblflg] ,[lognam] ,[acmode]
```

High-Level Language Format

```
SYS$DELLOG([tblflg] ,[lognam] ,[acmode])
```

tblflg

Logical name table number. A value of 0 (the default) indicates the system table, 1 indicates the group table, and 2 indicates the process table.

lognam

Address of a character string descriptor pointing to the logical name string. If omitted, all logical names the process is privileged to delete in the specified table are deleted.

acmode

Access mode associated with the process logical name table entry. The specified access mode is maximized with the access mode of the caller; only the logical name entered at the resulting access mode or a less privileged access mode is deleted. This argument is used only for deleting names from the process logical name table.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The logical name string or string descriptor cannot be read by the caller.

SS$_IVLOGNAM

The logical name string has a length of 0, or has more than 63 characters.

SS$_IVLOGTAB

An invalid logical name table number was specified.

SS$_NOLOGNAM

Either (1) the specified logical name does not exist in the specified logical name table, or (2) the specified logical name exists in the process logical name table but the entry was made from a more privileged access mode.

SS$_NOPRIV

The process does not have the privilege to delete an entry from the specified logical name table.

Privilege Restrictions

The user privileges GRPNAM and SYSNAM are required to delete names from the group and system logical name tables, respectively.

Resources Required/Returned

1. Deletion of a logical name from the group or system table returns storage to system dynamic memory.

2. When a logical name is deleted from the process logical name table, the number of bytes in the control region of the process's virtual address space required to maintain the table entry become available for other process logical name table entries.

Notes

1. Logical names can be deleted from the command stream with the DEASSIGN command.

2. Names in the process logical name table that were created from user mode are automatically deleted at image exit.

For an example of the $DELLOG system service and additional details on logical name creation and translation, see Chapter 5, "Logical Name Services."

$DELMBX - DELETE MAILBOX

The Delete Mailbox system service marks a permanent mailbox for deletion. The actual deletion of the mailbox and of its associated logical name assignment occur when no more I/O channels are assigned to the mailbox.

Macro Format

```
$DELMBX  chan
```

High-Level Language Format

```
SYS$DELMBX(chan)
```

chan

Number of the channel assigned to the mailbox.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_DEVNOTMBX

The specified channel is not assigned to a mailbox.

SS$_INTERLOCK

The bit map lock for allocating mailboxes from the specified shared memory is locked by another process.

SS$_IVCHAN

An invalid channel number was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The specified channel is not assigned to a device; the process does not have the privilege to delete a permanent mailbox or a mailbox in memory shared by multiple processors; or the access mode of the caller is less privileged than the access mode from which the channel was assigned.

Privilege Restrictions

1. The user privilege PRMMBX is required to delete a permanent mailbox.

2. The user privilege SHMEM is required to delete a mailbox located in memory that is shared by multiple processors.

3. A mailbox can be deleted only from an access mode equal to or more privileged than the access mode from which the mailbox channel was assigned.

Notes

1. Temporary mailboxes are automatically deleted when their reference count goes to zero.

2. The $DELMBX system service does not deassign the channel assigned by the caller, if any. The caller must deassign the channel with the Deassign I/O Channel ($DASSGN) system service.

For information on the creation and use of mailboxes, see Section 6.13, "Mailboxes."

$DELPRC - DELETE PROCESS

The Delete Process system service allows a process to delete itself or another process.

Macro Format

```
$DELPRC  [pidadr] ,[prcnam]
```

High-Level Language Format

```
SYS$DELPRC([pidadr] ,[prcnam])
```

pidadr

Address of a longword containing the process identification of the process to be deleted.

prcnam

Address of a character string descriptor pointing to the process name string. The process name is implicitly qualified by the group number of the process issuing the delete.

If neither a process identification nor a process name is specified, the caller is deleted and control is not returned. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to delete the specified process.

Privilege Restrictions

User privileges are required to delete:

- Other processes in the same group (GROUP privilege)
- Any process in the system (WORLD privilege)

Resources Required/Returned

1. The Delete Process system service requires system dynamic memory.
2. Deductible resource quotas granted to subprocesses are returned to the creator when the subprocesses are deleted.

Notes

1. When a subprocess is deleted, a termination message is sent to its creator, provided that the mailbox to receive the message still exists and the creating process has access to the mailbox. The termination message is sent before the final rundown is initiated; thus, the creator may receive the message before the process deletion is complete.
2. Due to the complexity of the required rundown operations, a significant time interval occurs between a delete request and the actual disappearance of the process. The Delete Process service, however, returns immediately after initiating the rundown operation. If subsequent delete requests are issued for a process currently being deleted, the requests return immediately with a return status code indicating successful completion.

For a complete list of the actions performed by the system when it deletes a process, see Sections 7.6, "Image Exit," and 7.7, "Process Deletion."

$DELTVA - DELETE VIRTUAL ADDRESS SPACE

The Delete Virtual Address Space system service deletes a range of addresses from a process's virtual address space. Upon successful completion of the service, the deleted pages are inaccessible; any references to them cause access violations.

Macro Format

```
$DELTVA  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$DELTVA(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be deleted. If the starting and ending virtual addresses are the same, a single page is deleted. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually deleted.

acmode

Access mode on behalf of which the service is to be performed. The specified access mode is maximized with the access mode of the caller. The resultant access mode is used to determine whether the caller can actually delete the specified pages.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The input address array cannot be read by the caller, or the return address array cannot be written by the caller.

SS$_NOPRIV

A page in the specified range is in the system address space.

SS$_PAGOWNVIO

A page in the specified range is owned by an access mode more privileged than the access mode of the caller.

Privilege Restrictions

Pages can only be deleted from access modes equal to or more privileged than the access mode of the owner of the pages.

Notes

1. The $DELTVA system service deletes pages starting at the address contained in the second longword of the INADR array and ending at the address in the first longword. Thus, if the same address array is used for the Create Virtual Address Space ($CRETVA) as for the $DELTVA system service, the pages are deleted in the reverse order from which they were created.

2. If any of the pages in the specified range have already been deleted or do not exist, the service continues as if the pages were successfully deleted.

3. If an error occurs while deleting pages, the return array, if requested, indicates the pages that were successfully deleted before the error occurred. If no pages are deleted, both longwords in the return address array contain a -1.

For an example of the $DELTVA system service and additional information on page creation and deletion, see Section 10.2, "Increasing and Decreasing Virtual Address Space."

$DGBLSC - DELETE GLOBAL SECTION

The Delete Global Section system service marks an existing permanent global section for deletion. The actual deletion of the global section takes place when all processes that have mapped the global section have deleted the mapped pages.

Macro Format

```
$DGBLSC [flags] ,gsdnam ,[ident]
```

High-Level Language Format

```
SYS$DGBLSC([flags] ,gsdnam ,[ident])
```

flags

Mask indicating global section characteristics. The only significant bit used for the deletion of global sections is the group/system flag. If this argument is specified as 0 (the default), it indicates that the global section is a group global section; if specified as SEC$M_SYSGBL, it indicates a system global section.

gsdnam

Address of a character string descriptor pointing to the text name string of the global section to be deleted. (Section 10.6.5.1 explains the format of this text name string.) For group global sections, the global section name is implicitly qualified by the group number of the caller.

ident

Address of a quadword indicating the version number of the global section to delete and the matching criteria to be applied.

The version number is in the second longword. The version number contains two fields: a minor identification in the low-order 24 bits and a major identification in the high-order 8 bits.

The first longword specifies, in the low-order 3 bits, the matching criteria. Their valid values, the symbolic names by which they can be specified, and their meanings are listed below:

Value/Name	Match Criteria
0 SEC$K_MATALL	Match all versions of the section
1 SEC$K_MATEQU	Match only if major and minor identifications match
2 SEC$K_MATLEQ	Match if the major identifications are equal and the minor identification of the mapper is less than or equal to the minor identification of the global section.

If no address is specified or is specified as 0 (the default), the version number and match control fields default to 0.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The global section name or name descriptor or the section identification field cannot be read by the caller.

SS$_INTERLOCK

The bit map lock for allocating global sections from the specified shared memory is locked by another process.

SS$_IVLOGNAM

The global section name has a length of 0, or has more than 15 characters.

SS$_IVSECFLG

An invalid flag has been specified. Either a reserved flag has been set, or one requiring a user privilege.

SS$_IVSECIDCTL

The section identification match control field is invalid.

SS$_NOPRIV

The caller does not have the privilege to delete a system global section (SYSGBL), or does not have read/write access to a group global section.

The caller does not have the privilege to delete a global section located in memory that is shared by multiple processors (SHMEM).

SS$_NOSUCHSEC

Warning. The specified global section does not exist, or the identifications do not match.

SS$_NOTCREATOR

The section is in memory shared by multiple processors, and was created by a process on another processor.

SS$_SHMNOTCNCT

The shared memory named in the GSDNAM string is not known to the system. This error can be caused by a spelling error in the string, an improperly assigned logical name, or the failure to identify the memory as shared at SYSGEN time.

SS$_TOOMANYLNAM

Logical name translation of the GSDNAM string exceeded the allowed depth of 10.

Privilege Restrictions

The user privileges SYSGBL and PRMGBL are required to delete system and permanent global sections, respectively.

The user privilege SHMEM is required to delete a global section located in memory that is shared by multiple processors.

The user privilege PFNMAP is required to delete a page frame section.

Notes

1. After a global section has been marked for deletion, any process that attempts to map it receives the warning return status code SS$_NOSUCHSEC.

2. Temporary global sections are automatically deleted when the count of processes using the section goes to 0.

3. This service does not unmap a section from a process's virtual address space. When a process no longer requires use of a section, it can unmap the section by calling the Delete Virtual Address Space ($DELTVA) system service to delete the pages to which the section is mapped.

4. A section located in memory that is shared by multiple processors can be marked for deletion only by a process running on the same processor that created the section.

For information on the creation and use of sections, see Section 10.6, "Sections."

$DLCEFC

$DLCEFC - DELETE COMMON EVENT FLAG CLUSTER

The Delete Common Event Flag Cluster system service marks a permanent common event flag cluster for deletion. The cluster is actually deleted when no more processes are associated with it.

Macro Format

```
$DLCEFC  name
```

High-Level Language Format

```
SYS$DLCEFC(name)
```

name

Address of a character string descriptor pointing to the name of the cluster. (Section 3.7.1 describes the format of this name string.) The name is implicitly qualified by the group number of the caller.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_IVLOGNAM

The cluster name string has a length of 0 or has more than 15 characters.

SS$_NOPRIV

The process does not have the privilege to delete a permanent common event flag cluster, or the process does not have the privilege to delete a common event flag cluster in memory shared by multiple processors.

Privilege Restrictions

The user privilege PRMCEB is required to delete a permanent common event flag cluster, except when the UIC of the caller is the same as the UIC of the creator of the cluster.

The user privilege SHMEM is required to delete an event flag cluster in memory shared by multiple processors.

Notes

1. The $DLCEFC system service does not perform an implicit disassociate request for the caller. A process disassociates with a cluster by calling the Disassociate Common Event Flag Cluster ($DACEFC) system service. The system performs an implicit disassociate for the cluster at image exit.

2. If the cluster has already been deleted or does not exist, the $DLCEFC service returns the status code SS$_NORMAL.

For an example of creating and using a common event flag cluster, see Section 3.4, "Common Event Flag Clusters."

$EXIT

$EXIT - EXIT

The Exit system service is used by the operating system to initiate image rundown when the current image in a process completes execution. Control normally returns to the command interpreter.

Macro Format

```
$EXIT  [code]
```

High-Level Language Format

```
SYS$EXIT([code])
```

code

Longword value to be saved in the process header as the completion status of the current image. If not specified in a macro call, a value of 1 is passed as the completion code for VAX-11 MACRO and VAX-11 BLISS-32 and a value of 0 is passed for other languages. This value can be tested at the command level to provide conditional command execution.

Return Status

No status codes are returned by this service because control is not returned to the caller; rather, an exit to the command interpreter is performed.

Notes

For a complete list of the actions taken by the system at image exit, see Section 7.6, "Image Exit."

$EXPREG

$EXPREG - EXPAND PROGRAM/CONTROL REGION

The Expand Program/Control Region system service adds a specified number of new virtual pages to a process's program region or control region for the execution of the current image. Expansion occurs at the current end of that region's virtual address space.

Macro Format

```
$EXPREG  pagcnt ,[retadr] ,[acmode] ,[region]
```

High-Level Language Format

```
SYS$EXPREG(pagcnt ,[retadr] ,[acmode] ,[region])
```

pagcnt

Number of pages to add to the current end of the program or control region.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually added.

acmode

Access mode and protection for the new pages. The specified access mode is maximized with the access mode of the caller. The protection of the pages is read/write for the specified access mode and more privileged access modes.

region

Region indicator. A value of 0 (the default) indicates that the program region (P0 region) is to be expanded. A value of 1 indicates that the control region (P1 region) is to be expanded.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The return address array cannot be written by the caller.

SS$_EXQUOTA

The process exceeded its paging file quota.

SS$_ILLPAGCNT

The specified page count was less than 1.

SS$_INSFWSL

The process's working set limit is not large enough to accommodate the increased virtual address space.

SS$_VASFULL

The process's virtual address space is full; no space is available in the process page table for the requested regions.

Resources Required/Returned

The process's paging file quota (PGFLQUOTA) and working set limit quota (WSQUOTA) must be sufficient to accommodate the increased size of the virtual address space.

Notes

1. The new pages, which were previously inaccessible to the process, are created as demand-zero pages.

2. Because the bottom of the user stack is normally located at the end of the control region, expanding the control region is equivalent to expanding the user stack. The effect is to increase the available stack space by the specified number of pages.

3. The starting address returned is always the first available page in the designated region; therefore, the ending address is smaller than the starting address when the control region is expanded and is larger than the starting address when the program region is expanded.

4. If an error occurs while adding pages, the return address array, if requested, indicates the pages that were successfully added before the error occurred. If no pages were added, both longwords of the return address array contain a -1.

5. The information returned in the location addressed by the RETADR argument, if specified, can be used as the input range to the Delete Virtual Address Space ($DELTVA) system service. Pages can also be deleted with the Contract Program/Control Region ($CNTREG) system service.

For an example of the $EXPREG system service and additional information on creating and deleting pages, see Section 10.2, "Increasing and Decreasing Virtual Address Space."

$FAO - FORMATTED ASCII OUTPUT

The Formatted ASCII Output system service converts binary values into ASCII characters and returns the converted characters in an output string. It can be used to:

- Insert variable character string data into an output string
- Convert binary values into the ASCII representations of their decimal, hexadecimal, or octal equivalents and substitute the results into an output string.

Syntactical notes, lists of valid FAO directives and parameters, and examples of using FAO appear later in this section.

The Formatted ASCII Output with List Parameter ($FAOL) macro provides an alternate way to specify input parameters for a call to the $FAO system service. The formats for both $FAO and $FAOL appear below.

Macro Format

```
$FAO  ctrstr ,[outlen] ,outbuf ,[p1] ,[p2] ...,[pn]
                       or
$FAOL ctrstr ,[outlen] ,outbuf ,prmlst
```

High-Level Language Format

```
SYS$FAO(ctrstr ,[outlen] ,outbuf ,[p1] ,[p2] ...,[pn])
                         or
SYS$FAOL(ctrstr ,[outlen] ,outbuf ,prmlst)
```

ctrstr

Address of a character string descriptor pointing to the control string. The control string consists of the fixed text of the output string and FAO directives.

outlen

Address of a word to receive the actual length of the output string returned.

outbuf

Address of a character string descriptor pointing to the output buffer. The fully formatted output string is returned in this buffer.

p1 - pn

Directive parameters contained in longwords. Depending on the directive, a parameter may be a value that is to be converted, the address of the string that is to be inserted, or a length or argument count. Each directive in the control string may require a corresponding parameter or parameters.

prmlst

Address of the parameter list of longwords to be used as P1 through Pn for the $FAOL macro. The parameter list may be a data structure that already exists in a program and from which certain values are to be extracted.

Return Status

SS$_BUFFEROVF

Service successfully completed. The formatted output string overflowed the output buffer and has been truncated.

SS$_NORMAL

Service successfully completed.

SS$_BADPARAM

An invalid directive was specified in the FAO control string.

Notes

1. The $FAO_S macro form uses a PUSHL instruction for all parameters (P1 through Pn) coded on the macro instruction; if a symbolic address is specified, it must be preceded with a number sign (#) character or loaded into a register.

2. A maximum of 20 parameters can be specified on the $FAO macro instruction. If more than 20 parameters are required, use the $FAOL macro.

3. The $FAO system service executes at the access mode of the caller and does not check whether address arguments are accessible before it executes. Therefore, an access violation causes an exception condition if an input field cannot be read or an output field cannot be written. Note that an access violation can occur if an invalid length is specified for an argument, or if an FAO parameter is coded incorrectly.

4. This service does not check the length of the argument list, and therefore cannot return the SS$_INSFARG (insufficient arguments) error status code. If the service does not receive enough arguments (for example, if you omit required commas in the call), you might not get the desired result.

FAO Directives

An FAO directive has the format:

!DD

! (exclamation mark) indicates that the following character or characters are to be interpreted as an FAO directive.

DD is a 1- or 2-character code indicating the action that FAO is to perform. Each directive may require one or more input parameters on the call to $FAO. All directive codes for FAO must be specified in uppercase letters.

Optionally, a directive may include:

- A repeat count
- An output field length

A repeat count is coded as follows:

```
!n(DD)
```

where n is a decimal value instructing FAO to repeat the directive for the specified number of parameters.

An output field length is specified as follows:

```
!lengthDD
```

where "length" is a decimal value instructing FAO to place the output resulting from a directive into a field of "length" characters in the output string.

A directive may contain both a repeat count and an output length, as shown below:

```
!n(lengthDD)
```

Repeat counts and output field lengths may be specified as variables, by using a # (number sign) in place of an absolute numeric value. If a # is specified for a repeat count, the next parameter passed to FAO must contain the count. If a # is specified for an output field length, the next parameter must contain the length value.

If a variable output field length is specified with a repeat count, only one length parameter is required; each output string will have the specified length.

FAO Control String and Parameter Processing

An FAO control string may be any length and may contain any number of FAO directives. The only restriction is on the use of the ! character (ASCII code ^X21) in the control string. If a literal ! is required in the output string, the directive !! provides an escape.

When FAO processes a control string, each character that is not part of a directive is written into the output buffer. When a directive is encountered, it is validated; if it is not a valid directive, FAO terminates and returns an error status code. If the directive is valid, and if it requires one or more parameters, the next consecutive parameters specified are analyzed and processed.

FAO reads parameters from the argument list; it does not check the number of arguments it has been passed. If there are not enough parameters coded in the argument list, FAO will continue reading past the end of the list. It is your responsibility, when coding a call to $FAO, to ensure that there are enough parameters to satisfy the requirements of all the directives in the control string.

Table 2 summarizes the FAO directives and lists the parameter(s) required by each directive. Table 3 summarizes how FAO determines the length of each output field in the control string as it processes directives and substitutes character strings in the control string while formatting the output buffer.

Examples in the next subsection, "FAO Examples," describe in more detail how to use FAO.

Table 2
Summary of FAO Directives

Directive	Function	Parameter(s)[1]
Character String Substitution		
!AC	Inserts a counted ASCII string	Address of the string; the first byte must contain the length
!AD	Inserts an ASCII string	1) Length of string 2) Address of string
!AF	Inserts an ASCII string; Replaces all nonprintable ASCII codes with periods (.)	1) Length of string 2) Address of string
!AS	Inserts an ASCII string	Address of quadword character string descriptor pointing to the string
Numeric Conversion (zero-filled)		
!OB	Converts a byte to octal	Value to be converted to ASCII representation For byte or word conversion, FAO uses only the low-order byte or word of the longword parameter
!OW	Converts a word to octal	
!OL	Converts a longword to octal	
!XB	Converts a byte to hexadecimal	
!XW	Converts a word to hexadecimal	
!XL	Converts a longword to hexadecimal	
!ZB	Converts an unsigned decimal byte	
!ZW	Converts an unsigned decimal word	
!ZL	Converts an unsigned decimal longword	
Numeric Conversion (blank-filled)		
!UB	Converts an unsigned decimal byte	Value to be converted to ASCII representation For byte or word conversion, FAO uses only the low-order byte or word of the longword parameter
!UW	Converts an unsigned decimal word	
!UL	Converts an unsigned decimal longword	
!SB	Converts a signed decimal byte	
!SW	Converts a signed decimal word	
!SL	Converts a signed decimal longword	

1. If a variable repeat count and/or a variable output field length is specified with a directive, parameters indicating the count and/or length must precede other parameters required by the directive.

Table 2 (Cont.)
Summary of FAO Directives

Directive	Function	Parameter(s)[1]
Output String Formatting		
!/	Inserts new line (CR/LF)	None
!_	Inserts a tab	
!^	Inserts a form feed	
!!	Inserts an exclamation mark	
!%S	Inserts the letter S if most recently converted numeric value is not 1	
!%T	Inserts the system time	Address of a quadword time value to be converted to ASCII. If 0 is specified, the current system time is used.
!%D	Inserts the system date and time	
!n< !>	Defines output field width of n characters. All data and directives within delimiters are left-justified and blank-filled within the field	None
!n*c	Repeats the specified character in the output string n times	
Parameter Interpretation		
!-	Reuses last parameter in the list	None
!+	Skips the next parameter in the list	

1. If a variable repeat count and/or a variable output field length is specified with a directive, parameters indicating the count and/or length must precede other parameters required by the directive.

Table 3
How FAO Determines Output Field Lengths and Fill Characters

Conversion /Substitution Type	Default Length of Output Field	Action When Explicit Output Field Length is Longer than Default	Action When Explicit Output Field Length is Shorter than Default
Hexadecimal Byte Word Longword	2 (zero-filled) 4 (zero-filled) 8 (zero-filled)	ASCII result is right-justified and blank-filled to the specified length	ASCII result is truncated on the left
Octal Byte Word Longword	3 (zero-filled) 6 (zero-filled) 11 (zero-filled)	Hexadecimal or octal output is always zero-filled to the default output field length then blank-filled to specified length	
Signed or Unsigned Decimal	As many characters as necessary	ASCII result is right-justified and blank-filled to the specified length	Signed and unsigned decimal output fields are completely filled with asterisks(*)
Unsigned Zero-filled Decimal	As many characters as necessary	ASCII result is right-justified and zero-filled to the specified length	
ASCII String Substitution	Length of input character string	ASCII string is left-justified and blank-filled to the specified length	ASCII string is truncated on the right

FAO Examples

Each of the examples on the following pages shows an FAO control string with several directives, parameters defined as input for the directives, and the calls to $FAO to format the output strings. The numbered examples illustrate:

1. $FAO macro, !AC, !AS, !AD, and !/ directives
2. $FAO macro, !!, and !AS directives, repeat count, output field length
3. $FAO macro, !UL, !XL, !SL directives
4. $FAOL macro, !UL, !XL, !SL directives
5. $FAOL macro, !UB, !XB, !SB directives
6. $FAO macro, !XW, !ZW, !- directives, repeat count, output field length
7. $FAOL macro, !AS, !UB, !%S, !- directives, variable repeat count
8. $FAO macro, !n*c (repeat character), !%D directives
9. $FAO macro, !%D and !%T (with output field lengths), !n* (with variable repeat count)
10. $FAO macro, !< and !> (define field width), !AC, and !UL directives

Each example is accompanied by notes, under the heading "Results". These notes show the output string created by the call to $FAO and describe in more detail some considerations for using directives. The sample output strings show delta characters (Δ) in all places where FAO output contains multiple blanks.

Each of the examples refers to the following output fields (these fields are not shown in the data areas for each example):

```
FAODESC:                        ;DESCRIPTOR FOR OUTPUT BUFFER
        .LONG   80              ;OUTPUT BUFFER LENGTH
        .LONG   FAOBUF          ;ADDRESS OF BUFFER
FAOBUF: .BLKB   80              ;80-CHARACTER BUFFER
FAOLEN: .BLKW   1               ;RECEIVE LENGTH OF OUTPUT
        .BLKW   1               ;RESERVE WORD FOR $QIO
```

These examples assume that each call to $FAO will be followed by a call to $QIO or to $OUTPUT to write the output string produced by FAO. The $QIO system service (and the $OUTPUT macro) require that the length be specified as a longword; therefore, an extra word is provided following the word defined to receive the length of the output string returned by $FAO.

Example 1

```
; CONTROL STRING AND INPUT PARAMETERS FOR EXAMPLE 1

SLEEPSTR: .ASCID @!/SAILORS: !AC !AS !AD@ ;DESCRIPTOR FOR CONTROL
          ;STRING. @ IS DELIMITER SINCE / IS IN CONTROL STRING

WINKEN: .ASCIC  /WINKEN/                    ;COUNTED ASCII STRING
BLINKEN: .ASCID /BLINKEN/                   ;CHARACTER STRING DESCRIPTOR
NOD:    .ASCII  /NOD/                       ;ASCII STRING
NODLEN: .LONG   NODLEN-NOD                  ;LENGTH OF ASCII STRING

; CALL TO $FAO

        $FAO_S  CTRSTR=SLEEPSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=#WINKEN,P2=#BLINKEN,P3=NODLEN,P4=#NOD
```

Results:

$FAO writes the output string into FAOBUF:

```
<CR><LF>SAILORS: WINKEN BLINKEN NOD
```

The !/ directive provides a carriage return/line feed character (shown as <CR><LF>) for terminal output.

The !AC directive requires the address of a counted ASCII string (P1 argument); the number sign (#) is required to specify the parameter, so that the PUSHL instruction used by the $FAO macro pushes the address rather than its contents.

The !AS directive requires the address of a character string descriptor (P2 argument).

The !AD directive requires two parameters: the length of the string to be substituted (P3 argument) and its address (P4 argument).

Example 2

```
; CONTROL STRING AND INPUT PARAMETERS FOR EXAMPLE 2

NAMESTR: .ASCID /UNABLE TO LOCATE !3(8AS)!!/        ;DESCRIPTOR FOR
                                                    CONTROL STRING

JONES:  .ASCID /JONES/                              ;NAME DESCRIPTOR
HARRIS: .ASCID /HARRIS/                             ;NAME DESCRIPTOR
WILSON: .ASCID /WILSON/                             ;NAME DESCRIPTOR

; CALL TO $FAO

        $FAO_S CTRSTR=NAMESTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
               P1=#JONES,P2=#HARRIS,P3=#WILSON
```

Results:

$FAO writes the output string into FAOBUF:

```
UNABLE TO LOCATE JONESΔΔΔHARRISΔΔWILSONΔΔ!
```

The !3(8AS) directive contains a repeat count: 3 parameters (addresses of character string descriptors) are required. $FAO left-justifies each string into a field of 8 characters (the output field length specified).

The !! directive supplies a literal ! in the output.

If the directive were specified without an output field length, that is, if the directive had been specified as !3(AS), the 3 output fields would be concatenated, as follows:

```
UNABLE TO LOCATE JONESHARRISWILSON!
```

Examples 3,4, and 5

```
; CONTROL STRINGS AND INPUT PARAMETERS FOR EXAMPLES 3, 4 AND 5

LONGSTR:        ;DESCRIPTOR FOR CONTROL STRING (LONGWORD CONVERSION)
        .ASCID /VALUES !UL (DEC) !XL (HEX) !SL (SIGNED)/

BYTESTR:        ;DESCRIPTOR FOR CONTROL STRING (BYTE CONVERSION)
        .ASCID /VALUES !UB (DEC) !XB (HEX) !SB (SIGNED)/

VAL1:   .LONG   200                     ;DECIMAL 200
VAL2:   .LONG   300                     ;DECIMAL 300
VAL3:   .LONG   -400                    ;NEGATIVE 400

; CALL TO $FAO (EXAMPLE 3)

        $FAO_S CTRSTR=LONGSTR,OUTBUF=FAODESC,OUTLEN=FAOLEN,-
        P1=VAL1,P2=VAL2,P3=VAL3
```

Results for Example 3:

$FAO writes the output string:

```
VALUES 200 (DEC) 0000012C (HEX) -400 (SIGNED)
```

The longword value 200 is converted to decimal, the value 300 is converted to hexadecimal, and the value -400 is converted to signed decimal. The ASCII results of each conversion are placed in the appropriate position in the output string.

Note that the hexadecimal output string has 8 characters and is zero-filled to the left. This is the default output length for hexadecimal longwords.

```
;  CALL TO $FAO (EXAMPLE 4)

          $FAOL_S CTRSTR=LONGSTR,OUTBUF=FAODESC,OUTLEN=FAOLEN,-
           PRMLST=VAL1
```

Results for Example 4:

$FAO writes the output string:

```
VALUES 200 (DEC) 0000012C (HEX) -400 (SIGNED)
```

The results are the same as the results of example 3. However, unlike the $FAO macro, which requires each parameter on the call to be coded, the $FAOL macro points to a list of consecutive longwords, which FAO reads as parameters.

```
;  CALL TO $FAO (EXAMPLE 5)

          $FAOL_S CTRSTR=BYTESTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
           PRMLST=VAL1
```

Results for Example 5:

$FAO writes the output string:

```
VALUES 200 (DEC) 2C (HEX) 112 (SIGNED)
```

The input parameters are the same as those for Example 4. However, the control string (BYTESTR) specifies that byte values are to be converted. FAO uses the low-order byte of each longword parameter passed to it. The high-order 3 bytes are not evaluated. Compare these results with the results of Example 4.

Example 6

```
; CONTROL STRING FOR EXAMPLE 6

MULTSTR: .ASCID /HEX: !2(6XW) ZERO-DEC: !2(-)!2(7ZW)/

; CALL TO FAO

        $FAO_S  CTRSTR=MULTSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=#10000,P2=#9999
```

Results:

FAO writes the output string:

```
HEX:△△△2710△△270F ZERO-DEC: 00100000009999
```

Each of the directives !2(6XW) and !2(7ZW) contain repeat counts and output lengths. First, FAO performs the !XW directive twice, using the low-order word of the numeric parameters passed. The output length specified is 2 characters longer than the default output field width of hexadecimal word conversion, so 2 spaces are placed between the resulting ASCII strings.

The !- directive causes FAO to back up over the parameter list. A repeat count is specified with the directive, so that FAO skips back over two parameters; then, it uses the same two parameters for the !ZW directive. The !ZW directive causes the output string to be zero-filled to the specified length, in this example, 7 characters. Thus, there are no blanks between the output fields.

Example 7

```
; CONTROL STRING AND INPUT PARAMETERS FOR EXAMPLE 7

ARGSTR: .ASCID /!AS RECEIVED !UB ARG!%S: !-!#(4UB)/

LISTA:  .LONG   ORION                   ;ADDRESS OF NAME STRING
        .LONG   3                       ;NUMBER OF ARGS IN LIST
        .LONG   10                      ;ARGUMENT 1
        .LONG   123                     ;ARGUMENT 2
        .LONG   210                     ;ARGUMENT 3

LISTB:  .LONG   LYRA                    ;ADDRESS OF NAME STRING
        .LONG   1                       ;NUMBER OF ARGS IN LIST
        .LONG   255                     ;ARGUMENT 1


ORION:  .ASCID  /ORION/         ;DESCRIPTOR FOR PROCESS ORION

LYRA:   .ASCID  /LYRA/          ;DESCRIPTOR FOR PROCESS LYRA

; CALLS TO FAO

        $FAOL_S CTRSTR=ARGSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                PRMLST=LISTA

        $FAOL_S CTRSTR=ARGSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                PRMLST=LISTB
```

Results:

Following the first call to $FAOL shown above, FAO writes the output string:

```
ORION RECEIVED 3 ARGS:ΔΔΔ10 123 210
```

Following the second call, FAO writes the output string:

```
LYRA RECEIVED 1 ARG:ΔΔ255
```

In each of the examples, the PRMLST argument points to a different parameter list; each list contains, in the first longword, the address of a character string descriptor. The second longword begins an argument list, with the number of arguments remaining in the list. The control string uses this second longword twice: first to output the value contained in the longword, and then to provide the repeat count to output the number of arguments in the list (the !- directive indicates that FAO should reuse the parameter).

The !%S directive provides a conditional plural. When the last value converted has a value not equal to 1, FAO outputs an "S"; if the value is a 1 (as in the second example), FAO does not output an "S".

The output field length defines a width of 4 characters for each byte value converted, to provide spacing between the output fields.

Example 8

```
; CONTROL STRING FOR EXAMPLE 8

TIMESTR: .ASCID /!5*> NOW IS: !%D/

; CALL TO $FAO

        $FAO_S CTRSTR=TIMESTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
               P1=#0
```

Results:

FAO writes the output string:

```
     >>>>> NOW IS: dd-mmm-yyyy hh:mm:ss.cc
```

where dd-mmm-yyyy is the current day, month, and year, and hh:mm:ss.cc is the current time of day in hours, minutes, seconds, and hundredths of seconds.

The !5*> directive requests FAO to write five greater than (>) characters into the output string. Since there is a space after the directive, FAO also writes a space after the > characters on output.

The !%D directive requires the address of a quadword time value, which must be in the system time format. However, when the address of the time value is specified as 0, FAO uses the current date and time. For information on how to obtain system time values in the required format, see Chapter 8, "Timer and Time Conversion Services." For a detailed description of the ASCII date and time string returned, see the discussion of the Convert Binary Time to ASCII String ($ASCTIM) system service in Part II.

Example 9

```
; CONTROL STRING FOR EXAMPLE 9

DAYTIMSTR: .ASCID /DATE: !11%D!#*_TIME: !5%T/

; CALL TO FAO

        $FAO_S CTRSTR=DAYTIMSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
               P1=#0,P2=#5,P3=#0
```

Results:

FAO writes the output string:

```
     DATE: dd-mmm-yyyy_____TIME: hh:mm
```

In this example, an output length of 11 bytes is specified with the !%D directive, so that FAO truncates the time from the date and time string, and outputs only the date.

The !#*_ directive requests that the underline character (_) be repeated the number of times specified by the next parameter. Since P2 is specified as 5, 5 underlines are written into the output string.

The !%T directive normally returns the full system time; in this example, the !5%T directive provides an output length for the time; only the hours and minutes fields of the time string are written into the output buffer.

Example 10

```
; CONTROL STRING AND PARAMETERS FOR EXAMPLE 10

WIDTHSTR: .ASCID /!25<VAR: !AC VAL: !UL!>TOTAL:!7UL/

VAR1NAME: .ASCIC /INVENTORY/                    ;VARIABLE 1 NAME
VAR1:     .LONG   334                           ;CURRENT VALUE
VAR1TOT:  .LONG   6554                          ;VAR 1 TOTAL

VAR2NAME: .ASCIC /SALES/                        ;VAR 2 NAME
VAR2:     .LONG   280                           ;CURRENT VALUE
VAR2TOT:  .LONG   10750                         ;VAR 2 TOTAL

; CALLS TO $FAO

        $FAO_S CTRSTR=WIDTHSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
               P1=#VAR1NAME,P2=VAR1,P3=VAR1TOT

        $FAO_S CTRSTR=WIDTHSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
               P1=#VAR2NAME,P2=VAR2,P3=VAR2TOT
```

Results:

Following the first call to FAO shown above, FAO writes the output string:

```
VAR: INVENTORY VAL: 334ΔΔTOTAL:ΔΔΔ6554
```

After the second call, FAO writes the output string:

```
VAR: SALES VAL: 280ΔΔΔΔΔΔTOTAL:ΔΔ10750
```

The !25< directive requests an output field width of 25 characters; the end of the field is delimited by the !> directive. Within the field defined in the example above are two directives, !AC and !UL. The strings substituted by these directives can vary in length, but the entire field always has 25 characters.

The !7UL directive formats the longword passed in each example (P2 argument) and right-justifies the result in a 7-character output field.

$FORCEX

$FORCEX - FORCE EXIT

The Force Exit system service causes an Exit ($EXIT) system service call to be issued on behalf of a specified process.

Macro Format

```
$FORCEX  [pidadr] ,[prcnam] ,[code]
```

High-Level Language Format

```
SYS$FORCEX([pidadr] ,[prcnam] ,[code])
```

pidadr

Address of a longword containing the process identification of the process to be forced to exit.

prcnam

Address of a character string descriptor pointing to the process name string. The name is implicitly qualified by the group number of the process issuing the force exit request.

code

Longword completion code value to be used as the exit parameter. If not specified, a value of 0 is passed as the completion code.

If neither a process identification nor a process name is specified, the caller is forced to exit and control is not returned. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to force an exit for the specified process.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

Privilege Restrictions

User privileges are required to force an exit for:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Resources Required/Returned

The Force Exit system service requires system dynamic memory.

Notes

1. The image executing in the target process follows normal exit procedures. For example, if any exit handlers have been specified, they gain control before the actual exit occurs. Use the Delete Process ($DELPRC) system service if you do not want a normal exit.

2. When a forced exit is requested for a process, a user mode AST is queued for the target process. The AST routine actually causes the Exit system service call to be issued by the target process. Because the AST mechanism is used, user mode ASTs must be enabled for the target process, or no exit occurs until ASTs are re-enabled. (Thus, for example, a suspended process cannot be stopped by $FORCEX.) The process that called $FORCEX receives no notification that the exit is not being performed.

3. The $FORCEX system service completes successfully if a force exit request is already in effect for the target process but the exit is not yet completed.

For an example of the $FORCEX system service and an explanation of the actions performed by the system when an image exits see Section 7.6, "Image Exit."

$GETCHN

$GETCHN - GET I/O CHANNEL INFORMATION

The Get I/O Channel Information system service returns information about a device to which an I/O channel has been assigned. Two sets of information are optionally returned:

- The primary device characteristics
- The secondary device characteristics

In most cases the two sets of characteristic information are identical. However, the two sets provide different information in the following cases:

- If the device has an associated mailbox, the primary characteristics are those of the assigned device and the secondary characteristics are those of the associated mailbox.
- If the device is a spooled device, the primary characteristics are those of the intermediate device and the secondary characteristics are those of the spooled device.
- If the device represents a logical link on the network, the secondary characteristics contain information about the link.

Macro Format

```
$GETCHN chan ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf]
```

High-Level Language Format

```
SYS$GETCHN(chan ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf])
```

chan

Number of the I/O channel assigned to the device.

prilen

Address of a word to receive the length of the primary characteristics.

pribuf

Address of a character string descriptor pointing to the buffer that is to receive the primary device characteristics. An address of 0 (the default) implies that no buffer is specified.

scdlen

Address of a word to receive the length of the secondary characteristics.

scdbuf

Address of a character string descriptor pointing to buffer that is to receive the secondary device characteristics. An address of 0 (the default) implies that no buffer is specified.

Return Status

SS$_BUFFEROVF

Service successfully completed. The device information returned overflowed the buffer(s) provided and has been truncated.

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

A buffer descriptor cannot be read by the caller, or a buffer or buffer length cannot be written by the caller.

SS$_IVCHAN

An invalid channel number was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The specified channel is not assigned or was assigned from a more privileged access mode.

Privilege Restrictions

The Get I/O Channel Information service can be performed only on assigned channels and from access modes that are equal to or more privileged than the access mode from which the original channel assignment was made.

Notes

1. The Get I/O Device Information ($GETDEV) system service returns the same information as the Get I/O Channel Information system service.

2. The $GETCHN and $GETDEV system services return information in a user-supplied buffer. Symbolic names defined in the $DIBDEF macro represent offsets from the beginning of the buffer. The length of the buffer is defined in the constant DIB$K_LENGTH.

The field offset names, lengths, and contents are listed below.

Field Name	Length (bytes)	Contents
DIB$L_DEVCHAR	4	Device characteristics
DIB$B_DEVCLASS	1	Device class
DIB$B_DEVTYPE	1	Device type
DIB$B_SECTORS	1	Number of sectors per track (disk)
DIB$B_TRACKS	1	Number of tracks per cylinder (disk)
DIB$W_CYLINDERS	2	Number of cylinders on the volume (disk)
DIB$W_DEVBUFSIZ	2	Device buffer size
DIB$L_DEVDEPEND	4	Device dependent information
DIB$L_MAXBLOCK	4	Number of logical blocks on the volume (disk)
DIB$W_UNIT	2	Unit number
DIB$W_DEVNAMOFF	2	Offset to device name string
DIB$L_PID	4	Process identification of device owner
DIB$L_OWNUIC	4	UIC of device owner
DIB$W_VPROT	2	Volume protection mask
DIB$W_ERRCNT	2	Error count
DIB$L_OPCNT	4	Operation count
DIB$W_VOLNAMOFF	2	Offset to volume label string
DIB$W_RECSIZ	2	Blocked record size (valid for magnetic tapes when DIB$W_VOLNAMOFF is nonzero)

The device name string and volume label string are returned in the buffer as counted ASCII strings and must be located by using their offsets from the beginning of the buffer.

Any fields not applicable to a particular device are returned as zeros.

For further details on the contents of this buffer and on device-dependent information returned, see the VAX/VMS I/O User's Guide.

$GETDEV - GET I/O DEVICE INFORMATION

The Get I/O Device Information system service returns information about an I/O device. This service allows a process to obtain information about a device to which the process has not assigned a channel. It returns the same information as described in the explanation of the Get I/O Channel Information ($GETCHN) system service. See Note 2 under the $GETCHN system for the format of information returned.

Macro Format

```
$GETDEV devnam ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf]
```

High-Level Language Format

```
SYS$GETDEV(devnam ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf])
```

devnam

Address of a character string descriptor pointing to the device name string. The string may be either a physical device name or a logical name. If the first character in the string is an underline character (_), the name is considered a physical device name. Otherwise, a single level of logical name translation is performed and the equivalence name, if any, is used.

prilen

Address of a word to receive the length of the primary characteristics.

pribuf

Address of a character string descriptor pointing to the buffer that is to receive the primary device characteristics. An address of 0 (the default) implies that no buffer is specified.

scdlen

Address of a word to receive the length of the secondary characteristics.

scdbuf

Address of a character string descriptor pointing to buffer that is to receive the secondary device characteristics. An address of 0 (the default) implies that no buffer is specified.

Return Status

SS$_BUFFEROVF

Service successfully completed. The device information returned overflowed the buffer(s) provided and has been truncated.

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

A buffer descriptor cannot be read by the caller, or a buffer or buffer length cannot be written by the caller.

SS$_IVDEVNAM

No device name was specified, or the device name string has invalid characters.

SS$_IVLOGNAM

The device name string has a length of 0 or has more than 63 characters.

SS$_NONLOCAL

Warning. The device is on a remote system.

SS$_NOSUCHDEV

Warning. The specified device does not exist on the host system.

$GETJPI - GET JOB/PROCESS INFORMATION

The Get Job/Process Information system service provides accounting, status, and identification information about a specified process.

Macro Format

```
$GETJPI  [efn],[pidadr],[prcnam],itmlst,[iosb],[astadr],[astprm]
```

High-Level Language Format

```
SYS$GETJPI([efn],[pidadr],[prcnam],itmlst,[iosb],[astadr],[astprm])
```

efn

Number of the event flag to be set when the request completes. If not specified, this argument defaults to 0.

pidadr

Address of a longword containing the process identification of the process for which information is requested.

prcnam

Address of a character string descriptor pointing to a 1- to 15-character process name string. The process name is implicitly qualified by the group number of the process issuing the request.

itmlst

Address of a list of item descriptors that describe the specific information requested and point to buffers to receive the information. The format of the list is described later in this section. The item codes are listed in Table 4.

iosb

Address of a quadword I/O status block that is to receive final completion status.

astadr

Address of the entry mask of an AST service routine to be executed when the service completes. If specified, the AST routine executes at the access mode from which the $GETJPI service was requested.

astprm

AST parameter longword to be passed to the AST completion routine.

If neither a process identification nor a process name is specified, information about the calling process is returned. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_BADPARAM

The item list contains an invalid identifier.

SS$_ACCVIO

The item list cannot be read by the caller, or the buffer length or buffer cannot be written by the caller.

SS$_IVLOGNAM

The process name string has a length of 0, or has more than 15 characters.

SS$_NOMOREPROC

Warning. During a "wildcard" process search (see Note 3), no more processes were found.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to obtain information about the specified process.

SS$_SUSPENDED

The specified process is suspended or in a miscellaneous wait state, and the requested information cannot be obtained.

Privilege Restrictions

User privileges are required to obtain information about:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Notes

1. Effective with Release 2 of VAX/VMS, the $GETJPI service sets event flag 0 at request completion by default. If any of your programs running under an earlier release depend on event flag 0 being clear after a call to $GETJPI, you will have to modify these programs.

2. If you request information about a process other than your own, $GETJPI operates asynchronously: that is, it returns control to your program before it places the requested information in the specified buffers. In such a case, if your program needs the information before it can proceed, you must wait for an event flag. For example:

```
$GETJPI_S EFN=#2,...
BSBW      ERROR
$WAITFR_S EFN=#2
BSBW      ERROR
```

   If you request information about your own process, $GETJPI does not return control to your program until after it places the requested information in the specified buffers.

   The reason that getting information about another process is an asynchronous operation is that the information may be contained in the other process's virtual address space and the process might have a lower priority or might be currently swapped out of the balance set. To allow your program to overlap other functions with the time needed to schedule the other process for execution or swap it into the balance set, $GETJPI returns immediately after it has queued its information-gathering request to the other process.

3. You can use "wildcard" process searching to get information about processes in the system for which you have the privilege to obtain information. To use this feature, set the longword pointed to by the PIDADR argument to negative one (-1), and then call $GETJPT continually (specifying the same PIDADR argument) until you receive the return status SS$_NOMOREPROC.

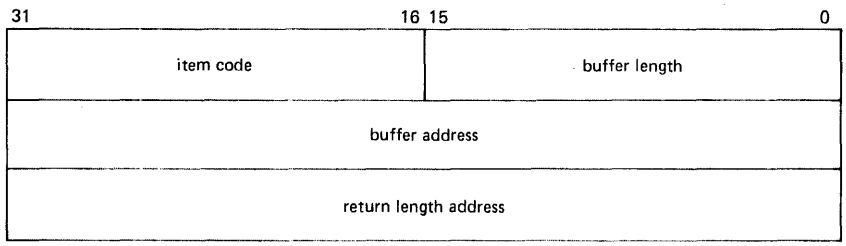
   This service uses the longword pointed to by the PIDADR argument to contain a value representing the current search context; therefore, you must specify the same PIDADR argument for each call to use this feature. To start a second "wildcard" process search after completing the first, you must set the longword pointed to by the PIDADR argument to -1 again.

   The following example shows a segment of code to obtain the user name of every process for which the caller has the privilege to obtain information.

```
            $JPIDEF                 ; Define $GETJPI item codes

PID:        .LONG   -1              ; "Wildcard" PID
ITEMS:      .WORD   12              ; Size of username buffer
            .WORD   JPI$_USERNAME   ; Username item code
            .LONG   UNAME           ; Address of username buffer
            .LONG   UNAMES          ; Address to return username size
            .LONG   0               ; End of list
UNAME:      .BLKB   12              ; Username buffer
UNAMES:     .BLKL   1               ; Username size buffer
IOSB:       .BLKQ   1               ; Completion status

START:      .WORD   0

LOOP:       $GETJPI_S EFN=#1,PIDADR=PID,ITMLST=ITEMS,IOSB=IOSB
            BLBS    R0,WAIT         ; If success, continue
            CMPW    R0,#SS$_NOPRIV  ; No privilege to set info on process?
            BEQL    LOOP            ; If no priv, try next process
            CMPW    R0,#SS$_SUSPENDED ; Process suspended?
            BEQL    LOOP            ; If yes, try next process
            CMPW    R0,#SS$_NOMOREPROC ; No more processes?
            BEQL    DONE            ; If yes, all done
            BSBW    ERROR           ; Else, error
WAIT:       $WAITFR_S EFN=#1        ; Wait for information
            MOVZWL  IOSB,R0         ; Get completion status
            BSBW    ERROR           ; Check for errors
            BSBW    DISPLAY_NAME    ; Display the name
BRB         LOOP                    ;
```

Format of Item List for $GETJPI System Service

The item list used for input to the $GETJPI system service consists of one or more consecutive item descriptors. Each item descriptor in this list has the format:



buffer length

Length of the buffer to receive the specified information. All buffers reserved to receive information should be longwords, unless otherwise indicated in Table 4.

item code

Symbolic name defining the information to be returned. The symbolic names have the format:

JPI$_code

These symbolic names are defined in the $JPIDEF macro. The codes are listed in Table 4.

buffer address

Address of the buffer to receive the specified information. If the buffer is too small for the requested information, $GETJPI truncates the information.

return length address

Address of a word to receive the length of the information returned. If this address is specified as 0, no length is returned.

The list of item descriptors must be terminated by an item code of 0 or a longword of 0.

All buffers are zero-filled on return, if necessary.

For example, an item list can be coded as follows to obtain the process identification and process name of a process:

```
GETLIST:.WORD 4                         ;LENGTH OF BUFFER
        .WORD JPI$_PID                  ;REQUEST PID
        .LONG GETPID                    ;ADDRESS TO RECEIVE PID
        .LONG 0                         ;DON'T NEED LENGTH RETURN
        .WORD 15                        ;LENGTH OF BUFFER
        .WORD JPI$_PRCNAM               ;REQUEST PROCESS NAME
        .LONG GETPRCNAM                 ;ADDRESS TO RECEIVE NAME
        .LONG PRCNAM_LEN                ;ADDRESS TO RECEIVE LENGTH
        .LONG 0                         ;END OF GETLIST
GETPID: .BLKL 1                         ;RETURN PID HERE
GETPRCNAM:
        .BLKB 15                        ;RETURN PROCESS NAME HERE
PRCNAM_LEN:
        .BLKW 1                         ;RETURN LENGTH OF PROCESS NAME
```

Table 4
Item Codes for Job/Process Information

Item Identifier	Data Type	Information Returned
JPI$_ACCOUNT	string	Account name string (1-8 characters)
JPI$_APTCNT	value	Active page table count
JPI$_ASTACT	value	Access modes with active ASTs
JPI$_ASTCNT	value	Remaining AST quota
JPI$_ASTEN	value	Access modes with ASTs enabled
JPI$_ASTLM	value	AST limit quota
JPI$_AUTHPRIV	value	Quadward mask of privileges the process is authorized to enable
JPI$_BIOCNT	value	Remaining buffered I/O quota
JPI$_BIOLM	value	Buffered I/O limit quota
JPI$_BUFIO	value	Count of process buffered I/O operations
JPI$_BYTCNT	value	Remaining buffered I/O byte count quota
JPI$_BYTLM	value	Buffered I/O byte count limit quota
JPI$_CPULIM	value	Limit on process CPU time
JPI$_CPUTIM	value	Accumulated CPU time (in 10-millisecond tics)
JPI$_CURPRIV	value	Quadword mask of process's current privileges
JPI$_DFPFC	value	Default page fault cluster size
JPI$_DFWSCNT	value	Default working set size
JPI$_DIOCNT	value	Remaining direct I/O quota
JPI$_DIOLM	value	Direct I/O limit quota
JPI$_DIRIO	value	Count of direct I/O operations for process
JPI$_EFCS	value	Local event flags 0 through 31
JPI$_EFCU	value	Local event flags 32 through 63
JPI$_EFWM	value	Event flag wait mask

(continued on next page)

Table 4 (Cont.)
Item Codes for Job/Process Information

Item Identifier	Data Type	Information Returned
JPI$_EXCVEC	address	Address of a list of exception vectors in the following order: primary and secondary exception vectors for kernel mode; primary and secondary exception vectors for executive mode; primary and secondary exception vectors for supervisor mode; primary and secondary exception vectors for user mode
JPI$_FILCNT	value	Remaining open file quota
JPI$_FILLM	value	Open file quota
JPI$_FINALEXC	address	Address of a list of final exception vectors for kernel, executive, supervisor, then user access mode
JPI$_FREP0VA	value	First free page at end of program region
JPI$_FREP1VA	value	First free page at end of control region
JPI$_GPGCNT	value	Global page count in working set
JPI$_GRP	value	Group number of UIC
JPI$_IMAGNAM	string	Current image file name (1 to 64 characters)
JPI$_IMAGPRIV	value	Quadword mask of privileges the current image was installed with
JPI$_LOGINTIM	value	Process creation time; returned as 64-bit system time value
JPI$_MEM	value	Member number of UIC
JPI$_OWNER	value	Process identification of process owner
JPI$_PAGEFLTS	value	Count of page faults
JPI$_PGFLQUOTA	value	Paging file quota (maximum virtual page count)
JPI$_PID	value	Process identification
JPI$_PPGCNT	value	Process page count in working set

(continued on next page)

Table 4 (Cont.)
Item Codes for Job/Process Information

Item Identifier	Data Type	Information Returned
JPI$_PRCCNT	value	Count of subprocesses
JPI$_PRCLM	value	Subprocess quota
JPI$_PRCNAM	string	Process name (1-15 characters)
JPI$_PRI	value	Current process priority
JPI$_PRIB	value	Process's base priority
JPI$_PROCPRIV	value	Quadword mask of process's default privileges
JPI$_STATE	value	Process state (Always SCH$K_CUR for the current process. States are defined by the $STATEDEF macro and contained in SYS$LIBRARY:LIB.MLB.)
JPI$_STS	value	Process status flags (defined by the $PCBDEF macro and contained in SYS$LIBRARY:LIB.MLB)
JPI$_TERMINAL	string	Login terminal name for interactive users (1-7 characters)
JPI$_TMBU	value	Termination mailbox unit number
JPI$_TQCNT	value	Remaining timer queue entry quota
JPI$_TQLM	value	Timer queue entry quota
JPI$_UIC	value	Process's UIC
JPI$_USERNAME	string	User name string (1-12 characters)
JPI$_VIRTPEAK	value	Peak virtual address size
JPI$_VOLUMES	value	Count of currently mounted volumes
JPI$_WSAUTH	value	Maximum authorized working set size
JPI$_WSPEAK	value	Working set peak
JPI$_WSQUOTA	value	Working set size quota
JPI$_WSSIZE	value	Process's current working set size

$GETMSG - GET MESSAGE

The Get Message system service locates and returns message text associated with a given message identification code into the caller's buffer. The message can be from the system message file or can be a user-defined message.

Macro Format

```
$GETMSG  msgid ,msglen ,bufadr ,[flags] ,[outadr]
```

High-Level Language Format

```
SYS$GETMSG(msgid ,msglen ,bufadr ,[flags] ,[outadr])
```

msgid

Identification of the message to be retrieved. Each message has a unique identification, contained in the high-order 29 bits of system longword status codes.

msglen

Address of a word to receive the length of the string returned.

bufadr

Address of a character string descriptor pointing to the buffer to receive the message string. The maximum size of any message that can be returned is 256 bytes.

flags

Mask defining message content. The bits in the mask and their meanings are:

Bit	Value	Meaning
0	1	Include text of message
	0	Do not include text of message
1	1	Include message identifier
	0	Do not include message identifier
2	1	Include severity indicator
	0	Do not include severity indicator
3	1	Include facility name
	0	Do not include facility name

If this argument is omitted in a MACRO or BLISS service call, it defaults to a value of 15; that is, all flags are set and all components of the message are returned. If this argument is omitted in a FORTRAN service call, it defaults to a value of 0.

outadr

Address of a 4-byte array to receive the following values:

Byte	Contents
0	Reserved
1	Count of FAO arguments associated with message
2	User-specified value in message; if any
3	Reserved

Return Status

SS$_BUFFEROVF

Service successfully completed. The string returned overflowed the buffer provided, and has been truncated.

SS$_MSGNOTFND

Service successfully completed; however, the message code cannot be found, and a default message has been returned (see Note 6).

SS$_NORMAL

Service successfully completed.

Notes

1. The operating system uses this service to retrieve messages based on unique message identifications and to prepare to output the messages.

2. The message identifications correspond to the symbolic names for status codes returned by system components, for example SS$_code from system services, RMS$_code for RMS messages, and so on.

3. When all bits in the FLAGS argument are set, $GETMSG returns a string in the format:

   facility-severity-ident, message-text

   where:

facility	identifies the component of the operating system
severity	is the severity code (the low-order three bits of the status code)
ident	is the unique message identifier
message-text	is the text of the message

   For example, if the MSGID argument is specified as:

   MSGID=#SS$_DUPLNAM

   $GETMSG returns the string:

   %SYSTEM-F-DUPLNAM, duplicate process name

4. This service does not check the length of the argument list, and therefore cannot return the SS$_INSFARG (insufficient arguments) error status code. If the service does not receive enough arguments (for example, if you omit required commas in the call), you might not get the desired result.

5. Users can define their own messages with the MESSAGE command. See the VAX-11 Utilities Reference Manual and the VAX/VMS Command Language User's Guide.

6. The message text associated with a particular 32-bit message identification can be retrieved from one of several places. This service takes the following steps to locate the message text:

    1. All message sections linked into the currently executing image are searched for the associated information.

    2. If the information is not found, the process permanent message file is searched. (The process permanent message file can be specified by the SET MESSAGE command.)

    3. If the information is not found, the system-wide message file is searched.

    4. If the information is not found, a message in the form

        ```
        %facility-severity-NONAME, message=xxxxxxxx[hex],
            (facility=n, message=n[dec])
        ```

        is returned to the caller's buffer and the status code SS$_MSGNOTFND is returned.

$GETTIM

$GETTIM - GET TIME

The Get Time system service furnishes the current system time in 64-bit format. The system time is updated every 10 milliseconds, and the time is returned in 100-nanosecond units from the system base time.

Macro Format

```
$GETTIM  timadr
```

High-Level Language Format

```
SYS$GETTIM(timadr)
```

timadr

Address of a quadword that is to receive the current time in 64-bit format.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The quadword to receive the time cannot be written by the caller.

Notes

For an example of the $GETTIM system service, and additional details on the system time format, see Chapter 8, "Timer and Time Conversion Services."

$HIBER - HIBERNATE

The Hibernate system service allows a process to make itself inactive but to remain known to the system so that it can be interrupted, for example to receive ASTs. A hibernate request is a wait-for-wake-event request. When a wake is issued for a hibernating process with the $WAKE system service or a result of a Schedule Wakeup ($SCHDWK) system service, the process continues execution at the instruction following the Hibernate call.

Macro Format[1]

$HIBER_S

High-Level Language Format

SYS$HIBER

Return Status

SS$_NORMAL

Service successfully completed.

Notes

1. A hibernating process can be swapped out of the balance set if it is not locked into the balance set.

2. The wait state caused by this system service can be interrupted by an asynchronous system trap (AST) if (1) the access mode at which the AST is to execute is equal to or more privileged than the access mode from which the hibernate request was issued and (2) the process is enabled for ASTs at that access mode.

   When the AST service routine completes execution, the system re-executes the $HIBER system service on the process's behalf. If a wakeup request has been issued for the process during the execution of the AST service routine (either by itself or another process), the process resumes execution. Otherwise, it continues to hibernate.

3. If one or more wakeup requests are issued for the process while it is not hibernating, the next hibernate call returns immediately, that is, the process does not hibernate. No count is maintained of outstanding wakeup requests.

---

1. Only the "_S" macro form is provided for the Hibernate system service.

4. Although this service has no arguments, a FORTRAN function reference must use parentheses to indicate a null argument list, as in:

```
ISTAT=SYS$HIBER()
```

For an example of the $HIBER system service and additional information on process hibernation, see Section 7.5, "Process Hibernation and Suspension." For an example of scheduled wakeup requests, see Section 8.6, "Scheduled Wakeups."

$INPUT - QUEUE INPUT REQUEST AND WAIT FOR EVENT FLAG

The $INPUT macro is a simplified form of the Queue I/O Request and Wait for Event Flag ($QIOW) system service. This macro queues a virtual input operation using the IO$_READVBLK function code and waits for I/O completion.

Macro Format

```
$INPUT  chan ,length ,buffer ,[iosb] ,[efn]
```

chan

Number of the I/O channel assigned to the device from which input is to be read.

length

Length of the input buffer.

buffer

Address of the input buffer.

iosb

Address of a quadword I/O status block.

efn

Number of the event flag to be set when the request is complete. The default is event flag 0.

Notes

The $INPUT macro has only one form. Arguments must be coded as for the $name_S macro form, but "_S" must not be included in the macro call.

Return Status, Privilege Restrictions, Resources Required/Returned, Additional Notes

See the description of the Queue I/O Request ($QIO) system service.

$LCKPAG

$LCKPAG - LOCK PAGES IN MEMORY

The Lock Pages In Memory system service locks a page or range of pages in memory. The specified virtual pages are forced into the working set and then locked in memory. A locked page is not swapped out of memory if its process's working set is. These pages are not candidates for page replacement and in this sense are locked in the working set as well.

Macro Format

```
$LCKPAG  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$LCKPAG(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be locked. If the starting and ending virtual addresses are the same, a single page is locked. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually locked.

acmode

Access mode of the locked pages. The specified access mode is maximized with the access mode of the caller. The resultant access mode must be equal to or more privileged than the access mode of the owner of each page in order to lock the page.

Return Status

SS$_WASCLR

Service successfully completed. All of the specified pages were previously unlocked.

SS$_WASSET

Service successfully completed. At least one of the specified pages was previously locked in memory.

SS$_ACCVIO

1. The input array cannot be read by the caller, or the output array cannot be written by the caller.

2. A page in the specified range is inaccessible or does not exist.

SS$_LCKPAGFUL

The system-defined maximum limit on the number of pages that can be locked in memory has been reached.

SS$_NOPRIV

The process does not have the privilege to lock pages in memory.

Privilege Restrictions

1. The user privilege PSWAPM is required to lock pages in memory.

2. The access mode of the caller must be equal to or more privileged than the access mode of the owner of the pages being locked.

Notes

1. If more than one page is being locked and it is necessary to determine specifically which pages had been previously locked, the pages should be locked one at a time.

2. If an error occurs while locking pages, the return array, if requested, indicates the pages that were successfully locked before the error occurred. If no pages are locked, both longwords in the return address array contain a -1.

3. Pages that are locked in memory can be unlocked with the Unlock Pages from Memory ($ULKPAG) system service. Locked pages are automatically unlocked at image exit.

$LWKSET

$LKWSET - LOCK PAGES IN WORKING SET

The Lock Pages in Working Set system service allows a process to specify that a group of pages that are heavily used should never be replaced in the working set. The specified pages are brought into the working set if they are not already there and are locked so that they do not become candidates for replacement.

Macro Format

```
$LKWSET  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$LKWSET(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be locked. If the starting and ending virtual addresses are the same, a single page is locked. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually locked.

acmode

Access mode of the locked pages. The specified access mode is maximized with the access mode of the caller. The resultant access mode must be equal to or more privileged than the access mode of the owner of each page in order to lock the page.

Return Status

SS$_WASCLR

Service successfully completed. All of the specified pages were previously unlocked.

SS$_WASSET

Service successfully completed. At least one of the specified pages was previously locked in the working set.

SS$_ACCVIO

1. The input address array cannot be read by the caller, or the output address array cannot be written by the caller.

2. A page in the specified range is inaccessible or nonexistent.

SS$_LKWSETFUL

The locked working set is full. If any more pages are locked, there will not be enough dynamic pages available to continue execution.

SS$_NOPRIV

A page in the specified range is in the system address space.

Privilege Restrictions

The access mode of the caller must be equal to or more privileged than the access mode of the owner of the pages being locked.

Notes

1. If more than one page is being locked and it is necessary to determine specifically which pages had been previously locked, the pages should be locked one at a time.

2. If an error occurs while locking pages, the return array, if requested, indicates the pages that were successfully locked before the error occurred. If no pages are locked, both longwords in the return address array contain a -1.

3. Pages that are locked in the working set can be unlocked with the Unlock Page from Working Set ($ULWSET) system service.

For an explanation of the relationship between a process's working set and its virtual address space, see Chapter 10, "Memory Management Services."

$MGBLSC

$MGBLSC - MAP GLOBAL SECTION

The Map Global Section provides a process with access to an existing global section. Mapping a global section establishes the correspondence between pages in the process's virtual address space and the physical pages occupied by the global section.

Macro Format

```
$MGBLSC  inadr ,[retadr] ,[acmode] ,[flags] ,gsdnam ,[ident]
         ,[relpag]
```

High-Level Language Format

```
SYS$MGBLSC(inadr ,[retadr] ,[acmode] ,[flags] ,gsdnam ,[ident]
           ,[relpag])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses in the process's virtual address space into which the section is to be mapped. The pages can be in the program (P0) region or the control (P1) region.

The second longword (ending address), however, is ignored by this service. The section is mapped as follows: the first relative page (RELPAG argument) is mapped at the starting virtual address, and the end of the section determines the actual ending virtual address.

If the SEC$M_EXPREG bit is set in the FLAGS argument, the addresses specified in the INADR argument determine only whether the section will be mapped in the program (P0) or control (P1) region.

Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages into which the section was actually mapped.

acmode

Access mode indicating the owner of the pages created during the mapping. The access mode is maximized with the access mode of the caller.

flags

Mask defining the section type and characteristics. This mask is the logical OR of the flag bits you wish to set. The flag bits for the mask are defined in the $SECDEF macro. Their meanings and the default values they override are:

Flag	Meaning	Default Attribute
SEC$M_WRT	Map section read/write	Map section read-only
SEC$M_SYSGBL	System global section	Group global section
SEC$M_EXPREG	Map into first available virtual address range	Map into address range specified by INADR

gsdnam

Address of a character string descriptor pointing to the text name string for the global section. (Section 10.6.5.1 explains the format of this text name string.) For group global sections, the global section name is implicitly qualified by the group number of the caller. All section names are implicitly qualified by their identification fields.

ident

Address of a quadword indicating the version number of the global section and the criteria for matching the identification.

The version number is in the second longword. The version number contains two fields: a minor identification in the low-order 24 bits and a major identification in the high-order 8 bits.

The first longword specifies, in the low-order 3 bits, the matching criteria. Their valid values, the symbolic names by which they can be specified, and their meanings are listed below:

Value/Name	Match Criteria
0 SEC$K_MATALL	Match all versions of the section
1 SEC$K_MATEQU	Match only if major and minor identifications match
2 SEC$K_MATLEQ	Match if the major identifications are equal and the minor identification of the mapper is less than or equal to the minor identification of the global section

If no address is specified or is specified as 0 (the default), the version number and match control fields default to 0.

relpag

Relative page number within the section of the first page to be mapped. If not specified or specified as 0 (the default), the global section is mapped beginning with the first virtual block in the section.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The input address array, the global section name or name descriptor, or the section identification field cannot be read by the caller, or the return address array cannot be written by the caller.

SS$_ENDOFFILE

Warning. The starting virtual block number specified is beyond the logical end-of-file.

SS$_EXQUOTA

The process exceeded its paging file quota creating copy-on-reference pages.

SS$_INSFWSL

The process's working set limit is not large enough to accommodate the increased virtual address space.

SS$_INTERLOCK

The bit map lock for allocating global sections from the specified shared memory is locked by another process.

SS$_IVLOGNAM

The global section name has a length of 0, or has more than 15 characters.

SS$_IVSECFLG

A reserved flag was set.

SS$_IVSECIDCTL

The match control field of the global section identification is invalid.

SS$_NOPRIV

The file protection mask specified when the global section was created prohibits the access or the type of access requested by the caller.

A page in the input address range is in the system address space.

SS$_NOSUCHSEC

Warning. The specified global section does not exist.

SS$_PAGOWNVIO

A page in the specified input address range is owned by a more privileged access mode.

SS$_SHMNOTCNCT

The shared memory named in the GSDNAM string is not known to the system. This error can be caused by a spelling error in the string, an improperly assigned logical name, or the failure to identify the memory as shared at SYSGEN time.

SS$_TOOMANYLNAM

Logical name translation of the GSDNAM string exceeded the allowed depth.

SS$_VASFULL

The process's virtual address space is full; no space is available in the page tables for the pages created to contain the mapped global section.

Privilege Restrictions

The privilege to map a global section, and whether it may be mapped read/write or read-only, is determined by the protection mask assigned to the global section when it was created.

Resources Required/Returned

The process's working set limit quota (WSQUOTA) must be sufficient to accommodate the increased size of the virtual address space when mapping a section. If the section pages are copy-on-reference, the process must also have sufficient paging file quota (PGFLQUOTA).

Notes

1. When the $MGBLSC system service maps a global section, it adds pages to the process's virtual address space. The section is mapped from a low address to a high address, regardless of whether the section is mapped in the program or control region.

2. If an error occurs during the mapping of a global section, the return address array, if specified, indicates the pages that were successfully mapped when the error occurred. If no pages were mapped, both longwords of the return address array contain -1.

For an example of the $MGBLSC system service and additional details on global section creation and use, see Section 10.6, "Sections."

$NUMTIM

$NUMTIM - CONVERT BINARY TIME TO NUMERIC TIME

The Convert Binary Time to Numeric Time system service converts an absolute or delta time from 64-bit system time format to binary integer date and time values. The numeric time is placed in a user-specified buffer as illustrated in Figure 1.

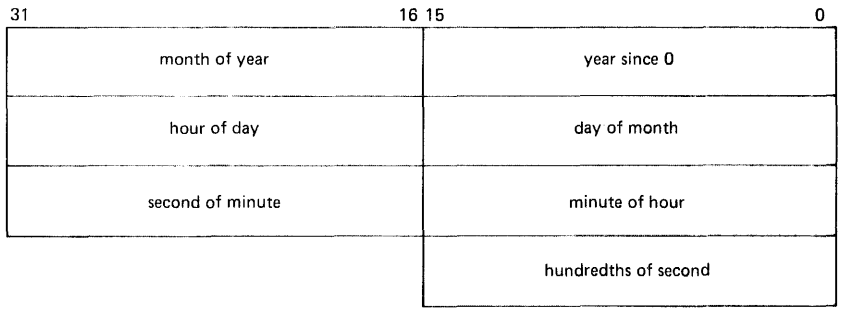


Figure 1 Format of Numeric Time Buffer

Macro Format

```
$NUMTIM  timbuf ,[timadr]
```

High-Level Language Format

```
SYS$NUMTIM(timbuf ,[timadr])
```

timbuf

Address of a 7-word buffer to receive the date and time information.

timadr

Address of a 64-bit time value to be converted. If not specified or specified as 0, the current system time is used. A positive time value represents an absolute time. A negative time value indicates a delta time.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The 64-bit time value cannot be read by the caller, or the numeric buffer specified cannot be written by the caller.

SS$_IVTIME

The specified delta time is equal to or greater than 10,000 days.

Notes

If a delta time is specified, the year and month fields of the information returned are zero. The day field contains the integer number of days specified by the delta time; it must be less than 10,000 days.

$OUTPUT

$OUTPUT - QUEUE OUTPUT REQUEST AND WAIT FOR EVENT FLAG

The $OUTPUT macro is a simplified form of the Queue I/O Request and Wait for Event Flag ($QIOW) system service. This macro performs a virtual output operation using the IO$_WRITEVBLK function code and waits for I/O completion.

Macro Format

```
$OUTPUT  chan ,length ,buffer ,[iosb] ,[efn]
```

chan

Number of the I/O channel assigned to the device to which output is to be written.

length

Length of the output buffer.

buffer

Address of the output buffer.

iosb

Address of quadword I/O status block.

efn

Number of the event flag to be set when the request is complete. The default is event flag 0.

Notes

1. The $OUTPUT macro has only one form. Arguments must be coded as for the $name_S macro form, but "_S" must not be included in the macro call.

2. The $OUTPUT macro supplies a P4 value of hexadecimal 20 to the $QIOW service. For output to a terminal, this value is a carriage control specifier indicating the following sequence: line feed, print buffer contents, return.

Return Status, Privilege Restrictions, Resources Required/Returned, Additional Notes

See the description of the Queue I/O Request ($QIO) system service for details.

$PURGWS

$PURGWS - PURGE WORKING SET

The Purge Working Set system service enables a process to remove pages from its current working set to reduce the amount of physical memory occupied by the current image.

Macro Format

```
$PURGWS  inadr
```

High-Level Language Format

```
SYS$PURGWS(inadr)
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be potentially purged from the working set. The $PURGWS system services locates pages within this range that are in the current working set and removes them.

If the starting and ending virtual addresses are the same, only that single page is a candidate for purging. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The input address array cannot be read by the caller.

Notes

To purge the entire working set, the caller can specify a range of pages from 0 through 7FFFFFFF. The image continues executing, and pages that are needed are brought back into the working set as the page faults occur.

$PUTMSG

$PUTMSG - PUT MESSAGE

The Put Message system service is a generalized message formatting and output routine used by the operating system to write informational and error messages to user processes.

Detailed information on the format of the message argument vector and the use of this service follows the "Return Status" description.

Macro Format

```
$PUTMSG  msgvec ,[actrtn] ,[facnam]
```

High-Level Language Format

```
SYS$PUTMSG(msgvec ,[actrtn] ,[facnam])
```

msgvec

Address of a message argument vector that lists the message identifications of messages to be output and FAO arguments associated with each message, if any. The format of the message vector is described later in this section.

actrtn

Address of the entry mask of a user-specified action routine to receive control during message processing. The action routine receives control after a message is formatted but before it is actually written to the user. If no address is specified, or specified as 0 (the default), it indicates that there is no action routine.

facnam

Address of a character string descriptor pointing to the facility name to be used in the first or only message formatted by $PUTMSG.

If not specified, the default facility name associated with the message is used in the first message.

Return Status

SS$_NORMAL

Service successfully completed.

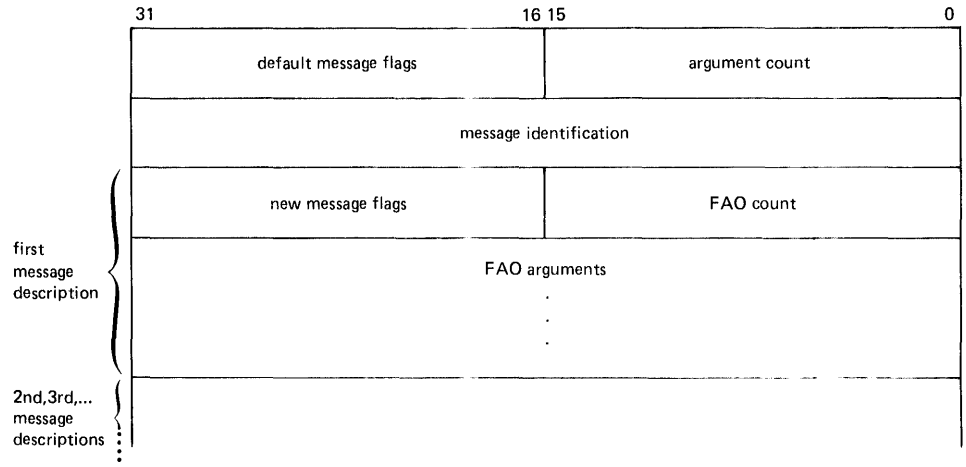
Notes

1. $PUTMSG returns the first message with the percent sign (%) prefix in front of the message. By convention, messages after the first message in a series are prefixed with a hyphen (-).

2. This service does not check the length of the argument list, and therefore cannot return the SS$_INSFARG (insufficient arguments) error status code. If the service does not receive enough arguments (for example, if you omit required commas in the call), you might not get the desired result.

Format of the Message Argument Vector for $PUTMSG

The general format of a message argument vector is as shown below. Messages with facility codes of either 0 (system status codes) or 1 (RMS status codes) vary from the basic format.



argument count

Specifies the total number of longwords in the message vector.

default message flags

Specifies a mask defining the portions of the message(s) to be requested from the $GETMSG system service. If not specified, the process default message flags are used. (These flags can be set using the SET MESSAGE command; see the VAX/VMS Command Language User's Guide.) If a mask is specified, it is passed to $GETMSG as the FLAGS argument.

This mask establishes the default flags for each message in this call until a new set of flags (if any) is specified. That is, each specified "new message flags" field sets a new default.

The bits in the mask and their meanings are:

Bit	Value	meaning
0	1	Include text of message
	0	Do not include text of message
1	1	Include message identifier
	0	Do not include message identifier
2	1	Include severity level indicator
	0	Do not include severity level indicator
3	1	Include facility name
	0	Do not include facility name

Bits 4 through 15 must be zeros.

message identification

32-bit numeric value that uniquely identifies this message. Messages can be identified by symbolic names defined for system return status codes, RMS status codes, and so on.

FAO count

Number of FAO arguments for this message, if any, that follow in the message vector. The FAO argument count is required for any message identifier for which the facility code is other than 0 (the system) or 1 (RMS). If a message with any other facility code has no associated FAO arguments, the FAO argument count must be specified as 0, unless the message identifier is the final item in the message vector.

new message flags

New mask for the $GETMSG flags, defining a new default for this message and all subsequent messages.

FAO arguments...

FAO arguments required by the message.

2nd, 3rd,... message descriptions

Descriptions of next associated messages, if messages are linked in a series.

Message identifications for system status codes, system exception condition values, and RMS status codes are handled as follows:

1. If the status code is a system message (that is, it has a facility code of 0), an FAO argument count, new messages flags, or FAO arguments cannot be specified. Each longword in the list (following the first message identification) is treated as an additional message identification.

2. If the message identification is a system exception message number (for example, SS$_COMPAT), the FAO arguments for the message must immediately follow the message identification in the message vector. $PUTMSG determines the count of FAO arguments from the message number.

   Note that the format of the message argument vector for an exception condition status code is identical to the signal array argument list passed to a condition handler when the system signals an exception condition.

3. If the message identification is an RMS status code (that is, it has a facility code of 1), you must specify a second longword following the status code in place of the FAO argument count and new message flags. This longword is reserved for an RMS status value (STV) for those RMS messages that have status values associated with them. If the status code has no STV value associated with it, $PUTMSG ignores the second longword. $PUTMSG uses the STV value as an FAO argument or as another message identification, depending on the value of the RMS message number.

   No FAO arguments can be specified for RMS status codes. If specified, $PUTMSG treats them as additional message identifiers.

The following example shows a message argument vector that requests $PUTMSG to output:

1. The complete message associated with the system status code SS$_ABORT

2. The complete message associated with the system status code RMS$_FNF

```
VECTOR: .LONG   3                ;ARGUMENT COUNT & NULL MSG. FLAGS
        .LONG   SS$_ABORT        ;ABORT MESSAGE
        .LONG   RMS$_FNF         ;FILE NOT FOUND MESSAGE
        .LONG   0                ;NULL STV PARAMETER
         .
         .
        $PUTMSG_S MSGVEC=VECTOR
```

When this message vector has been processed, the following messages are written to the current SYS$OUTPUT device (and to SYS$ERROR, if it is different):

```
%SYSTEM-F-ABORT, abort
-RMS-E-FNF, file not found
```

Using the $PUTMSG System Service

$PUTMSG retrieves a message from the system message file by calling the Get Message ($GETMSG) system service and formats the message by calling the Formatted ASCII Output ($FAO) system service, if necessary.

The Put Message ($PUTMSG) system service writes one or more formatted messages to a process's current output and/or error devices. A message is written after an action routine specified in the call to $PUTMSG, if any, returns control with a successful status value. If there is no action routine, the message is always written.

The actual disposition of each message depends on the severity level of the status value associated with the message. The following table indicates:

- Whether the message is written to the current output device (SYS$OUTPUT)
- Whether the message is written to the current error device (SYS$ERROR)
- Whether the message cancels the effect of CTRL/O, that is, if the message is displayed when the CTRL/O function has canceled all output to the terminal

Severity Level	Written to SYS$OUTPUT	Written to SYS$ERROR	Cancels CTRL/O
Warning	yes	yes	yes
Success	yes	no	no
Error	yes	yes	yes
Informational	yes	yes	no
Severe error	yes	yes	yes

$GETMSG Processing - The $GETMSG system service returns a message string based on the numeric status code value passed to it. The content of the string returned depends on the flags, if any, specified in the message argument vector. You can request that the message include or not include the facility name, severity level, message code, or text. The following example shows a message vector that requests only the text portion of the message associated with the system status code SS$_DUPLNAM:

```
VECTOR: .WORD  1                ;ARGUMENT COUNT
        .WORD  ^B0001           ;MSG. FLAGS - TEXT ONLY
        .LONG  SS$_DUPLNAM      ;MESSAGE IDENTIFICATION
```

If this message vector is specified for a call to $PUTMSG, $PUTMSG outputs the message:

```
duplicate process name
```

$GETMSG uses the facility code in the message identification to obtain the facility name string to insert in a message. Each system component has a unique code. The facility code is contained in bits 16 through 27 of the message identification. For example, the system has facility code of 0, the command interpreter is 1, the debugger is 2, and so on.

You can override the facility name by specifying the FACNAM argument to $PUTMSG. For example:

```
FAC:    .ASCID /HELLO/      ;DESCRIPTOR FOR NEW FACILITY NAME
VECTOR: .LONG  1            ;ARG. COUNT, NO MSG. FLAGS
        .LONG  SS$_NOPRIV   ;MESSAGE IDENTIFICATION
          .
          .
        $PUTMSG_S MSGVEC=VECTOR,FACNAM=FAC
```

This call to $PUTMSG results in the message:

```
%HELLO-F-NOPRIV, no privilege for attempted operation
```

You can modify a facility code in a message identification before calling $PUTMSG by changing bits 16 through 27. For example, a system status code can be specified as follows:

```
.LONG  2@16!SS$_code
```

In this example, the facility number 2 is inserted in the message identification. You can override the facility name string DEBUG in the message by specifying message flags in the argument vector to suppress the facility name, or you can use the FACNAM argument to $PUTMSG to specify an alternate facility name.

This technique allows you to use shared system message codes that have associated FAO arguments. If you do not modify the facility number in the shared system message identifications, you cannot specify FAO arguments.

When a message identification contains an unknown facility code, $GETMSG places the string NONAME in place of the facility name in the message string.

$FAO Processing - If the string returned by $GETMSG contains any FAO directives, and if the facility code is other than 0 or 1, $PUTMSG calls the $FAO system service to format the message. $PUTMSG calls $FAO with the argument count and arguments specified in the message argument vector.

The FAO argument count, if any, for a message is indicated in the message file that defines the message text. The message text itself contains embedded FAO directives. You can examine the message text to determine the arguments required by FAO. For example, the message text associated with the system status code SHR$_BEGIN is defined as:

```
!AS beginning
```

This text requires the address of a character string descriptor pointing to the text to be substituted in place of the FAO directive !AS. (For details on how to use FAO and how to specify arguments for other FAO directives, see the description of the $FAO system service.)

To use $PUTMSG to access and/or output a system shared message that has FAO arguments associated with it, you must change the facility code. The following example shows a message vector, including the FAO argument count and argument, to output the message associated with the status code SHR$_BEGIN.

```
VECTOR: .WORD  3                 ;ARGUMENT COUNT (LONGWORDS)
        .WORD  ^B0001            ;MESSAGE FLAGS
        .LONG  2@16!SHR$_BEGIN   ;MESSAGE IDENTIFICATION
        .WORD  1                 ;FAO ARGUMENT COUNT
        .WORD  0                 ;NO NEW MSG. FLGS.
        .LONG  NAME              ;FAO ARGUMENT
NAME:   .ASCID /PUTMSG tests/
```

When $PUTMSG is called with this message vector, it displays the line:

```
PUTMSG tests beginning
```

Note that the facility code in the message identification is modified to allow the specification of FAO arguments; and that the message flags in the second word of the vector suppresses the printing of facility name, severity level, and message code.

The Action Routine - The action routine, if any, is called as a normal procedure each time a message is formatted, but before it is actually output. The action routine receives as an argument the address of a character string descriptor pointing to the formatted message. The action routine can access the message text, scan it, write it to a user-specified file or device, modify it, and so on.

On return from the action routine, $PUTMSG examines the completion code from the routine specified in Register 0. If the completion code indicates success (any odd numeric value), $PUTMSG outputs the message as described earlier under "Using the $PUTMSG System Service." If the completion code indicates non-success (any even numeric value), $PUTMSG does not output the message.

$QIO

$QIO - QUEUE I/O REQUEST

The Queue I/O Request system service initiates an input or output operation by queueing a request to a channel associated with a specific device. Control returns immediately to the issuing process, which can synchronize I/O completion in one of three ways:

1. Specify the address of an AST routine that is to execute when the I/O completes.

2. Wait for a specified event flag to be set.

3. Poll the specified I/O status block for a completion status.

The event flag and I/O status block, if specified, are cleared before the I/O request is queued.

Macro Format

```
$QIO  [efn] ,chan ,func ,[iosb] ,[astadr] ,[astprm]
      ,[p1] ,[p2] ,[p3] ,[p4] ,[p5] ,[p6]
```

High-Level Language Format

```
SYS$QIO([efn] ,chan ,func ,[iosb] ,[astadr] ,[astprm]
        ,[p1] ,[p2] ,[p3] ,[p4] ,[p5] ,[p6])
```

efn

Number of the event flag that is to be set at request completion. If not specified, it defaults to 0.

chan

Number of the I/O channel assigned to the device to which the request is directed.

func

Function code and modifier bits that specify the operation to be performed. The code is expressed symbolically. For reference purposes, the function codes are listed in Appendix A, Section A.2. Complete details on valid I/O function codes and parameters required by each are documented in the VAX/VMS I/O User's Guide.

iosb

Address of a quadword I/O status block that is to receive final completion status.

astadr

Address of the entry mask of an AST service routine to be executed when the I/O completes. If specified, the AST routine executes at the access mode from which the $QIO service was requested.

astprm

AST parameter to be passed to the AST service routine.

p1 to p6

Optional device- and function-specific I/O request parameters.

The first parameter may be specified as P1 or P1V, depending on whether the function code requires an address or a value, respectively. If the keyword is not used, P1 is the default; that is, the argument is considered an address.

P2 through Pn are always interpreted as values.

Return Status

SS$_NORMAL

Service successfully completed. The I/O request packet was successfully queued.

SS$_ABORT

A network logical link was broken.

SS$_ACCVIO

The I/O status block cannot be written by the caller.

This status code may also be returned if parameters for device-dependent function codes are incorrectly specified.

SS$_DEVOFFLINE

The specified device is offline, that is, not currently available for use.

SS$_EXQUOTA

The process has exceeded its buffered I/O quota, direct I/O quota, or buffered I/O byte count quota and has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service; or the process has exceeded its AST limit quota.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVCHAN

An invalid channel number was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The specified channel does not exist or was assigned from a more privileged access mode.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Privilege Restrictions

The Queue I/O Request system service can be performed only on assigned I/O channels and only from access modes that are equal to or more privileged than the access mode from which the original channel assignment was made.

Resources Required/Returned

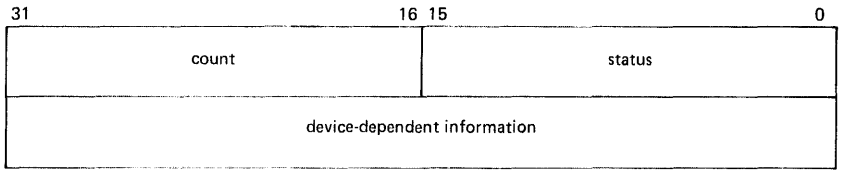
1. Queued I/O requests use the process's quota for buffered I/O (BIOLM) or direct I/O (DIOLM); the process's buffered I/O byte count (BYTLM) quota; and, if an AST service routine is specified, the process's AST limit quota (ASTLM).

2. System dynamic memory is required to construct a data base to queue the I/O request. Additional memory may be required on a device-dependent basis.

Notes

1. The specified event flag is set if the service terminates without queuing an I/O request.

2. The I/O status block has the format:



status

Completion status of the I/O request.

byte count

Number of bytes actually transferred.

device and function dependent information

Varies according to the device and operation being performed. The information returned for each device and function code is documented in the VAX/VMS I/O User's Guide.

3. Many services return character string data and write the length of the data returned in a word provided by the caller. Function codes for the $QIO system service (and the LENGTH argument of the $OUTPUT system service) require length specifications in longwords. If lengths returned by other services are to be used as input parameters for $QIO requests, a longword should be reserved to ensure that no error occurs when $QIO reads the length.

4. For information on performing input and output operations on a network, see the DECnet-VAX User's Guide.

For examples of the $QIO system service, including the use of event flags, AST service routines, and an I/O status block, see Chapter 6, "Input/Output Services."

$QIOW

$QIOW - QUEUE I/O REQUEST AND WAIT FOR EVENT FLAG

The Queue I/O Request and Wait for Event Flag system service combines the $QIO and $WAITFR (Wait for Single Event Flag) system services. It can be used when a program must wait for I/O completion.

Macro Format

```
$QIOW  [efn] ,chan ,func ,[iosb] ,[astadr] ,[astprm]
       ,[p1] ,[p2] ,[p3] ,[p4] ,[p5] ,[p6]
```

High-Level Language Format

```
SYS$QIOW([efn] ,chan ,func ,[iosb] ,[astadr] ,[astprm]
         ,[p1] ,[p2] ,[p3] ,[p4] ,[p5] ,[p6])
```

efn

Number of the event flag that is to be set at request completion. If not specified, it defaults to 0.

chan

Number of the I/O channel assigned to the device to which the request is directed.

func

Function code and modifier bits that specify the operation to be performed. The code is expressed symbolically.

iosb

Address of a quadword I/O status block that is to receive final completion status.

astadr

Address of the entry mask of an AST service routine to be executed when the I/O completes. If specified, the AST routine executes at the access mode from which the $QIO service was requested.

astprm

AST parameter to be passed to the AST completion routine.

p1 to p6

Optional device- and function-specific I/O request parameters.

The first parameter may be specified as P1 or P1V, depending on whether the function code requires an address or a value, respectively. If the keyword is not used, P1 is the default; that is, the argument is considered an address.

P2 through Pn are always interpreted as values.

Return Status, Privilege Restrictions, Resources Required/Returned, Notes

See the description of the $QIO system service for details.

$READEF

$READEF - READ EVENT FLAGS

The Read Event Flags system service returns the current status of all 32 event flags in a local or common event flag cluster.

Macro Format

```
$READEF  efn ,state
```

High-Level Language Format

```
SYS$READEF(efn ,state)
```

efn

Number of any event flag within the cluster to be read. A flag number of 0 through 31 specifies cluster 0, 32 through 63 specifies cluster 1, and so forth.

state

Address of a longword to receive the current status of all event flags in the cluster.

Return Status

SS$_WASCLR

Service successfully completed. The specified event flag is clear.

SS$_WASSET

Service successfully completed. The specified event flag is set.

SS$_ACCVIO

The longword that is to receive the current state of all event flags in the cluster cannot be written by the caller.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

$RESUME

$RESUME - RESUME PROCESS

The Resume Process system service causes a process previously suspended by the Suspend Process ($SUSPND) system service to resume execution, or cancels the effect of a subsequent suspend request.

Macro Format

```
$RESUME  [pidadr] ,[prcnam]
```

High-Level Language Format

```
SYS$RESUME([pidadr] ,[prcnam])
```

pidadr

Address of a longword containing the process identification of the process to be resumed.

prcnam

Address of a character string descriptor pointing to the 1- to 15-character process name string. The process name is implicitly qualified by the group number of the process issuing the resume request.

If neither a process identification nor a process name is specified, the resume request is for the caller. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_IVLOGNAM

The specified process name has a length of 0, or has more than 15 characters.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to resume the execution of the specified process.

Privilege Restrictions

User privileges are required to resume execution of:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Notes

If one or more resume requests are issued for a process that is not suspended, a subsequent suspend request completes immediately, that is, the process is not suspended. No count is maintained of outstanding resume requests.

For more information on process suspension see Section 7.5, "Process Hibernation and Suspension."

$SCHDWK

$SCHDWK - SCHEDULE WAKEUP

The Schedule Wakeup system service schedules the awakening of a process that has placed itself in a state of hibernation with the Hibernate ($HIBER) system service. A wakeup can be scheduled for a specified absolute time or for a delta time. Optionally, the request can specify that the wakeup is to be repeated at fixed intervals.

Macro Format

```
$SCHDWK  [pidadr] ,[prcnam] ,daytim ,[reptim]
```

High-Level Language Format

```
SYS$SCHDWK([pidadr] ,[prcnam] ,daytim ,[reptim])
```

pidadr

Address of a longword containing the process identification of the process to be awakened.

prcnam

Address of a character string descriptor pointing to the 1- to 15-character process name string. The process name is implicitly qualified by the group number of the process issuing the schedule wakeup request.

daytim

Address of a quadword containing the expiration time in the system 64-bit time format. A positive time value indicates an absolute time at which the specified process is to be awakened. A negative time value indicates an offset (delta time) from the current time.

reptim

Address of a quadword containing the time interval (expressed in delta time format) at which to repeat the wakeup request. If not specified, it defaults to 0, which indicates that the request is not to be repeated.

If neither a process identification nor a process name is specified, the scheduled wakeup request is for the caller. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The expiration time, repeat time, process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_EXQUOTA

The process has exceeded its AST limit quota.

SS$_INSFMEM

Insufficient system dynamic memory is available to allocate a timer queue entry, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVLOGNAM

The process name string has a length of 0 or has more than 15 characters.

SS$_IVTIME

The specified delta repeat time is a positive value, or an absolute time plus delta repeat time is less than the current time.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to schedule a wakeup request for the specified process.

Privilege Restrictions

User privileges are required to schedule wakeup requests for:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Resources Required/Returned

A scheduled wakeup request uses the caller's AST limit quota (ASTLM) and requires system dynamic memory to allocate a timer queue entry.

Notes

1. If one or more scheduled wakeup requests are issued for a process that is not hibernating, a subsequent hibernate request by the target process completes immediately, that is, the process does not hibernate. No count is maintained of outstanding wakeup requests.

2. Scheduled wakeup requests that have not yet been processed can be canceled with the Cancel Wakeup ($CANWAK) system service.

3. If a specified absolute time value has already passed and no repeat time is specified, the timer expires at the next clock cycle (that is, within 10 milliseconds).

4. A repeat time value cannot be less than 10 milliseconds. (Any smaller value is increased automatically to 10 milliseconds.)

For an example of the $SCHDWK system service, and for information on how to format a system time value for input to this service, see Chapter 8, "Timer and Time Conversion Services." For more information on process hibernation and waking, see Chapter 7, "Process Control Services."

$SETAST

$SETAST - SET AST ENABLE

The Set AST Enable system service enables or disables the delivery of ASTs for the access mode from which the service call was issued.

Macro Format

```
$SETAST  enbflg
```

High-Level Language Format

```
SYS$SETAST(enbflg)
```

enbflg

AST enable indicator. A value of 1 enables AST delivery for the calling access mode. A value of 0 disables AST delivery.

Return Status

SS$_WASCLR

Service successfully completed. AST delivery was previously disabled for the calling access mode.

SS$_WASSET

Service successfully completed. AST delivery was previously enabled for the calling access mode.

Notes

1. When an image is executing in user mode, the system keeps ASTs enabled for all higher access modes. If a higher access mode disables AST delivery, it should reenable ASTs for its own access mode before returning to a lower access mode.

2. If an AST is queued for an access mode that has disabled AST delivery, the system cannot deliver ASTs to less privileged access modes until the access mode reenables AST delivery.

For additional notes on AST delivery and the usage of ASTs, see Chapter 4, "Asynchronous System Trap (AST) Services."

$SETEF - SET EVENT FLAG

The Set Event Flag system service sets an event flag in a local or common event flag cluster to 1. Any processes waiting for the event flag are made runnable.

Macro Format

```
$SETEF  efn
```

High-Level Language Format

```
SYS$SETEF(efn)
```

efn

Number of the event flag to be set.

Return Status

SS$_WASCLR

Service successfully completed. The specified event flag was previously 0.

SS$_WASSET

Service successfully completed. The specified event flag was previously 1.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

For an example of the $SETEF system service and more information on event flags and event flag clusters, see Chapter 3, "Event Flag Services."

$SETEXV

$SETEXV - SET EXCEPTION VECTOR

The Set Exception Vector system service assigns a condition handler address to an exception vector or cancels an address previously assigned to a vector.

Macro Format

```
$SETEXV  [vector] ,[addres] ,[acmode] ,[prvhnd]
```

High-Level Language Format

```
SYS$SETEXV([vector] ,[addres] ,[acmode] ,[prvhnd])
```

vector

Vector number. A value of 0 (the default) indicates that the primary vector is to be modified. A value of 1 indicates that the secondary vector is to be modified. A value of 2 indicates that a last chance exception vector is to be modified.

addres

Condition handler address. If not specified or specified as 0, it indicates that there is no condition handler or that the vector is to be canceled. If an address is specified, it is the address of the entry mask of the condition handler.

acmode

Access mode for which the exception vector is to be modified. The access mode of the caller is maximized with the specified access mode to determine which vector to modify.

prvhnd

Address of a longword to receive the previous contents of the vector.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The longword that is to receive the previous contents of the vector cannot be written by the caller.

Privilege Restrictions

A process cannot modify a vector associated with a more privileged access mode.

Notes

1. Condition handlers are normally declared on the procedure call stack.

2. The primary exception vector and the last chance exception vector are used by the system debugger. The command interpreter uses the last chance exception vector.

3. User mode exception vectors are canceled at image exit.

Condition handling and conventions for coding condition-handling routines are described in Chapter 9, "Condition-Handling Services."

$SETIME

$SETIME - SET SYSTEM TIME

The Set System Time service causes the current system time to be changed or recalibrated.

Macro Format

```
$SETIME  [timadr]
```

High-level Language Format

```
SYS$SETIME([timadr])
```

timadr

Address of a quadword that contains the time (in 64-bit format) that will become the new current system time. If the argument is not specified or is specified as 0, the current time is recalibrated using the processor's hardware time-of-year clock. A negative (delta) time value is invalid.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The quadword that contains the new system time value cannot be read by the caller.

SS$_NOIOCHAN

No I/O channel is available for assignment. (See Note 2.)

SS$_NOPRIV

The process does not have the privileges to set the system time.

Privilege Restrictions

The operator (OPER) and logical I/O (LOG_IO) user privileges are required to set the system time.

Notes

1. Any change to the system time does not change the interval remaining for any existing timer requests. This is true for both absolute and delta time requests.

2. The $SETIME service saves the new time (for future reboots) in the system image SYS$SYSTEM:SYS.EXE. To save the time, the service assigns a channel to the system boot device and calls the $QIOW service. This I/O operation requires the LOG_IO user privilege.

For further information and an example using this service, see Section 8.8, "Setting the System Time."

$SETIMR

$SETIMR - SET TIMER

The Set Timer system service allows a process to schedule the setting of an event flag and/or the queuing of an AST at some future time. The time for the event can be specified as an absolute time or as a delta time.

Macro Format

```
$SETIMR  [efn] ,daytim ,[astadr] ,[reqidt]
```

High-Level Language Format

```
SYS$SETIMR([efn] ,daytim ,[astadr] ,[reqidt])
```

efn

Event flag number of the event flag to set when the time interval expires. If not specified, it defaults to 0.

daytim

Address of the quadword expiration time. A positive time value indicates an absolute time at which the timer is to expire. A negative time value indicates an offset (delta time) from the current time.

astadr

Address of the entry mask of an AST service routine to be called when the time interval expires. If not specified, it defaults to 0, indicating no AST is to be queued.

reqidt

Number indicating a request identification. If not specified, it defaults to 0. A unique request identification can be specified in each set timer request, or the same identification can be given to related timer requests. The identification can be used later to cancel the timer request(s). If an AST service routine is specified, the identification is passed as the AST parameter.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The expiration time cannot be read by the caller.

SS$_EXQUOTA

The process exceeded its quota for timer entries or its AST limit quota; or there is insufficient system dynamic memory to complete the request and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_INSFMEM

Insufficient dynamic memory is available to allocate a timer queue entry and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Resources Required/Returned

1. The Set Timer system service requires dynamic memory.

2. The Set Timer system service uses the process's quota for timer queue entries (TQELM) and, if an AST service routine is specified, the process's AST limit quota (ASTLM).

Notes

1. The access mode of the caller is the access mode of the request and of the AST.

2. If a specified absolute time value has already passed, the timer expires at the next clock cycle (that is, within 10 milliseconds).

3. The Convert ASCII String to Binary Time ($BINTIM) system service converts a specified ASCII string to the quadword time format required as input to the $SETIMR service.

For examples of the $SETIMR system service, see Chapter 8, "Timer and Time Conversion Services." For an example of an AST service routine, see Chapter 4, "AST (Asynchronous System Trap) Services."

$SETPRA

$SETPRA - SET POWER RECOVERY AST

The Set Power Recovery AST system service establishes a routine to receive control using the AST mechanism after a power recovery is detected.

Macro Format

```
$SETPRA  astadr ,[acmode]
```

High-Level Language Format

```
SYS$SETPRA(astadr ,[acmode])
```

astadr

Address of the entry mask for a power recovery AST routine. An address of 0 indicates that power recovery AST notification for the process is disabled.

acmode

Access mode at which the power recovery AST routine is to execute. The specified access mode is maximized with the access mode of the caller to determine the access mode to use.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_EXQUOTA

The process exceeded its quota for outstanding AST requests.

Resources Required/Returned

The $SETPRA system service uses the process's AST limit quota (ASTLM).

Notes

1. The AST parameter contains the amount of time that the power was off in hundredths of seconds.

2. Only one power recovery AST routine can be specified for a process. The AST entry point address is cleared at image exit.

3. The entry and exit conventions for the power recovery AST routine are the same as for all AST service routines. These conventions are described in Chapter 4, "Asynchronous System Trap (AST) Services."

$SETPRI

$SETPRI - SET PRIORITY

The Set Priority system service changes a process's base priority. The system scheduler uses the base priority to determine the order in which executable processes are to run.

Macro Format

```
$SETPRI  [pidadr] ,[prcnam] ,pri ,[prvpri]
```

High-Level Language Format

```
SYS$SETPRI([pidadr] ,[prcnam] ,pri ,[prvpri])
```

pidadr

Address of the process identification of the process whose priority is to be set.

prcnam

Address of a character string descriptor pointing to a 1- to 15-character process name string. The process name is implicitly qualified by the group number of the process issuing the set priority request.

pri

New base priority to be established for the process. The new priority is contained in bits 0 through 4 of the argument.

Normal priorities are in the range 0 through 15, and real-time priorities are in the range 16 through 31.

If the specified priority is higher than the caller's priority, and if the caller does not have the privilege to set the target process's priority to a value higher than its own, the caller's priority is used.

prvpri

Address of a longword to receive the previous base priority of the specified process.

If neither a process identification nor a process name is specified, the set priority request is for the caller. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification or previous priority longword cannot be written by the caller.

SS$_IVLOGNAM

The process name string has a length of 0, or has more than 15 characters.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to set the specified priority for the specified process.

Privilege Restrictions

User privileges are required to:

- Change the priority for other processes in the same group (GROUP privilege)
- Change the priority for any other process in the system (WORLD privilege)
- Set any process's priority to a value greater than one's own initial base priority (ALTPRI privilege)

Notes

A process's base priority remains in effect until specifically changed or until the process is deleted.

$SETPRN

$SETPRN - SET PROCESS NAME

The Set Process Name system service allows a process to establish or to change its own process name.

Macro Format

```
$SETPRN  [prcnam]
```

High-Level Language Format

```
SYS$SETPRN([prcnam])
```

prcnam

Address of a character string descriptor pointing to the 1- to 15-character process name string. The process name is implicitly qualified by the group number of the caller. If not specified, or specified as 0, the process's current name is deleted.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller.

SS$_DUPLNAM

The specified process name duplicates one already specified within that group.

SS$_IVLOGNAM

The specified process name has a length of 0 or has more than 15 characters.

Notes

1. A process name remains in effect until specifically changed or until the process is deleted.

2. Process names provide an identification mechanism for processes executing with the same group number. Processes can also be identified by process identifications.

For an example of the $SETPRN system service, and details on process identification and system services providing process control functions, see Chapter 7, "Process Control Services."

$SETPRT

$SETPRT - SET PROTECTION ON PAGES

The Set Protection On Pages system service allows an image running in a process to change the protection on a page or range of pages.

Macro Format

```
$SETPRT  inadr ,[retadr] ,[acmode] ,prot ,[prvprt]
```

High-Level Language Format

```
SYS$SETPRT(inadr ,[retadr] ,[acmode] ,prot ,[prvprt])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages on which protection is to be changed. If the starting and ending virtual addresses are the same, a single page is changed. Only the virtual page number portion of the virtual address is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages that had their protection changed.

acmode

Access mode on behalf of which the request is being made. The specified access mode is maximized with the access mode of the caller. The resultant access mode must be equal to or more privileged than the access mode of the owner of each page in order to change the protection.

prot

New protection specified in bits 0 through 3 in the format of the hardware page protection. The high-order 28 bits are ignored. Symbolic names defining the protection codes are listed in Appendix A, Section A.5 "$PRTDEF - Hardware Protection Code Definitions."

If the protection is specified as 0, the protection defaults to kernel read-only.

prvprt

Address of a byte to receive the protection previously assigned to the last page whose protection was changed. This argument is useful only when protection for a single page is being changed.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

1. The input address array cannot be read by the caller, or the output address array or the byte to receive the previous protection cannot be written by the caller.

2. An attempt was made to change the protection of a nonexistent page.

SS$_EXQUOTA

The process exceeded its paging file quota while changing a page in a read-only private section to a read/write page.

SS$_IVPROTECT

The specified protection code has a numeric value of 1 or is greater than 15.

SS$_LENVIO

A page in the specified range is beyond the end of the program or control region.

SS$_NOPRIV

A page in the specified range is in the system address space.

SS$_PAGOWNVIO

Page owner violation. An attempt was made to change the protection on a page owned by a more privileged access mode.

Privilege Restrictions

For pages in global sections, the new protection can alter only the accessibility of the page for modes less privileged than the owner of the page.

Resources Required/Returned

If a process changes any pages in a private section from read-only to read/write, the service uses the process's paging file quota (PGFLQUOTA).

Notes

If an error occurs while changing page protection, the return array, if requested, indicates the pages that were successfully changed before the error occurred. If no pages have been affected, both longwords in the return address array contain a -1.

$SETPRV

$SETPRV - SET PRIVILEGES

The Set Privileges system service allows a process to enable or disable specified user privileges.

Macro Format

```
$SETPRV [enbflg],[prvadr],[prmflg],[prvprv]
```

High-Level Language Format

```
SYS$SETPRV([enbflg],[prvadr],[prmflg],[prvprv])
```

enbflg

Enable indicator. A value of 1 indicates that the privileges specified in the PRVADR argument are to be enabled. A value of 0, the default, indicates that the privileges are to be disabled.

prvadr

Address of a 64-bit mask defining the privileges to be enabled or disabled. The mask is formed by setting the bits corresponding to specific privileges (see Section 7.3.4 for an example). Privilege bit settings are defined by the $PRVDEF macro, and the symbolic names are listed in the PRVADR argument description for the Create Process ($CREPRC) service. If this argument is not specified or is specified as 0, the privileges are not altered.

prmflg

Permanent indicator. A value of 1 indicates that the specified privileges are to be permanently enabled or disabled, that is, until they are again changed or until the process is deleted. A value of 0, the default, indicates that the specified privileges are to be enabled or disabled temporarily, that is, until the current image exits (at which time the process's permanently enabled privileges will be restored).

prvprv

Address of a quadword buffer to receive the previous privilege mask. If this argument is not specified or is specified as 0, the previous privileges mask is not returned.

Return Status

SS$_NORMAL

Service successfully completed. All specified privileges that the process can enable (see "Privilege Restrictions") were enabled, or all specified privileges were disabled.

SS$_ACCVIO

The privilege mask cannot be read or the previous privilege mask cannot be written by the caller.

Privilege Restrictions

To enable a privilege permanently, at least one of the following must be true: the process is authorized to set the specified privilege (see Notes 1 and 2), or the process is executing in kernel or executive mode.

To enable a privilege temporarily, at least one of the following must be true: the process is authorized to set the specified privilege (see Notes 1 and 2), the process is executing in kernel or executive mode, or the image currently executing is a known image installed with the specified privilege.

Notes

1. The system maintains four separate privilege masks for each process:

   - AUTHPRIV - Privileges that the process is authorized to enable, as designated by the system manager or the process creator. The AUTHPRIV mask never changes during the life of the process.
   - PROCPRIV - Privileges that are designated as permanently enabled for the process. The PROCPRIV mask can be modified by this service.
   - IMAGPRIV - Privileges that the current image is installed with.
   - CURPRIV - Privileges that are currently enabled. The CURPRIV mask can be modified by this service.

   When a process is created, its AUTHPRIV, PROCPRIV, and CURPRIV masks have the same contents. Whenever a system service (other than $SETPRV) must check the process privileges, it checks the CURPRIV mask. When a process runs a known image, the privileges that the image was installed with are enabled in the CURPRIV mask; when the known image exits, the PROCPRIV mask is copied to the CURPRIV mask.

2. When the $SETPRV service checks whether the process has the SETPRV privilege, it examines the AUTHPRIV mask. Therefore, it is useless for a process to call this service to "give" itself the SETPRV privilege, because the service can set bits only in the CURPRIV and PROCPRIV masks.

3. You can obtain a process's privilege masks with the Get Job/Process Information ($GETJPI) service. The item identifier for a given mask is the mask name preceded by JPI$_ (for example, JPI$_AUTHPRIV to obtain the mask of privileges the process is authorized to enable).

4. You can also enable or disable process privileges with the SET PROCESS/PRIVILEGES command (see the VAX/VMS Command Language User's Guide).

$SETRWM - SET RESOURCE WAIT MODE

The Set Resource Wait Mode system service allows a process to indicate what action a system service should take when it lacks a system resource required for its execution:

- When resource wait mode is enabled (the default mode), the service waits until a resource is available and then resumes execution.
- When resource wait mode is disabled, the service returns control to the caller immediately with a status code indicating that a resource is unavailable.

Macro Format

```
$SETRWM  [watflg]
```

High-Level Language Format

```
SYS$SETRWM([watflg])
```

watflg

Wait indicator. A value of 0 (the default) indicates that resources are to be awaited; this is the initial setting for resource wait mode. A value of 1 indicates that failure status should be returned immediately.

Return Status

SS$_WASCLR

Service successfully completed. Resource wait mode was previously enabled.

SS$_WASSET

Service successfully completed. Resource wait mode was previously disabled.

Notes

1. The following system resources and process quotas are affected by resource wait mode:
   - System dynamic memory
   - UNIBUS adapter map registers
   - Direct I/O quota (DIOLM)
   - Buffered I/O quota (BIOLM)
   - Buffered I/O byte count limit (BYTLM)
2. If resource wait mode is disabled, it remains disabled until it is explicitly reenabled or until the process is deleted.

For further information on resource wait mode, see Section 2.1.5.4 (for MACRO programmers) or Section 2.2.2.3 (for high-level language programmers).

$SETSFM - SET SYSTEM SERVICE FAILURE EXCEPTION MODE

The Set System Service Failure Exception Mode system service controls whether a software exception is generated when an error or severe error status code is returned from a system service call. Initially, system service failure exceptions are disabled; the caller should explicitly test for successful completion following a system service call.

Macro Format

```
$SETSFM  [enbflg]
```

High-Level Language Format

```
SYS$SETSFM([enbflg])
```

enbflg

Enable indicator. A value of 1 indicates that system service failure exceptions are to be generated. A value of 0 (the default) disables their generation.

Return Status

SS$_WASCLR

Service successfully completed. Failure exceptions were previously disabled.

SS$_WASSET

Service successfully completed. Failure exceptions were previously enabled.

Notes

1. When enabled, system service failure exceptions are generated only if the service call originated from user mode. The $SETSFM system service can be called, however, from any access mode. If enabled, system service failure exception mode remains enabled until explicitly disabled or until the image exits.

2. If failure exceptions are enabled, a condition handler can be specified in the first longword of the procedure call stack or with the Set Exception Vector ($SETEXV) system service. If no condition handler is specified by the user, a default system handler is used. This condition handler causes the image to exit and then displays the exit status.

3. The argument list provided to the condition handler has the code SS$_SSFAIL in the condition name argument of the signal array.

For further information on system service failure exception mode, see Section 2.1.5.4 (for MACRO programmers) or Section 2.2.2.3 (for high-level language programmers).

For an explanation and examples of condition handling routines, the format of the argument lists passed to the condition handler, and a discussion of the appropriate actions a condition handler may take, see Chapter 9, "Condition-Handling Services."

$SETSWM - SET PROCESS SWAP MODE

The Set Process Swap Mode system service allows a process to control whether it can be swapped out of the balance set. Once a process is locked in the balance set, it cannot be swapped out of memory until it is explicitly unlocked.

Macro Format

```
$SETSWM  [swpflg]
```

High-Level Language Format

```
SYS$SETSWM([swpflg])
```

swpflg

Swap indicator. A value of 0 (the default) allows the process to be swapped; this is the initial setting for swap mode. A value of 1 inhibits swapping.

Return Status

SS$_WASCLR

Service successfully completed. The process was not previously locked in the balance set.

SS$_WASSET

Service successfully completed. The process was previously locked in the balance set.

SS$_NOPRIV

The process does not have the privilege to alter its swap mode.

Privilege Restrictions

The user privilege PSWAPM is required to alter process swap mode.

Notes

1. If a process is locked in the balance set it remains locked until explicitly unlocked or until the process is deleted.

2. Specific pages of a process's virtual address space can be locked in the balance set with the Lock Pages in Memory ($LCKPAG) system service.

$SNDACC

$SNDACC - SEND MESSAGE TO ACCOUNTING MANAGER

The Send Message to Accounting Manager system service controls accounting log activity and allows a process to write an arbitrary data message into the accounting log file. This file, located on the system disk in the directory [SYSMGR] and named ACCOUNTNG.DAT, is sequentially organized and contains variable-length records. Detailed information about the format of messages sent to and received from the accounting manager follows the "Notes" section. Table 5 shows the format of accounting log file records.

Macro Format

```
$SNDACC msgbuf ,[chan]
```

High-Level Language Format

```
SYS$SNDACC(msgbuf ,[chan])
```

msgbuf

Address of a character string descriptor pointing to the message buffer. The types of message and the buffer formats are described later in this section.

chan

Number of the channel assigned to the mailbox to receive the reply. If no channel number is specified or if it is specified as 0 (the default), no reply is returned.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The message buffer or buffer descriptor cannot be read by the caller.

SS$_BADPARAM

The specified message has a length of 0 or has more than 254 characters.

SS$_DEVNOTMBX

The channel specified is not assigned to a mailbox.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVCHAN

An invalid channel number was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The caller does not have write access to the specified mailbox.

Privilege Restrictions

The user privilege OPER is required to create a new log file or to enable or disable accounting.

Resources Required/Returned

The Send Message to Accounting Manager system service requires system dynamic memory.

Notes

1. The general procedure for coding a call to this service involves the following steps:

   a. Construct the message buffer and place its final length in the first word of the buffer descriptor.

   b. Call the $SNDACC system service.

   c. Check the return status code from the service to ensure successful completion.

   d. Issue a read request to the mailbox specified, if any. When the read completes, check that the operation was successfully performed.

2. By default, the system writes a record into the accounting log file whenever a job terminates. Termination records are written for interactive users, batch jobs, non-interactive processes, login failures, and print jobs. The $SNDACC system service allows users to write additional data into the accounting log and allows privileged users to disable or enable all accounting or accounting for particular types of jobs.

   Table 5 lists the fields in the accounting record and notes which portions of the accounting record are written for each type of job. The $ACCDEF macro defines symbolic names for the message types, fields within the accounting record, and job type record codes for selective accounting.

Table 5
Format of Accounting Log File Records

Accounting Log File Record Header (Present in all types of log file records)

Offset	Field Name	Length	Contents
0	ACC$W_MSGTYP	word	Record type code [1]
2	ACC$W_MSGSIZ	word	Length of data message
4	ACC$L_FINALSTS	longword	Final exit status
8	ACC$L_PID	longword	Process identification
12	ACC$L_JOBID	longword	Job identification
16	ACC$Q_TERMTIME	quadword	System time at job termination
24	ACC$T_ACCOUNT	8 bytes	Account name (blank-filled)
32	ACC$T_USERNAME	12 bytes	User name (blank-filled)

Job Information (Present in termination messages for interactive processes, non-interactive processes, and batch jobs)

Offset	Field Name	Length	Contents
44	ACC$L_CPUTIM	longword	CPU time in 10-millisecond units [2]
48	ACC$L_PAGEFLTS	longword	Count of page faults during process lifetime
52	ACC$L_PGFLPEAK	longword	Peak size of process paging file
56	ACC$L_WSPEAK	longword	Peak size of working set
60	ACC$L_BIOCNT	longword	Count of buffered I/O operations performed
64	ACC$L_DIOCNT	longword	Count of direct I/O operations performed
68	ACC$L_VOLUMES	longword	Count of volumes mounted
72	ACC$Q_LOGIN	quadword	System time at login
80	ACC$L_OWNER	longword	Process identification of process's owner
	ACC$K_TERMLEN	constant	Length of non-batch job termination message

Batch Job Accounting Information (Present only in batch job termination records)

Offset	Field Name	Length	Contents
84	ACC$T_JOB_NAME	8 bytes	Job name (blank-filled)
92	ACC$T_JOB_QUE	16 bytes	Queue name (counted ASCII string)
	ACC$K_JOB_LEN	constant	Length of termination record for batch jobs

Printer Job Information (Present only in printer job termination records. The record contains default header record and CPU time followed by the data listed below)

Offset	Field Name	Length	Contents
48	ACC$L_PAGCNT	longword	Symbiont page count
52	ACC$L_QIOCNT	longword	Symbiont QIO count
56	ACC$L_GETCNT	longword	Symbiont GET count
60	ACC$Q_QUETIME	quadword	System time that job was queued
68	ACC$T_PRT_NAME	8 bytes	Name of print job
76	ACC$T_PRT_QUE	12 bytes	Name of print queue
	ACC$K_PRT_LEN	constant	Length of print job accounting record

User Data (Present in user-written messages)

Offset	Field Name	Length	Contents
44	ACC$T_USER_DATA	144 bytes	User data written to accounting file
	ACC$K_INS_LEN	constant	Length of user-written accounting file log record

1. The record type code can be one of the following values:

ACC$K_BATTRM	Batch job termination
ACC$K_INTTRM	Interactive job termination
ACC$K_PRCTRM	Subprocess or detached process termination
ACC$K_LOGTRM	Login failure termination
ACC$K_PRTJOB	Print job accounting message
ACC$K_INSMSG	User-inserted message

2. CPU time accounting is not performed for a print job since there is no process creation or termination involved with the job.

Format of Messages Sent to the Accounting Manager

A message buffer for a message to the accounting manager begins with a word defining the message type. Some message types require that data follow the message type code in the buffer. The message types and data, if any, required by each are listed below.

1. ACC$K_INSMESG

   Insert an arbitrary message in the accounting log file. The message code is followed by any arbitrary data. When the message is inserted in the accounting log file, the default header precedes the user-specified data.

2. ACC$K_NEWFILE

   Requests that the current log file be closed and a new file created. Operator privilege is required to create a new log file. No data is required for the message.

3. ACC$K_ENABACC

   Enables accounting for all types of jobs. Operator privilege is required to enable accounting. No data is required for the message.

4. ACC$K_DISAACC

   Disables accounting for all types of job. Operator privilege is required to disable accounting. No data is required for the message.

5. ACC$K_ENABSEL

   Enables accounting for certain types of job. Operator privilege is required to selectively enable accounting. The message type code must be followed by one or more bytes indicating the type of job for which accounting is to be enabled. (The job type codes below are also used to indicate the record type in the first word of each accounting log file record. See Table 5.)

Code	Job Type
ACC$K_BATTRM	Batch job
ACC$K_INSMSG	Arbitrary (user-inserted) messages
ACC$K_INTTRM	Interactive job
ACC$K_LOGTRM	Login failure termination
ACC$K_PRCTRM	Non-interactive process (subprocess or detached process)
ACC$K_PRTJOB	Print job

   The list of job type codes must be terminated with a byte containing 0.

6. ACC$K_DISASEL

   Disables accounting for certain types of job. Operator privilege is required to selectively disable accounting. The message type code is followed by one or more bytes indicating the types of job for which accounting is to be disabled. The codes are listed above, under ACC$K_ENABSEL.

Format of Response from the Accounting Manager

If a mailbox is specified, the accounting manager returns a message in the format:

Bits	Contents
0-15	MSG$_ACCRSP indicates that the message is a response from the accounting manager. (This symbolic name is defined in the $MSGDEF macro.)
16-31	0
32-63	Status code indicating the success of the operation.

If the mailbox cannot handle the message (because there is insufficient buffer space or because a message is too long), or if the mailbox no longer exists when the reply is sent, the response is lost.

Status Codes Returned in the Mailbox:

SS$_NORMAL
Request successfully performed.

JBC$_ACMINVOP
An invalid operation was requested.

JBC$_NOPRIV
The process does not have the privilege to perform the requested operation.

The symbols for these status codes are defined by the $JBCMSGDEF macro and are contained in the macro library SYS$LIBRARY:LIB.MLB.

$SNDERR - SEND MESSAGE TO ERROR LOGGER

The Send Message To Error Logger system service writes an arbitrary message to the system error log file. The user-specified message is preceded by the date and time.

Macro Format

```
$SNDERR msgbuf
```

High-Level Language Format

```
SYS$SNDERR(msgbuf)
```

msgbuf

Address of character string descriptor pointing to the message to be inserted in the system error log file.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The message buffer or buffer descriptor cannot be read by the caller.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_NOPRIV

The process does not have the BUGCHK privilege.

Privilege Restrictions

The user privilege BUGCHK is required to send a message to the error log file.

Resources Required/Returned

The Send Message To Error Logger system service requires system dynamic memory.

$SNDOPR

$SNDOPR - SEND MESSAGE TO OPERATOR

The Send Message To Operator system service allows a process to send a message to one or more terminals designated as operators' terminals and optionally receive a reply. The service also allows a process to enable a terminal as an operator's terminal or to initialize the operator communication log file (that is, close the current version of the file and open a new version).

Detailed information about $SNDOPR message types and message formats follows the "Notes" section.

Macro Format

```
$SNDOPR msgbuf ,[chan]
```

High-Level Language Format

```
SYS$SNDOPR(msgbuf ,[chan])
```

msgbuf

Address of character string descriptor pointing to the message buffer. The types of message and the buffer formats are described later in this section.

chan

Number of the channel assigned to the mailbox to which the reply is to be sent, if any. A channel number of 0 (the default) implies no mailbox unit.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The message buffer or buffer descriptor cannot be read by the caller.

SS$_BADPARAM

The specified message has a length of 0 or has more than 128 bytes.

SS$_DEVNOTMBX

The channel specified is not assigned to a mailbox.

SS$_DEVOFFLINE

There is no operator designated to receive messages.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVCHAN

An invalid channel number was specified, that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The process does not have the privilege to send a message to the operator, the process does not have read/write access to the specified mailbox, or the channel was assigned from a more privileged access mode.

Privilege Restrictions

The user privilege OPER is required to issue the Send Message To Operator system service to enable a terminal as an operator's terminal, to reply to or cancel a user's request, or to initialize the operator communication log file.

Resources Required/Returned

The Send Message To Operator system service requires system dynamic memory.

Notes

1. The general procedure for using this service is as follows:

   a. Construct the message buffer and place its final length in the first word of the buffer descriptor.

   b. Issue the $SNDOPR system service.

   c. Check the return status code from the service to ensure successful completion.

   d. Issue a read request to the mailbox specified, if any. When the read completes, check that the operation was successfully performed.

2. This service is used by the system to implement the REQUEST and REPLY commands, which provide communications between users and operators. An operator establishes a terminal as an operator's console by issuing the REPLY/ENABLE command, specifying the types of message that will be handled. Users can then send messages to the operator with the REQUEST command, optionally requesting replies.

   Messages are displayed on a specified operator's terminal in the format:

```
Opcom -- time -- User="username" ACNT="account"
[Opcom -- *** REPLY-ID = n ***]
Opcom -- message-text
```

   If a reply is requested, the operator request is kept active until the operator responds.

   The VAX/VMS Operator's Guide describes the REQUEST and REPLY commands in greater detail.

$SNDOPR Message Types and Message Formats

The $OPCDEF macro defines symbolic names for operator message types, offsets within messages, and return status codes.

The $SNDOPR system service handles these message types:

Code	Type of Request
OPC$_RQ_RQST	Request operator functions
OPC$_RQ_CANCEL	Cancel a user request
OPC$_RQ_REPLY	Reply to user request
OPC$_RQ_TERME	Enable terminal for operator's use
OPC$_RQ_LOGI	Initialize log file
OPC$_RQ_STATUS	Report operator's status to the terminal

Each message type has a different format. The maximum length of any message is 128 bytes, including message text. The message formats are explained below.

OPC$_RQ_RQST Request Code

Constructs a message to be displayed at an operator's terminal (REQUEST command). The message format is:

Offset	Length	Contents
OPC$B_MS_TYPE	byte	OPC$_RQ_RQST identifies the type of message
OPC$B_MS_TARGET	3 bytes	Mask indicating which operators will receive the message. The symbolic names to create the mask are: OPC$M_NM_CARDS Card device operator OPC$M_NM_CENTRL Central operator OPC$M_NM_DEVICE Device status information OPC$M_NM_DISKS Disk operator OPC$M_NM_NTWORK Network operator OPC$M_NM_TAPES Tape operator OPC$M_NM_PRINT Printer operator OPC$M_NM_OPER1 System manager-defined operator functions . . . OPC$M_NM_OPER12
OPC$L_MS_RQSTID	Longword	User-specified message identification to be used for replying
OPC$L_MS_TEXT	0-120 bytes	Up to 120 bytes of message text

OPC$_RQ_CANCEL Request Code

Notifies an operator that a request is to be canceled.

The message format is the same as for the message type OPC$_RQ_ROST except that:

- The message type field must contain OPC$_RQ_CANCEL
- The message has no message text.

OPC$_RQ_REPLY Request Code

Constructs a reply to a user request (REPLY command). The message format is:

Offset	Length	Contents
OPC$B_MS_TYPE	byte	OPC$_RQ_REPLY identifies the type of message
OPC$W_MS_STATUS	word	Return status: OPC$_RQSTCMPLTE Request completed OPC$_RQSTABORT Request denied OPC$_RQSTPEND Request pending OPC$_RQSTCAN Request canceled
OPC$L_MS_RPLYID	longword	Identification of message to which reply is directed
OPC$W_MS_OUNIT	word	Unit number of terminal
OPC$T_MS_ONAME	--	Device name (counted ASCII string)
OPC$L_MS_OTEXT	--	Reply message text, if any

OPC$_RQ_TERME Request Code

Enables a terminal for operator use (REPLY/ENABLE command). The message format is:

Offset	Length	Contents
OPC$B_MS_TYPE	byte	OPC$_RQ_TERME identifies the type of message
OPC$B_MS_ENAB OPC$L_MS_MASK	3 bytes longword	Masks defining the type of messages for which the terminal is enabled (The same message types must be specified in both masks.)
OPC$W_MS_OUNIT	word	Unit number of terminal
OPC$T_MS_ONAME	--	Device name (counted ASCII string)

OPC$_RQ_LOGI Request Code

Initializes the log file of operator messages (REPLY/LOG command). This file is explained in the VAX/VMS Operator's Guide. The message format is:

Offset	Length	Contents
OPC$B_MS_TYPE	byte	OPC$_RQ_LOGI identifies the type of message
--	7 bytes	Ignored
OPC$W_MS_OUNIT	word	Unit number of terminal
OPC$T_MS_ONAME	--	Device name (counted ASCII string)

OPC$_RQ_STATUS Request Code

Reports the operator's status to the terminal. The message format is:

Offset	Length	Contents
OPC$B_MS_TYPE	byte	OPC$_RQ_STATUS identifies the type of message
OPC$W_MS_OUNIT	word	Unit number of terminal
OPC$T_MS_ONAME	--	Device name (counted ASCII string)

Format of Response from Operator Communication Manager

When the operator replies to a message, the reply is placed in the specified mailbox in the format:

Offset	Length	Contents
OPC$B_MS_TYPE	word	MSG$_OPREPLY indicates that the message is a response to an operator's request. This symbolic name is defined in the $MSGDEF macro.
OPC$W_MS_STATUS	word	Return status.
OPC$L_MS_RPLYID	longword	Identification of message for which reply is made (specified in user request message)
OPC$L_MS_TEXT	0-128 bytes	Up to 128 bytes of message text taken from reply

If the mailbox specified to receive the reply cannot handle the reply message (either because of insufficient buffer space or because the message is too big), the message is lost.

Status Codes Returned in Mailbox:

OPC$_NOPERATOR

Success. There was no operator enabled to receive the message.

OPC$_RQSTCMPLTE

Success. The operator completed the request.

OPC$_RQSTPEND

Success. The operator will perform the request when possible.

OPC$_RQSTABORT

The operator could not satisfy the request.

OPC$_RQSTCAN

The caller canceled the request.

$SNDSMB - SEND MESSAGE TO SYMBIONT MANAGER

The Send Message To Symbiont Manager system service is used by the operating system to queue user's print files to a system printer or to queue command procedure files for detached job execution.

Symbiont manager requests do the following:

- Create and delete queues
- Add or delete files from a queue
- Change the attributes of files in a queue
- Start and restart dequeuing

Detailed information about the format of messages to and responses from the symbiont manager follow the "Notes" section. Table 6 shows request types for symbiont manager messages. Table 7 shows the options for symbiont manager messages.

Macro Format

```
$SNDSMB  msgbuf ,[chan]
```

High-Level Language Format

```
SYS$SNDSMB(msgbuf ,[chan])
```

msgbuf

Address of a character string descriptor pointing to the message buffer. The buffer formats and the types of messages are described later in this section

chan

Number of the channel assigned to the mailbox to receive the reply. If no channel number is specified, or if it is specified as 0 (the default), it indicates that no reply is desired.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The message buffer or buffer descriptor cannot be read by the caller.

SS$_BADPARAM

The specified message has a length of 0 or has more than 200 characters.

SS$_DEVNOTMBX

The specified channel is not assigned to a mailbox.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service, and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVCHAN

An invalid channel number was specified; that is, a channel number of 0 or a number larger than the number of channels available.

SS$_NOPRIV

The caller does not have write access to the specified mailbox.

Resources Required/Returned

The Send Message To Symbiont Manager system service requires system dynamic memory.

Privilege Restrictions

There are several levels of privilege involved in symbiont control:

- The OPER privilege allows you to perform all the functions of this service. You need the OPER privilege for any function that affects a queue itself (for example, initializing or deleting a queue).
- The WORLD privilege allows you to perform functions that affect any entry in a queue, regardless of which process owns the job or file associated with the entry.
- The GROUP privilege allows you to perform functions that affect any entry in a queue, as long as the job or file associated with the entry is owned by a process in your group.

Notes

1. The general procedure for using this service is as follows:
   a. Construct the message buffer and place its final length in the first word of the buffer descriptor.
   b. Issue the $SNDSMB system service.
   c. Check the return status code from the service to ensure successful completion.
   d. Issue a read request to the mailbox specified, if any. When the read completes, check that the operation was successfully performed.

2. A working set default size and a working set quota (maximum size) are included in each user record in the system user authorization file (UAF), and can be specified for individual jobs and/or for all jobs in a given queue. The following decision table shows the action taken for different combinations of specifications involving working set size and working set quota values.

Value specified for job?	Value specified for queue?	Action taken
No	No	Use UAF value
No	Yes	Use value for queue
Yes	Yes	Use lower of the two
Yes	No	Compare specified value with UAF value; use lower

3. A CPU time limit for the process is included in each user record in the system user authorization file (UAF). You can also specify any or all of the following: a CPU time limit for individual jobs, a default CPU time limit for all jobs in a given queue, and a maximum CPU time limit for all jobs in a given queue. The following decision table shows the action taken for each of these possible combinations.

CPU time limit specified for job?	Default CPU time limit specified for queue?	Maximum CPU time specified for queue?	Action taken
No	No	No	Use UAF value
Yes	No	No	Use smaller of job's limit and UAF value
Yes	Yes	No	Use smaller of job's limit and UAF value
Yes	No	Yes	Use smaller of job's limit and maximum
Yes	Yes	Yes	Use smaller of job's limit and maximum
No	Yes	Yes	Use smaller of queue's default and maximum
No	No	Yes	Use maximum
No	Yes	No	Use smaller of UAF value and queue's default

Format of Messages Sent to Symbiont Manager

Messages are variable-length, and their formats depend on the request type. Each request type can require from 0 through 5 additional data fields, and can be followed by options. Some options require additional data.

The general message format is:

```
request[queuename][devname][fileid][dirid]
          [filename][jobid][jobname][option[opdata]]
```

request

16-bit field indicating the request type. The $SMRDEF macro defines symbolic codes for each request in the format:

SMR$C_code

Valid request codes, and the required and optional fields for each, are listed in Table 6.

queuename

16-byte queue name. The length of the name must be in the first byte. A queue name can be a physical device name (for example, LPA0:), a logical name (for example, SYS$PRINT), or a designated name string, such as BATCH or AFTER5.

Some request types require two queue names, for example SMR$K_MERGE.

devname

16-byte field containing the name of the device on which the file resides. The length of the device name must be in the first byte. The device name is returned by RMS as a counted ASCII string in the NAM$T_DVI field of the auxiliary name block (NAM) when the file is opened.

fileid

6-byte file identification. RMS returns the file identification in the auxiliary name block (NAM) beginning at the offset NAM$W_FID when the file is opened.

dirid

6-byte directory identification returned by RMS in the name block (NAM) at the offset NAM$W_DID.

filename

20-byte field containing the name of a file to be queued. The first byte in the field must contain the length.

jobid

16-bit job header identifying the job. This information is returned in the message queued to the mailbox on completion of the operation.

jobname

8-byte blank-filled ASCII name string.

option

Byte indicating an optional parameter for the request. The $SMRDEF macro defines symbolic names for the options in the format:

SMO$C_option

Valid options for each request type are listed in Table 6. The options and any data required by each are listed in Table 7.

opdata

Any data required by the specified option.

Syntax Notes

1. Fields within the message buffer must be placed in consecutive positions in the buffer, with no intervening blanks.

2. The message length passed to the service indicates the total length of the buffer. If a byte of binary 0's follows an option or its required data, the message scan is terminated. Therefore, fixed-length message buffers can be used, with a 0 indicating termination of the option list.

The following example shows an input message buffer for the $SNDSMB system service:

```
ADDLIST:                            ;MESSAGE BUFFER
        .WORD   SMR$K_ADDFIL        ;REQUEST TYPE TO ADD A FILE
DEV:    .BLKB   16                  ;MOVE DEVICE NAME HERE (COUNTED STRING)
FILID:  .BLKW   3                   ;MOVE FILEID HERE
FILEN:  .BLKB   20                  ;MOVE FILENAME HERE
OPTS:   .BLKB   10                  ;LEAVE ROOM FOR 10 OPTIONS
ADDESC:                             ;DESCRIPTOR FOR MESSAGE
        .LONG   ADDESC-ADDLIST      ;LENGTH OF BUFFER
        .LONG   ADDLIST             ;ADDRESS OF BUFFER
          .
          .
          .
        $SNDSMB_S MSGBUF=ADDESC     ;ADD FILE TO QUEUE
```

Table 6
Request Types for Symbiont Manager Messages

Request	Function	Required Data	Valid Options
SMR$K_ABORT	Stops printing the current file and skips to the next file	queuename	SMO$K_REQUEUE
SMR$K_ADDFIL	Adds a file to a job	devname fileid dirname[1] filename[2]	SMO$K_COPIES SMO$K_BRSTPAG SMO$K_DELETE SMO$K_DOUBLE SMO$K_FLAGPAG SMO$K_NOBRSTPAG SMO$K_NOFEED SMO$K_NOFLAGPAG SMO$K_PAGCNT SMO$K_PAGHDR
SMR$K_ALTER	Changes attributes of a previously queued job and requeues the job	queuename jobid	SMO$K_CRPULIM SMO$K_DQCHAR SMO$K_FORMTYP SMO$K_HOLD SMO$K_JOBCOPY SMO$K_JOBNAME SMO$K_JOBPRI SMO$K_LOWER SMO$K_NOCPULM SMO$K_NOLOWER SMO$K_NOWSDFT SMO$K_NOWSQUO SMO$K_RLSTIM SMO$K_WSDEFLT SMO$K_WSQUOTA
SMR$K_ASSIGN	Directs a queue to a specific device	queuename [devname]	None
SMR$K_CLSJOB	Closes the job	None	SMO$K_FORMTYP SMO$K_HOLD SMO$K_JOBPRI SMO$K_RLSTIM
SMR$K_CREJOB	Creates a job	queuename	SMO$_CPULIM SMO$K_DQCHAR SMO$K_FORMTYP SMO$K_HOLD SMO$K_JOBCOPY SMO$K_JOBPRI SMO$K_LOWER SMO$K_NOCPULM SMO$K_NOLOWER SMO$K_NOWSDFT SMO$K_NOWSQUO SMO$K_PARAMS SMO$K_RLSTIM SMO$K_WSDEFLT SMO$K_WSQUOTA
SMR$K_DELETE	Deletes a device queue	queuename	None
SMR$K_ENTER	Enters a file in a queue for a device	queuename devname fileid dirname[1] filename[2]	SMO$K_BRSTPAG SMO$K_COPIES SMO$K_DELETE SMO$K_DOUBLE SMO$K_FLAGPAG SMO$K_FORMTYP SMO$K_HOLD SMO$K_JOBCOPY SMO$K_LOWER SMO$K_NOBRSTPAG SMO$K_NOFEED SMO$K_NOFLAGPAG SMO$K_NOLOWER SMO$K_PAGCNT SMO$K_PAGHDR SMO$K_JOBPRI SMO$K_RLSTIM

1. The dirname field is required only if file is to be deleted after processing.

2. The filename field is optional; it can be used for informational purposes.

Table 6 (Cont.)
Request Types for Symbiont Manager Messages

Request	Function	Required Data	Valid Options
SMR$K_INITIAL	Initializes or reinitializes a queue	queuename	SMO$K_CURDQCHAR SMO$K_CURFORM SMO$K_DCPULM SMO$K_DEFBRST SMO$K_DEFFLAG SMO$K_DETJOB SMO$K_DISWAP SMO$K_GENDEV SMO$K_GENPRT SMO$K_INIPRI SMO$K_JOBLIM SMO$K_MCPULM SMO$K_NODCPULM SMO$K_NODEFBRST SMO$K_NODEFFLAG SMO$K_NOGENDEV SMO$K_NOGENPRT SMO$K_NOMCPULM SMO$K_NOTRMDEV SMO$K_NOWSDFLT SMO$K_NOWSQUTA SMO$K_SMBNAME SMO$K_TRMDEV SMO$K_WSDFLT SMO$K_WSQUTA
SMR$K_JUSTIFY	Issues hardware form feed	queuename	None
SMR$K_MERGE	Deletes jobs from second queue and places them in first queue	queuename1 queuename2	None
SMR$K_PAUSE	Temporarily suspends current operation	queuename	None
SMR$K_REDIRECT	Redirects second queue to first queue	queuename1 [queuename2]	None
SMR$K_RELEASE	Releases a held job for printing	queuename jobid[1]	None
SMR$K_RMVJOB	Removes a job from a queue	jobid	None
SMR$K_START	Enables printing on a device, resumes printing on a paused device, or restarts printing on a stopped device	queuename	SMO$K_CURDQCHAR SMO$K_CURFORM SMO$K_DCPULM SMO$K_DEFBRST SMO$K_DEFFLAG SMO$K_DETJOB SMO$K_GENDEV SMO$K_GENPRT SMO$K_INIPRI SMO$K_JOBLIM SMO$K_MCPULM SMO$K_NEXTJOB SMO$K_NODCPULM SMO$K_NODEFBRST SMO$K_NODEFFLAG SMO$K_NOGENDEV SMO$K_NOGENPRT SMO$K_NOMCPULM SMO$K_NOTRMDEV SMO$K_NOWSDFLT SMO$K_NOWSQUTA SMO$K_PAGNUM SMO$K_SMBNAME SMO$K_TOPOFILE SMO$K_TRMDEV SMO$K_WSDFLT SMO$K_WSQUTA
SMR$K_STOP	Stops printing on a device (for a batch job, equivalent to PAUSE)	queuename	None
SMR$K_SYNCJOB	Waits for a batch job to complete	queuename [jobid][2] [jobname]	

1. A jobid is optional; if specified as 0 or not specified, the first job in queue is released.

2. Either the jobid or the jobname must be specified.

Table 7
Options for Symbiont Manager Messages

Option	Function	Required Data
SMO$K_BRSTPAG	Specifies that a burst page should be printed	None
SMO$K_COPIES	Specifies the number of copies of the file to print	Number of copies (1 byte)
SMO$K_CPULIM	Specifies CPU time limit for batch job	Number of 10-ms units (unsigned longword)
SMO$K_CURDQCHAR	Specifies current queue characteristics	16 bytes (128 bits, each corresponding to a characteristic)
SMO$K_CURFORM	Defines form type currently on printer	Type of form (1 byte)
SMO$K_DCPULM	Specifies default CPU time limit for jobs originating from a specific batch job queue (must be less than or equal to SMO$K_MCPULM)	Number of 10-ms units (unsigned longword)
SMO$K_DEFBRST	Specifies that queue prints burst page by default	None
SMO$K_DEFFLAG	Specifies that queue prints flag page by default	None
SMO$K_DELETE	Deletes file after printing	None
SMO$K_DETJOB	Defines queue as a detached job (batch) queue	None
SMO$K_DISWAP	Disables swapping of all batch jobs in queue	None
SMO$K_DOUBLE	Double-spaces printer output	None
SMO$K_DQCHAR	Specifies characteristics the device queue must have before a job in it can be dequeued	16 bytes (128 bits, each corresponding to a characteristic)
SMO$K_FLAGPAG	Specifies that a flag page should be printed	None
SMO$K_FORMTYPE	Specifies the form type	Type of form (1 byte)
SMO$K_GENDEV	Defines the queue as a generic device queue	None
SMO$K_GENPRT	Defines the queue as a generic printer file queue	None
SMO$K_HOLD	Holds job until specifically released	None
SMO$K_INIPRI	Specifies initial priority of batch job	Priority (1 byte) range: 0 through 15
SMO$K_JOBCOPY	Specifies a repeat count for the entire job	Repeat count (1 byte)
SMO$K_JOBLIM	Specifies maximum number of jobs in batch queue	Number of jobs (1 byte)
SMO$K_JOBNAME	Specifies the job name	Counted ASCII string (1 to 8 bytes)
SMO$K_JOBPRI	Specifies priority for queuing of a job	Priority (1 byte) range: 0 through 31
SMO$K_LOWER	Specifies that printer must be equipped with upper-case and lowercase characters	None
SMO$K_MCPULM	Specifies maximum CPU time for jobs originating from a specific batch queue	Number of 10-ms units (unsigned longword)
SMO$K_NEXTJOB	Terminates current job and start printing with next job	None

Table 7 (Cont.)
Options for Symbiont Manager Messages

Option	Function	Required Data
SMO$K_NOBRSTPAG	Specifies that no burst page should be printed	None
SMO$K_NOCPULM	No CPU time limit is specified for batch job	None
SMO$K_NODCPULM	No default CPU time limit is specified for jobs originating from this queue	None
SMO$K_NODEFBRST	Specifies that printer does not generate burst page by default	None
SMO$K_NODEFFLAG	Specifies that printer does not generate flag page by default	None
SMO$K_NOFEED	Cancels automatic form feed for output	None
SMO$K_NOFLAGPAG	Specifies that no flag page should be printed	None
SMO$K_NOGENDEV	Disallows generic spooling to the device	None
SMO$K_NOGENPRT	Disallows generic printing on the specified device	None
SMO$K_NOLOWER	Specifies that lowercase printer is not reUired	None
SMO$K_NOMCPULM	No maximum CPU time limit is specified for jobs originating from this queue.	None
SMO$K_NOTRMDEV	Specifies that device is not a terminal	None
SMO$K_NOWSDFLT	No working set default size is specified for jobs originating from this batch queue	None
SMO$K_NOWSDFT	No working set default size is specified for this job	None
SMO$K_NOWSQUO	No working set quota is specified for this job	None
SMO$K_NOWSQUTA	No working set quota is specified for jobs originating from this batch queue	None
SMO$K_PAGCNT	Specifies the number of pages to print	Number of pages (1 word)
SMO$K_PAGHDR	Prints file specification on the top of each output page	None
SMO$K_PARAMS	Specifies parameters for a batch job	One or more counted ASCII strings terminated by 0 (maximum length of all strings is 63 bytes)
SMO$K_SMBNAME	Specifies name of print symbiont for jobs originating from this queue	Image file specification (counted ASCII string, max. 15 bytes plus count byte)
SMO$K_REQUEUE	Places aborted line printer job back into the queue	None
SMO$K_RLSTIM	Specifies time to release a held job	Binary absolute time value (quadword)
SMO$K_SPCCNT	Restarts current job backspacing or forward spacing pages	Signed 16-bit integer specifying plus or minus page count
SMO$K_TOPOFILE	Restarts current job at top of file	None
SMO$K_TRMDEV	Specifies that device is a terminal	None
SMO$K_WSDEFLT	Specifies default working set size for batch job must be less than or equal to SMO$K_WSQUOTA)	Number of memory pages (1 word)
SMO$K_WSDFLT	Specifies default working set size for jobs originating from this queue (must be less than or equal to SMO$_WSQUTA)	Number of memory pages (1 word)
SMO$K_WSQUOTA	Specifies working set quota for batch job	Number of memory pages (1 word)
SMO$K_WSQUTA	Specifies working set quota for jobs originating from this queue	Number of memory pages (1 word)

Format of Response from Symbiont Manager

If a mailbox is specified, the symbiont manager returns to it the following information:

Bits	Contents
0-15	MSG$_SMBRSP indicates that the message is from the symbiont manager. (This name is defined in the $MSGDEF macro.)
16-31	Jobid.
32-63	Status code indicating the success of the operation.

If the mailbox cannot handle the message (because there is insufficient buffer space or because a message is too long), or if the mailbox no longer exists when the reply is sent, the response is lost.

Status Codes Returned in Mailbox:

JBC$_NORMAL

Service successfully completed.

JBC$_ILLDEVNAM

The device name specified has more than 15 characters.

JBC$_ILLDEVTYP

The symbiont manager cannot create a queue for the device type specified.

JBC$_ILLFILNAM

The filename specified has more than 19 characters.

JBC$_ILLQUENAM

The specified queue name has more than 15 characters; or the type of queue associated with the name is invalid for this request.

JBC$_INVREQ

An invalid request type was specified.

JBC$_NOOPENJOB

There is no outstanding open print job for the caller.

JBC$_NOPRIV

The process does not have the privilege to perform the requested operation.

JBC$_NOQUEHDR

The symbiont manager has no more space to allocate a queue header.

JBC$_NOQUESPACE

The specified device queue is full.

JBC$_NOSUCHJOB

The specified record was not a print job.

JBC$_NOSUCHQUE

There is no queue for the specified device.

JBC$_PARLENEXD

The parameter string exceeds the maximum permitted length.

JBC$_QUENOSTOP

The specified queue is still active.

JBC$_SMINVOPR

The request type specified is illegal; or an attempt was made to start a queue that was already started.

JBC$_SMINVOPT

A specified option is invalid for the request type.

JBC$_SMINVREQ

An invalid request type was specified.

JBC$_SMZEROJOB

A job was released that had no files in it.

JBC$_SYMBDSAB

The symbiont manager is disabled.

JBC$_TRMMBXUSE

For a SMR$K_SYNCJOB request, another job is already waiting for the specified job to complete. (Only one job can be waiting for a specified job to complete.)

These status codes are defined in the $JBCMSGDEF macro.

$SUSPND

$SUSPND - SUSPEND PROCESS

The Suspend Process system service allows a process to suspend itself or another process. A suspended process cannot receive ASTs or otherwise be executed until another process resumes or deletes it.

Macro Format

```
$SUSPND  [pidadr] ,[prcnam]
```

High-Level Language Format

```
SYS$SUSPND([pidadr] ,[prcnam])
```

pidadr

Address of a longword containing the process identification of the process to be suspended.

prcnam

Address of a character string descriptor pointing to the 1- to 15-character process name string. The process name is implicitly qualified by the group number of the process issuing the suspend.

If neither a process identification nor a process name is specified, the caller is suspended. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or process identification cannot be written by the caller.

SS$_INSFMEM

Insufficient system dynamic memory is available to complete the service and the process has disabled resource wait mode with the Set Resource Wait Mode ($SETRWM) system service.

SS$_IVLOGNAM

The specified process name has a length of 0 or has more than 15 characters.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The target process was not created by the caller and the requesting process does not have group or world process control privilege.

Privilege Restrictions

User privileges are required to suspend:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privilege)

Resources Required/Returned

The Suspend Process system service requires system dynamic memory.

Notes

1. The suspend process system service completes successfully if the target process is already suspended.
2. Unless it has pages locked in the balance set, a suspended process can be removed from the balance set to allow other processes to execute.
3. The Resume Process ($RESUME) system service allows a suspended process to continue. If one or more resume requests are issued for a process that is not suspended, a subsequent suspend request completes immediately; that is, the process is not suspended. No count is maintained of outstanding resume requests.

For more information on process suspension, see Section 7.5, "Process Hibernation and Suspension."

$TRNLOG

$TRNLOG - TRANSLATE LOGICAL NAME

The Translate Logical Name system service searches the logical name tables for a specified logical name and returns an equivalence name string. The process, group, and system logical name tables are searched in that order.

The first string match returns the equivalence string into a user-specified buffer; the search is not recursive.

Macro Format

```
$TRNLOG  lognam ,[rsllen] ,rslbuf ,[table] ,[acmode] ,[dsbmsk]
```

High-Level Language Format

```
SYS$TRNLOG(lognam ,[rsllen] ,rslbuf ,[table] ,[acmode] ,[dsbmsk])
```

lognam

Address of a character string descriptor pointing to the logical name string.

rsllen

Address of a word to receive the length of the translated equivalence name string.

rslbuf

Address of a character string descriptor pointing to the buffer which is to receive the resultant equivalence name string.

table

Address of a byte to receive the number of the logical name table in which the match was found. A return value of 0 indicates that the logical name was found in the system logical name table; 1 indicates the group table, and 2 indicates the process table.

acmode

Address of a byte to receive the access mode from which the logical name table entry was made. Data received in this byte is valid only if the logical name match was found in table 2, the process logical name table.

dsbmsk

Mask in which bits set to 1 disable the search of particular logical name tables. If bit 0 is set, the system logical name table is not searched; if bit 1 is set, the group logical name table is not searched; if bit 2 is set, the process logical name table is not searched.

If no mask is specified or is specified as 0 (the default), all three logical name tables are searched.

Return Status

SS$_NORMAL

Service successfully completed. The equivalence name string was placed in the output buffer.

SS$_NOTRAN

Service successfully completed. The input logical name string was placed in the output buffer because no equivalence name was found.

SS$_ACCVIO

The logical name string or string descriptor cannot be read by the caller; or the output length, output buffer, or table or access mode field cannot be written by the caller.

SS$_IVLOGNAM

The specified logical name string has a length of 0 or has more than 63 characters.

SS$_RESULTOVF

The buffer to receive the resultant string has a length of zero, or it is smaller than the string.

Notes

If the first character of a specified logical name is an underline character (_), no translation is performed. However, the underscore character is removed from the string and the modified string is returned in the output buffer.

For an example of the $TRNLOG system service, see Figure 2-1 at the end of Chapter 2. For additional information on this service, see Chapter 5, "Logical Name Services."

$ULKPAG

$ULKPAG - UNLOCK PAGES FROM MEMORY

The Unlock Pages from Memory system service releases the page lock on a page or range of pages previously locked in memory by the Lock Pages in Memory ($LCKPAG) service.

Macro Format

```
$ULKPAG  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$ULKPAG(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be unlocked. If the starting and ending virtual addresses are the same, a single page is unlocked. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually unlocked.

acmode

Access mode of the locked pages. The specified access mode is maximized with the access mode of the caller. The resultant access mode must be equal to or more privileged than the access mode of the owner of each page in order to unlock the page.

Return Status

SS$_WASCLR

Service successfully completed. At least one of the specified pages was previously unlocked.

SS$_WASSET

Service successfully completed. All of the specified pages were previously locked.

SS$_ACCVIO

1. The input array cannot be read by the caller, or the output array cannot be written by the caller.

2. A page in the specified range is inaccessible or does not exist.

Privilege Restrictions

1. The user privilege PSWAPM is required to lock or unlock pages from memory.

2. The access mode of the caller must be equal to or more privileged than the access mode of the owner of the pages that are to be unlocked.

Notes

1. If more than one page is being unlocked and it is necessary to determine specifically which pages had been previously unlocked, the pages should be unlocked one at a time.

2. If an error occurs while multiple pages are being unlocked, the return array, if requested, indicates the pages that were successfully unlocked before the error occurred. If no pages were unlocked, both longwords of the return address array contain a -1.

3. Locked pages are automatically unlocked at image exit, when the system deletes the pages.

$ULWSET

$ULWSET - UNLOCK PAGES FROM WORKING SET

The Unlock Pages from Working Set system service allows a process to specify that a group of pages that were previously locked in the working set are to be unlocked and become candidates for page replacement like other working set pages.

Macro Format

```
$ULWSET  inadr ,[retadr] ,[acmode]
```

High-Level Language Format

```
SYS$ULWSET(inadr ,[retadr] ,[acmode])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be unlocked. If the starting and ending virtual address are the same, a single page is unlocked. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the pages actually unlocked.

acmode

Access mode on behalf of which the request is being made. The specified access mode is maximized with the access mode of the caller. The resultant access mode must be equal to or more privileged than the access mode of the owner of each page in order to unlock the page.

Return Status

SS$_WASCLR

Service successfully completed. At least one of the specified pages was previously unlocked.

SS$_WASSET

Service successfully completed. All of the specified pages were previously locked in the working set.

SS$_ACCVIO

1. The input array cannot be read by the caller, or the output array cannot be written by the caller.

2. A page in the specified range is inaccessible or does not exist.

SS$_NOPRIV

A page in the specified range is in the system address space.

Privilege Restriction

The access mode of the caller must be equal to or more privileged than the access mode of the owner of the pages that are to be unlocked.

Notes

1. If more than one page is being unlocked and it is necessary to determine specifically which pages had been previously unlocked, the pages should be unlocked one at a time.

2. If an error occurs while multiple pages are being unlocked, the return array, if requested, indicates the pages that were successfully unlocked before the error occurred. If no pages were unlocked, both longwords in the return address array contain a -1.

$UNWIND

$UNWIND - UNWIND CALL STACK

The Unwind Call Stack system service allows a condition-handling routine to unwind the procedure call stack to a specified depth. Optionally, a new return address can be specified to alter the flow of execution when the topmost call frame has been unwound.

Macro Format

```
$UNWIND  [depadr] ,[newpc]
```

High-Level Language Format

```
SYS$UNWIND([depadr] ,[newpc])
```

depadr

Address of a longword indicating the depth to which the stack is to be unwound. A depth of 0 indicates the call frame that was active when the condition occurred, 1 indicates the caller of that frame, 2 indicates the caller of the caller of the frame, and so on. If depth is specified as 0 or less, no unwind occurs; a successful status code is returned. If no address is specified, the unwind is performed to the caller of the frame that established the condition handler.

newpc

Address to be given control when the unwind is complete.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The call stack is not accessible to the caller. This condition is detected when the call stack is scanned to modify the return address.

SS$_INSFRAME

There are insufficient call frames to unwind to the specified depth.

SS$_NOSIGNAL

Warning. No signal is currently active for an exception condition.

SS$_UNWINDING

Warning. An unwind is already in progress.

Notes

The actual unwind is not performed immediately. Rather, the return addresses in the call stack are modified so that when the condition handler returns, the unwind procedure is called from each frame that is being unwound.

For an explanation of condition handling and an example of a call to $UNWIND, see Chapter 9, "Condition-Handling Services."

$UPDSEC

$UPDSEC - UPDATE SECTION FILE ON DISK

The Update Section File on Disk system service writes all modified pages in an active private or global section back into the section file on disk. One or more I/O requests are queued, based on the number of pages that have been modified.

Macro Format

```
$UPDSEC  inadr ,[retadr] ,[acmode] ,[updflg] ,[efn] ,[iosb]
         ,[astadr] ,[astprm]
```

High-Level Language Format

```
SYS$UPDSEC(inadr ,[retadr] ,[acmode] ,[updflg] ,[efn] ,[iosb]
          ,[astadr] ,[astprm])
```

inadr

Address of a 2-longword array containing the starting and ending virtual addresses of the pages to be potentially written back into the section file. The $UPDSEC system service locates pages within this range that were modified and writes only the modified pages (with contiguous pages, if convenient) back into the section file on disk.

If the starting and ending virtual addresses are the same, a single page is a candidate for writing. Only the virtual page number portion of the virtual addresses is used; the low-order 9 bits are ignored.

retadr

Address of a 2-longword array to receive the starting and ending virtual addresses of the first and last pages queued for writing in the first I/O request.

acmode

Access mode on behalf of which the service is performed. The specified access mode is maximized with the access mode of the caller. The resultant access mode is used to determine whether the caller can actually write the pages.

updflg

Update indicator for read/write global sections. If specified as 0 (the default), all read/write pages in the global section are updated in the section file on disk, regardless of whether or not they have been modified. If specified as 1, the caller is the only process actually writing the global section, and only those pages that were actually modified by the caller are to be written.

efn

Number of an event flag to set when the section file is updated. If not specified, it defaults to 0.

iosb

Address of a quadword I/O status block that is to receive the completion status when the section file has been updated.

astadr

Address of the entry mask of an AST service routine to be executed when the section file has been updated. If specified, the AST service routine executes at the access mode from which the section file update was requested.

astprm

AST parameter to be passed to the AST service routine.

Return Status

SS$_NORMAL

Service successfully completed. One or more I/O requests were queued.

SS$_NOTMODIFIED

Service successfully completed. No pages in the input address range were section pages that had been modified; no I/O requests were queued.

SS$_ACCVIO

The input address array cannot be read by the caller, or the output address array cannot be written by the caller.

SS$_EXQUOTA

The process has exceeded its AST limit quota.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_IVSECFLG

An invalid flag was specified.

SS$_NOTCREATOR

The section is in memory shared by multiple processors and was created by a process on another processor.

SS$_NOPRIV

A page in the specified range is in the system address space.

SS$_PAGOWNVIO

A page in the specified range is owned by an access mode more privileged than the access mode of the caller.

SS$_SHMNOTCNCT

The section is specified as being in memory shared by multiple processors, but this shared memory is not known to the system.

SS$_UNASCEFC

The process is not associated with the cluster containing the specified event flag.

Privilege Restrictions

Only pages that are owned by the calling or a less privileged access mode can be updated.

Resources Required/Returned

The Update Section File on Disk system service requires the process's direct I/O limit (DIRIO) to queue the I/O request; and, if the ASTADR argument is specified, the process's AST limit quota (ASTLM).

Notes

1. The $UPDSEC system service scans pages starting at the address contained in the first longword of the location pointed to by the INADR argument and ending with the address in the second longword. Within this range, pages are candidates for being updated based on whether they are read/write pages that were modified. Unmodified pages that share a cluster with modified pages are also written. The ending address can be lower than the starting address.

2. If the $UPDSEC system service returns an error, both longwords in the return address array contain a -1. In this case, no I/O completion is indicated, that is, the event flag is not set, no AST is delivered, and the I/O status block is not posted.

3. Proper use of this service requires the caller to synchronize completion of the update request by checking the return status from $UPDSEC. If SS$_NOTMODIFIED is returned, the caller can continue. If SS$_NORMAL is returned, the caller should wait for the I/O to complete and then check the status returned in the I/O status block.

   When all I/O is complete, the I/O status block, if specified, is filled in as follows:

   a. The first word contains the completion status of the output request.

   b. If an error occurred in the I/O request, the first bit in the second word is set if a hardware write error occurred.

   c. The second longword contains the virtual address of the first page that was not written.

4. For a global section located in memory shared by multiple processors, only processes running on the processor that created the section can call the $UPDSEC service specifying that section. Processes on another processor that attempt to update the section file will receive an error status code indicating that the request was not performed.

$WAITFR - WAIT FOR SINGLE EVENT FLAG

The Wait for Single Event Flag system service tests a specific event flag and returns immediately if the flag is set. Otherwise, the process is placed in a wait state until the event flag is set.

Macro Format

```
$WAITFR  efn
```

High-Level Language Format

```
SYS$WAITFR(efn)
```

efn

Number of the event flag for which to wait.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Notes

The wait state caused by this service can be interrupted by an asynchronous system trap (AST) if (1) the access mode at which the AST executes is less than or equal to the access mode from which the wait was issued and (2) the process is enabled for ASTs at that access mode.

When the AST service routine completes execution, the system repeats the $WAITFR request. If the event flag has been set, the process resumes execution.

$WAKE

$WAKE - WAKE

The Wake system service activates a process that has placed itself in a state of hibernation with the Hibernate ($HIBER) system service.

Macro Format

```
$WAKE  [pidadr] ,[prcnam]
```

High-Level Language Format

```
SYS$WAKE([pidadr] ,[prcnam])
```

pidadr

Address of a longword containing the process identification of the process to be awakened.

prcnam

Address of a character string descriptor pointing to the process name string. The name is implicitly qualified by the group number of the process issuing the wake.

If neither a process identification nor a process name is specified, the wake request is for the caller. For details on how the service interprets the PIDADR and PRCNAM arguments, see Table 7-1 in Chapter 7, "Process Control Services."

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ACCVIO

The process name string or string descriptor cannot be read by the caller, or the process identification cannot be written by the caller.

SS$_IVLOGNAM

The specified process name string has a length of 0 or has more than 15 characters.

SS$_NONEXPR

Warning. The specified process does not exist, or an invalid process identification was specified.

SS$_NOPRIV

The process does not have the privilege to wake the specified process.

Privilege Restrictions

User privileges are required to wake:

- Other processes in the same group (GROUP privilege)
- Any other process in the system (WORLD privlege)

Notes

1. If one or more wake requests are issued for a process that is not currently hibernating, a subsequent hibernate request completes immediately, that is, the process does not hibernate. No count is maintained of outstanding wakeup requests.
2. A hibernating process can also be awakened with the Schedule Wakeup ($SCHDWK) system service.

For an example of the $WAKE system service and a discussion of the hibernate/wake mechanism, see Chapter 7, "Process Control Services."

$WFLAND

$WFLAND - WAIT FOR LOGICAL AND OF EVENT FLAGS

The Wait for Logical AND of Event Flags system service allows a process to specify a mask of event flags for which it wishes to wait. All of the indicated event flags within a specified event cluster must be set; otherwise, the process is placed in a wait state until they are all set.

Macro Format

```
$WFLAND  efn ,mask
```

High-Level Language Format

```
SYS$WFLAND(efn ,mask)
```

efn

Number of any event flag within the cluster being used.

mask

32-bit mask in which bits set to 1 indicate the event flags within the cluster that must be set.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Notes

The wait state caused by this service can be interrupted by an asynchronous system trap (AST) if (1) the access mode at which the AST is to execute is less than or equal to the access mode from which the wait was issued and (2) the process is enabled for ASTs at that access mode.

When the AST service routine completes execution, the system repeats the $WFLAND request. If the specified event flags are all set, the process resumes execution.

For an example of the $WFLAND system service, see Chapter 3, "Event Flag Services."

$WFLOR - WAIT FOR LOGICAL OR OF EVENT FLAGS

The Wait for Logical OR of Event Flags system service tests the event flags specified by a mask within a specified cluster and returns immediately if any of them is set. Otherwise, the process is placed in a wait state until at least one of the selected event flags is set.

Macro Format

```
$WFLOR  efn ,mask
```

High-Level Language Format

```
SYS$WFLOR(efn ,mask)
```

efn

Number of any event flag within the cluster being used.

mask

32-bit mask in which bits set to 1 indicate the event flags of interest.

Return Status

SS$_NORMAL

Service successfully completed.

SS$_ILLEFC

An illegal event flag number was specified.

SS$_UNASEFC

The process is not associated with the cluster containing the specified event flag.

Notes

The wait state caused by this service can be interrupted by an asynchronous system trap (AST) if (1) the access mode at which the AST is to execute is less than or equal to the access mode from which the wait was issued and (2) the process is enabled for ASTs at that access mode.

When the AST service routine completes execution, the system repeats the $WFLOR request. If any of the event flags has been set, the process resumes execution.

APPENDIX A

SYSTEM SYMBOLIC DEFINITION MACROS

This appendix summarizes system-provided macros that define symbolic values for use with system services, and lists the symbols defined by each macro. The macros listed in this appendix are:

Macro	Symbols Defined
$IODEF	Symbolic names for I/O function codes
$MSGDEF	Symbolic names to identify mailbox message senders
$PRDEF	Internal processor registers
$PRTDEF	Symbolic names for hardware protection codes
$PSLDEF	Processor status longword (PSL) mask and field definitions, and symbolic names for access modes
$SSDEF	Symbolic names for system status codes

The symbolic definitions generated by each of the above macros are listed on the following pages. Definitions generated by the following macros are listed elsewhere in this manual (consult the Index for page number references).

Macro	Symbols Defined
$ACCDEF	Accounting manager request type codes and process termination message and accounting record information offsets
$CHFDEF	Condition handler argument offsets
$DIBDEF	Device information buffer offsets
$JBCMSGDEF	Job controller return status codes (Symbols are in SYS$LIBRARY:LIB.MLB.)
$JPIDEF	Job/process information request type codes
$OPCDEF	Operator communication manager request type codes, buffer offsets, and return status codes
$PQLDEF	Quota types for process creation quota list
$PRVDEF	User privileges
$SECDEF	Attribute flags for private/global section creation and mapping
$SMRDEF	Symbiont manager request type and option codes

SYSTEM SYMBOLIC DEFINITION MACROS

A.1 USING SYSTEM SYMBOLS

The default system macro library, STARLET.MLB, contains the macro definitions for most system symbols. When you assemble a source program that calls any of these macros, the assembler automatically searches STARLET.MLB for the macro definitions.

Each symbol name has a numeric value. To obtain a list of symbols and their values in alphabetic order, use the following procedure:

1. Create a file with the file type of MAR containing the lines:

```
$xxDEF
.END
```

   where xx is the prefix of the macro defining the symbols you need, for example, $SSDEF or $MSGDEF. You can specify more than one macro in the same assembly source file to obtain the numeric values for more than one set of definitions.

2. Assemble the file and request a listing with the MACRO command:

```
$ MACRO/LIST file-name
```

   where file-name is the file name of the file containing the $xxDEF macro call(s). The input file type defaults to MAR.

   The symbols and their hexadecimal values appear in the listing file file-name.LIS.

A.2 $IODEF MACRO - SYMBOLIC NAMES FOR I/O FUNCTION CODES

The function codes and function modifiers defined in the $IODEF macro are grouped according to the devices for which the I/O operation is requested. For your convenience, the arguments (P1, P2, and so on), are also listed. This section provides information for the following device drivers:

- Terminal driver
- Disk drivers
- Magnetic tape drivers
- Line printer driver
- Card reader driver
- Mailbox driver
- DMC11 driver
- ACP interface driver
- LPA-11 driver
- DR32 driver

For detailed information on the functions, arguments, and modifiers accepted by a specific device driver, see the appropriate chapter in the VAX/VMS I/O User's Guide.

A.2.1 Terminal Driver

Functions	Arguments	Modifiers
IO$_READVBLK IO$_READLBLK IO$_READPBLK IO$_READPROMPT	P1 - buffer address P2 - buffer size P3 - timeout P4 - read terminator block address P5 - prompt string buffer address[1] P6 - prompt string buffer size[1]	IO$M_NOECHO IO$M_CVTLOW IO$M_NOFILTR IO$M_TIMED IO$M_PURGE IO$M_DSABLMBX IO$M_TRMNOECHO IO$M_REFRESH
IO$_WRITEVBLK IO$_WRITELBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size P3 - (ignored) P4 - carriage control specifier[2]	IO$M_CANCTRLO IO$M_ENABLMBX IO$M_NOFORMAT IO$M_REFRESH
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address P2 - (ignored) P3 - speed specifier P4 - fill specifier P5 - parity flags	
IO$_SETMODE!IO$M_HANGUP IO$_SETCHAR!IO$M_HANGUP	(none)	
IO$_SETMODE!IO$M_CTRLCAST IO$_SETMODE!IO$M_CTRLYAST IO$_SETCHAR!IO$M_CTRLCAST IO$_SETCHAR!IO$M_CTRLYAST	P1 - AST service routine address P2 - AST parameter P3 - access mode to deliver AST	

1. Only for IO$_READPROMPT

2. Only for IO$_WRITELBLK and IO$_WRITEVBLK

A.2.2 Disk Drivers

Functions	Arguments	Modifiers
IO$_READVBLK IO$_READLBLK IO$_READPBLK IO$_WRITEVBLK IO$_WRITELBLK IO$_WRITEPBLK	P1 - buffer address P2 - byte count P3 - disk address	IO$M_DATACHECK IO$M_INHRETRY IO$M_INHSEEK[1] IO$M_DELDATA[4,5]
IO$_SETMODE IO$_SETCHAR	P1 - characteristic buffer address	IO$_INHRETRY
IO$_CREATE IO$_ACCESS IO$_DEACCESS IO$_MODIFY IO$_DELETE	P1 - FIB descriptor address P2 - file name string address P3 - result string length address P4 - result string descriptor address P5 - attribute list address	IO$M_CREATE[2] IO$M_ACCESS[2] IO$M_DELETE[3]
IO$_FORMAT5	P1 - density with which to reformat the diskette	

1. Only for IO$_READPBLK and IO$_WRITEPBLK

2. Only for IO$_CREATE and IO$_ACCESS

3. Only for IO$_CREATE and IO$_DELETE

4. Only for IO$_WRITE_PBLK

5. Only for RX02 diskette

A.2.3 Magnetic Tape Drivers

Functions	Arguments	Modifiers
IO$_READVBLK IO$_READLBLK IO$_READPBLK IO$_WRITEVBLK IO$_WRITELBLK IO$_WRITEPBLK	P1 - buffer address P2 - byte count	IO$M_DATACHECK IO$M_INHRETRY IO$M_REVERSE [1] IO$M_INHEXTGAP [2]
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address	IO$M_INHRETRY IO$M_INHEXTGAP
IO$_CREATE IO$_ACCESS IO$_DEACCESS IO$_MODIFY IO$_ACPCONTROL	P1 - FIB descriptor address P2 - file name string address P3 - result string length address P4 - result string descriptor address P5 - attribute list address	IO$M_CREATE [3] IO$M_ACCESS [3] IO$M_DMOUNT [4]
IO$_SKIPFILE	P1 - skip n tape marks	IO$M_INHRETRY
IO$_SKIPRECORD	P1 - skip n records	IO$M_INHRETRY
IO$_MOUNT	(none)	
IO$_REWIND IO$_REWINDOFF	(none)	IO$M_INHRETRY IO$M_NOWAIT
IO$_WRITEOF	(none)	IO$M_INHEXTGAP IO$M_INHRETRY
IO$_SENSEMODE	(none)	IO$M_INHRETRY

1. Only for read functions

2. Only for write functions

3. Only for IO$_CREATE and IO$_ACCESS

4. Only for IO$_ACPCONTROL

A.2.4 Line Printer Driver

Functions	Arguments	Modifiers
IO$_WRITEVBLK IO$_WRITELBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size P3 - (ignored) P4 - carriage control specifier[1]	(none)
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address	(none)

1. Only for IO$_WRITEVBLK and IO$_WRITELBLK

A.2.5 Card Reader Driver

Functions	Arguments	Modifiers
IO$_READLBLK IO$_READVBLK IO$_READPBLK	P1 - buffer address P2 - byte count	IO$M_BINARY IO$M_PACKED
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address	(none)
IO$_SENSEMODE	(none)	

A.2.6 Mailbox Driver

Functions	Arguments	Modifiers
IO$_READVBLK IO$_READLBLK IO$_READPBLK IO$_WRITEVBLK IO$_WRITELBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size	IO$M_NOW
IO$_WRITEOF	(none)	
IO$_SETMODE!IO$M_READATTN	P1 - AST address	
IO$_SETMODE!IO$M_WRTATTN	P1 - AST parameter	

A.2.7 DMC11 Driver

Functions	Arguments	Modifiers
IO$_READLBLK IO$_READPBLK IO$_READVBLK IO$_WRITELBLK IO$_WRITEPBLK IO$_WRITEVBLK	P1 - buffer address P2 - message size P6 - diagnostic buffer[2]	IO$M_DSABLMBX[1] IO$M_NOW[1] IO$M_ENABLMBX[3]
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address	
IO$_SETMODE!IO$M_ATTNAST IO$_SETCHAR!IO$M_ATTNAST	P1 - AST service routine address P2 - (ignored) P3 - AST access mode	
IO$_SETMODE!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_SHUTDOWN	P1 - characteristics block address	
IO$_SETMODE!IO$M_STARTUP IO$_SETCHAR!IO$M_STARTUP	P1 - characteristics block address P2 - (ignored) P3 - receive message blocks	

1. Only for IO$_READLBLK and IO$_READPBLK
2. Only for IO$_READPBLK and IO$_WRITEPBLK
3. Only for IO$_WRITELBLK and IO$_WRITEPBLK

A.2.8 ACP Interface Driver

Functions	Arguments	Modifiers
IO$_CREATE IO$_ACCESS IO$_DEACCESS IO$_MODIFY IO$_DELETE IO$_ACPCONTROL	P1 - FIB descriptor address P2 - file name string address P3 - result string length address P4 - result string descriptor address P5 - attribute list address	IO$M_CREATE[1] IO$M_ACCESS[1] IO$M_DELETE[2] IO$M_DMOUNT[3]
IO$_MOUNT	(none)	

1. Only for IO$_CREATE and IO$_ACCESS
2. Only for IO$_CREATE and IO$_DELETE
3. Only for IO$_ACPCONTROL

A.2.9 LPA-11 Driver

Functions	Arguments	Modifiers
IO$_LOADMCODE	P1 - address of microcode image P2 - size of microcode image P3 - starting microcode address	
IO_STARTPROC	(none)	
IO$_INITIALIZE	P1 - address of initialization table P2 - size of table	
IO$_SETCLOCK	P2 - mode word P3 - clock control and status P4 - clock preset	
IO$_STARTDATA	P1 - starting address of command table P2 - length of command table P3 - AST address of normal buffer completion AST routine P4 - AST address of buffer overrun completion AST routine	IO$M_SETEVF

A.2.10 DR32 Driver

Functions	Arguments	Modifiers
IO$_LOADMCODE	P1 - address of microcode P2 - size of microcode	
IO$_STARTDATA	P1 - address of command table P2 - size of command table	IO$M_SETEVF

A.3 $MSGDEF MACRO - SYMBOLIC NAMES FOR SYSTEM MAILBOX MESSAGES

Symbolic Name	Meaning
MSG$_TRMUNSOLIC	Unsolicited terminal data
MSG$_CRUNSOLIC	Unsolicited card reader data
MSG$_DELPROC	Delete process
MSG$_SNDSMB	Send to symbiont manager
MSG$_DEVOFFLIN	Device offline
MSG$_TRMHANGUP	Terminal hangup
MSG$_DEVONLIN	Device online
MSG$_OPRQST	Operator request
MSG$_OPREPLY	Operator reply
MSG$_SMBINI	Symbiont is initiated
MSG$_SMBDON	Symbiont has finished
MSG$_SNDACC	Send to accounting manager
MSG$_XM_DATAVL	Data available (DMC-11)
MSG$_XM_SHUTDN	Unit shutdown (DMC-11)
MSG$_XM_ATTN	Unit attention (DMC-11)
MSG$_INIOPR	Initiate file printing
MSG$_ABOOPR	Abort printing a file
MSG$_SUSOPR	Pause printing a file
MSG$_RESOPR	Resume printing a file
MSG$_DELSMB	Symbiont should delete itself
MSG$_SMBRSP	Symbiont response
MSG$_ACCRSP	Accounting manager response
MSG$_SCANBAD	
MSG$_SCANRSP	
MSG$_ABORT	Network partner aborted link
MSG$_CONFIRM	Network connect confirm
MSG$_CONNECT	Network inbound connect initiate
MSG$_DISCON	Network partner disconnected-hangup
MSG$_EXIT	Network partner exited prematurely
MSG$_INTMSG	Network interrupt message; unsolicited data
MSG$_PATHLOST	Network path lost to partner
MSG$_PROTOCOL	Network protocol error
MSG$_REJECT	Network connect reject
MSG$_THIRDPARTY	Network third party disconnect
MSG$_TIMEOUT	Network connect timeout

A.4 $PRDEF MACRO - SYMBOLIC NAMES FOR PROCESSOR REGISTERS

Symbolic Name	Register
PR$_KSP	Kernel stack pointer
PR$_ESP	Executive stack pointer
PR$_SSP	Supervisor stack pointer
PR$_USP	User stack pointer
PR$_ISP	Interrupt stack pointer
PR$_P0BR	P0 base register
PR$_P0LR	P0 limit register
PR$_P1BR	P1 base register
PR$_P1LR	P1 limit register
PR$_SBR	System base register
PR$_SLR	System limit register
PR$_PCBB	Process control block base register
PR$_SCBB	System control block base register
PR$_IPL	Interrupt priority level register
PR$_ASTLVL	AST level register
PR$_SIRR	Software interrupt request register
PR$_SISR	Software interrupt summary register
PR$_MAPEN	Mapping enable register
PR$_TBIA	Translation buffer invalidate all
PR$_TBIS	Translation buffer invalidate single
PR$_ICCS	Interval clock control status register
PR$_NICR	Interval clock next interval register
PR$_ICR	Interval clock interval count register
PR$_TODR	Time of day register
PR$_RXCS	Console receiver control status register
PR$_RXDB	Console receiver data buffer register
PR$_TXCS	Console transmit control status register
PR$_TXDB	Console transmit data buffer register
PR$_ACCS	Accelerator control status register
PR$_ACCR	Accelerator reserved
PR$_PME	Performance monitor enable
PR$_SID	System identification register
PR$_WCSA	WCS address register
PR$_WCSD	WCS data register
PR$_SBIFS	SBI fault status register
PR$_SBIS	SBI silo register
PR$_SBISC	SBI comparator register
PR$_SBIMT	SBI maintenance register
PR$_SBIER	SBI error register
PR$_SBITA	SBI timeout address register
PR$_SBIQC	SBI quadword clear register

A.5 $PRTDEF - HARDWARE PROTECTION CODE DEFINITIONS

Symbolic Name	Meaning
PRT$C_NA	No access
PRT$C_KR	Kernel read only
PRT$C_KW	Kernel write
PRT$C_ER	Executive read only
PRT$C_EW	Executive write
PRT$C_SR	Supervisor read only
PRT$C_SW	Supervisor write
PRT$C_UR	User read only
PRT$C_UW	User write
PRT$C_ERKW	Executive read; kernel write
PRT$C_SRKW	Supervisor read; kernel write
PRT$C_SREW	Supervisor read; executive write
PRT$C_URKW	User read; kernel write
PRT$C_UREW	User read; executive write
PRT$C_URSW	User read; supervisor write

A.6 $PSLDEF MACRO - PROCESSOR STATUS LONGWORD SYMBOL DEFINITIONS

Symbolic Name	Meaning
PSL$V_TBIT	TBIT enable field
PSL$S_TBIT	Length of TBIT enable field
PSL$M_TBIT	Mask for TBIT enable field
PSL$V_IV	Integer overflow field
PSL$S_IV	Length of integer overflow field
PSL$M_IV	Mask for integer overflow field
PSL$V_FU	Floating undefined field
PSL$S_FU	Length of floating undefined field
PSL$M_FU	Mask for floating undefined field
PSL$V_DV	Divide by zero field
PSL$S_DV	Length of divide by zero field
PSL$M_DV	Mask for divide by zero field
PSL$V_IPL	Interrupt priority field
PSL$S_IPL	Length of interrupt priority field
PSL$V_PRVMOD	Previous processor mode field
PSL$S_PRVMOD	Length of previous processor mode field
PSL$V_CURMOD	Current processor mode field
PSL$S_CURMOD	Length of current processor mode field
PSL$V_IS	Interrupt stack field
PSL$S_IS	Length of interrupt stack field
PSL$M_IS	Mask for interrupt stack field
PSL$V_FPD	First part done field
PSL$S_FPD	Length of first part done field
PSL$M_FPD	Mask for first part done field
PSL$V_TP	Trace trap pending field
PSL$S_TP	Length of trace trap pending field
PSL$M_TP	Mask for trace trap pending field
PSL$V_CM	Compatibility mode field
PSL$S_CM	Length of compatibility mode field
PSL$M_CM	Mask for compatibility mode field

Symbolic Names for Access Modes

Symbolic Name	Access Mode	Number
PSL$C_KERNEL	Kernel	0
PSL$C_EXEC	Executive	1
PSL$C_SUPER	Supervisor	2
PSL$C_USER	User	3

A.7 $SSDEF MACRO - SYMBOLIC NAMES FOR SYSTEM STATUS CODES

The $SSDEF macro instruction defines symbolic names for system service return status codes and for exception condition names. The "Type" column, below, indicates one of the following:

Type	Meaning
Success	Successful completion
Warning	Warning return
Error	Error return
Severe	Severe error return
Condition	Exception condition

Status Code	Type	Meaning
SS$_ABORT	Severe	Abort
SS$_ACCONFLICT	Warning	File access conflict
SS$_ACCQUOTA	Severe	ACCOUNT had inadequate quota at remote mode
SS$_ACCVIO	Severe	Access violation
SS$_ACCVIO	Condition	Access violation
SS$_ACPVAFUL	Severe	MTAACP's virtual address space is full
SS$_ARTRES	Condition	Reserved arithmetic trap
SS$_ASTFLT	Condition	AST fault
SS$_BADATTRIB	Severe	Bad attribute control list
SS$_BADCHKSUM	Warning	Bad file header checksum
SS$_BADESCAPE	Severe	Syntax error in escape sequence
SS$_BADFILEHDR	Warning	Bad file header
SS$_BADFILENAME	Warning	Bad file name syntax
SS$_BADFILEVER	Warning	Bad file version number
SS$_BADIMGHDR	Severe	Bad image header
SS$_BADIRECTORY	Warning	Bad directory file format
SS$_BADISD	Severe	Illegal image section descriptor
SS$_BADPARAM	Severe	Bad parameter value
SS$_BADQFILE	Severe	Invalid disk quota file format
SS$_BADQUEUEHDR	Severe	Interlocked queue corrupted
SS$_BADSTACK	Severe	Bad stack encountered during exception dispatch
SS$_BADVEC	Severe	Invalid charge-mode or message vector
SS$_BEGOFFILE	Warning	Beginning of file
SS$_BLOCKCNTERR	Warning	Block count error
SS$_BREAK	Condition	Breakpoint instruction fault
SS$_BUFBYTALI	Severe	Device does not support byte-aligned transfers
SS$_BUFFEROVF	Success	Output buffer overflow
SS$_BUFNOTALIGN	Severe	Buffer incorrectly aligned
SS$_BUGCHECK	Severe	Internal consistency failure
SS$_CANCEL	Warning	I/O operation canceled
SS$_CHANINTLK	Severe	Channel usage interlocked
SS$_CLIFRCEXT	Warning	CLI forced exit
SS$_CMODSUPR	Condition	Change mode to supervisor trap
SS$_CMODUSER	Condition	Change mode to user trap
SS$_COMPAT	Condition	Compatibility mode fault
SS$_CONTINUE	Success	Continue execution at point of condition
SS$_CONTROLC	Success	Operation completed under CRTL/C
SS$_CONTROLO	Success	Output completed under CTRL/O
SS$_CONTROLY	Success	Operation completed under CTRL/Y
SS$_CREATED	Success	File did not exist; was created

Status Code	Type	Meaning
SS$_CTRLERR	Severe	Fatal controller error
SS$_DATACHECK	Severe	Write check error
SS$_DATAOVERUN	Warning	Data overrun
SS$_DEBUG	Condition	Command interpreter debugger signal
SS$_DECOVF	Condition	Decimal overflow
SS$_DEVACTIVE	Severe	Device active
SS$_DEVALLOC	Warning	Device already allocated to another user
SS$_DEVALRALLOC	Success	Device already allocated to this job
SS$_DEVASSIGN	Warning	Device has channels assigned
SS$_DEVCMDERR	Severe	Device command error
SS$_DEVFOREIGN	Severe	Device is mounted foreign
SS$_DEVICEFULL	Warning	Device full - allocation failure
SS$_DEVMOUNT	Severe	Device is already mounted
SS$_DEVNOTALLOC	Warning	Device not allocated
SS$_DEVNOTMBX	Severe	Device not mailbox
SS$_DEVNOTMOUNT	Severe	Device not mounted
SS$_DEVOFFLINE	Severe	Device not in configuration
SS$_DEVREQERR	Severe	Device request error
SS$_DIRFULL	Warning	Directory is full
SS$_DISCONNECT	Severe	Process is disconnected from the requested interrupt vector
SS$_DRVERR	Severe	Fatal drive error
SS$_DUPDSKQUOTA	Severe	Duplicate disk quota file entry
SS$_DUPFILENAME	Warning	Duplicate file name
SS$_DUPLNAM	Severe	Duplicate process name
SS$_ENDOFFILE	Warning	End of file reached
SS$_ENDOFTAPE	Warning	End of tape
SS$_ENDOFUSRLBL	Warning	End of user labels
SS$_ENDOFVOLUME	Warning	End of volume
SS$_EXCPUTIM	Severe	CPU time limit expired
SS$_EXDISKQUOTA	Severe	Disk quota exceeded
SS$_EXPORTQUOTA	Severe	Exceeded quota permitted by processes on this port of a multiport (shared) memory
SS$_EXQUOTA	Severe	Exceeded quota
SS$_FCPREADERR	Warning	File processor read error
SS$_FCPREPSTN	Warning	File processor reposition error
SS$_FCPREWNDERR	Warning	File processor rewind error
SS$_FCPSPACERR	Warning	File processor space error
SS$_FCPWRITERR	Warning	File processor write error
SS$_FILACCERR	Severe	Magnetic tape file access non-blank
SS$_FILALRACC	Severe	File already accessed on channel
SS$_FILELOCKED	Warning	File is deaccess locked
SS$_FILENUMCHK	Warning	File ID file number check
SS$_FILEPURGED	Success	Oldest file version purged
SS$_FILESEQCHK	Warning	File ID file sequence number check
SS$_FILESTRUCT	Warning	Unsupported file structure level
SS$_FILNOTACC	Severe	File not accessed on channel
SS$_FILNOTCNTG	Severe	File is not contiguous as required
SS$_FILNOTEXP	Severe	File not expired
SS$_FLTDIV	Condition	Floating/decimal divide by zero
SS$_FLTDIV_F	Condition	Floating divide by zero fault
SS$_FLTOVF	Condition	Floating overflow
SS$_FLTOVF_F	Condition	Floating overflow fault
SS$_FLTUND	Condition	Floating underflow
SS$_FLTUND_F	Condition	Floating underflow fault
SS$_FORMAT	Severe	Invalid media format
SS$_GPTFULL	Severe	Global page table full

Status Code	Type	Meaning
SS$_GSDFULL	Severe	Global section descriptor table full
SS$_HANGUP	Severe	Data set hang-up
SS$_HEADERFULL	Warning	File header full
SS$_IDMISMATCH	Severe	Identification does not match existing section
SS$_IDXFILEFULL	Warning	Index file full
SS$_ILLBLKNUM	Severe	Illegal logical block number
SS$_ILLCNTRFUNC	Severe	Illegal ACP control function
SS$_ILLEFC	Severe	Illegal event flag cluster
SS$_ILLIOFUNC	Severe	Illegal I/O function code
SS$_ILLLBLAST	Warning	Illegal user label AST control block address
SS$_ILLPAGCNT	Severe	Illegal page count parameter
SS$_ILLSEQOP	Severe	Illegal sequential operation
SS$_ILLSER	Severe	Illegal service call number
SS$_ILLUSRLBLRD	Warning	Illegal read of user labels
SS$_ILLUSRLBLWT	Warning	Illegal write of user labels
SS$_INCVOLLABEL	Severe	Incorrect volume label
SS$_INSFARG	Severe	Insufficient call arguments
SS$_INSFBUFDP	Severe	Unable to allocate a buffered data path
SS$_INSFMAPREG	Severe	Insufficient map registers
SS$_INSFMEM	Severe	Insufficient dynamic memory
SS$_INSFRAME	Severe	Insufficient call frames to unwind
SS$_INSFSPTS	Severe	Insufficient system page table entries to map process buffer to system
SS$_INSFWSL	Severe	Insufficient working set limit
SS$_INTDIV	Condition	Integer divide by zero
SS$_INTERLOCK	Severe	Unable to acquire system data structure interlock
SS$_INTOVF	Condition	Integer overflow
SS$_INVLOGIN	Severe	Login information invalid at remote mode
SS$_IVADDR	Severe	Invalid media address
SS$_IVBUFLEN	Severe	Invalid buffer length
SS$_IVCHAN	Severe	Invalid I/O channel
SS$_IVCHNLSEC	Severe	Invalid channel for create and map section
SS$_IVDEVNAM	Severe	Invalid device name
SS$_IVGSDNAM	Severe	Invalid global section name
SS$_IVLOGNAM	Severe	Invalid logical name
SS$_IVLOGTAB	Severe	Invalid logical name table number
SS$_IVLVEC	Severe	Section not installed with privilege
SS$_IVMODE	Severe	Invalid mode for requested function
SS$_IVPROTECT	Severe	Invalid page protection code
SS$_IVQUOTAL	Severe	Invalid quota list
SS$_IVSECFLG	Severe	Invalid process/global section flags
SS$_IVSECIDCTL	Severe	Invalid section identification match control
SS$_IVSSQR	Severe	Invalid system service request
SS$_IVSTSFLG	Severe	Invalid status flag
SS$_IVTIME	Severe	Invalid time
SS$_LCKPAGFUL	Severe	No more pages can be locked in memory
SS$_LENVIO	Severe	Address space length violation
SS$_LKWSETFUL	Severe	Locked portion of working set is full

Status Code	Type	Meaning
SS$_MBFULL	Warning	Mailbox full
SS$_MBTOOSML	Severe	Mailbox is too small for request
SS$_MCHECK	Severe	Detected hardware error
SS$_MCNOTVALID	Severe	Device microcode is not valid
SS$_MEDOFL	Severe	Medium offline
SS$_MSGNOTFND	Success	Message not in system message file
SS$_MTLBLLONG	Severe	Magnetic tape volume label can be no more than six characters
SS$_MULTRMS	Severe	Multiple RMS vectors specified for privileged shareable image
SS$_MUSTCLOSEFL	Warning	Must close file
SS$_NOAQB	Severe	ACP queue header not found
SS$_NODATA	Severe	Mailbox empty
SS$_NODISKQUOTA	Severe	No disk quota entry for this UIC
SS$_NOHANDLER	Warning	No condition handler found
SS$_NOHOMEBLK	Warning	Home block not found on volume
SS$_NOIOCHAN	Severe	No I/O channel available
SS$_NOLINKS	Severe	No slots in logical link vector
SS$_NOLOGNAM	Severe	No logical name match
SS$_NOMBX	Severe	No associated mailbox for inbound connects
SS$_NOMOREFILES	Warning	No more files
SS$_NOMOREPROC	Warning	No more processes found
SS$_NONEXDRV	Severe	Nonexistent drive
SS$_NONEXPR	Warning	Nonexistent process
SS$_NONLOCAL	Warning	Nonlocal device
SS$_NOP1VA	Severe	P1 space not supported in shareable images
SS$_NOPRIV	Severe	No privilege for attempted operation
SS$_NOQFILE	Severe	No disk quota file available
SS$_NORMAL	Success	Normal successful completion
SS$_NOSHMBLOCK	Severe	No free shared memory control block available for creation
SS$_NOSIGNAL	Warning	No signal currently active
SS$_NOSLOT	Severe	No process control block or swap slot available
SS$_NOSOLICIT	Severe	Interrupt message not solicited
SS$_NOSUCHDEV	Warning	No such device available
SS$_NOSUCHFILE	Warning	No such file
SS$_NOSUCHNODE	Severe	Specified node does not exist
SS$_NOSUCHOBJ	Severe	Networks object is unknown at remote mode
SS$_NOSUCHSEC	Warning	No such (global) section
SS$_NOSUCHUSER	Severe	Login information not recognized at remote mode
SS$_NOTAPEOP	Severe	No tape operator
SS$_NOTCREATOR	Severe	Request denied: user is not on creator port
SS$_NOTFILEDEV	Severe	Device is not file-structured
SS$_NOTINSTALL	Severe	Writable shareable images must be installed
SS$_NOTINTBLSZ	Severe	Block size is greater than 2048
SS$_NOTLABELMT	Severe	Not labeled tape
SS$_NOTMODIFIED	Success	No section pages were modified
SS$_NOTNETDEV	Severe	Not a network communication device
SS$_NOTRAN	Success	No string translation performed
SS$_NOTSQDEV	Severe	Not sequential device
SS$_NOTVOLSET	Warning	Volume is not part of a volume set
SS$_NOWRT	Severe	Cannot create writable section to read-only file

Status Code	Type	Meaning
SS$_OPCCUS	Condition	Opcode reserved to customer fault
SS$_OPCDEC	Condition	Opcode reserved to DIGITAL fault
SS$_OPINCOMPL	Severe	Operation incomplete
SS$_OPRABORT	Severe	Aborted by operator
SS$_OVRDSKQUOTA	Success	Disk usage exceeds disk quota
SS$_PAGOWNVIO	Severe	Page owner violation
SS$_PAGRDERR	Condition	Page read error
SS$_PARITY	Severe	Parity error
SS$_PARTESCAPE	Severe	Partial escape
SS$_PFMBSY	Severe	Page fault monitor in use
SS$_PLHLDR	Condition	Reserved for future use
SS$_POWERFAIL	Severe	Power failure occurred
SS$_PRIVINSTALL	Severe	Shareable images must be installed to run privileged image
SS$_PROTINSTALL	Severe	Protected images must be installed
SS$_PROTOCOL	Severe	Network protocol error
SS$_PSTFULL	Severe	Process section table is full
SS$_QFACTIVE	Severe	Disk quota file is already active
SS$_QFNOTACT	Severe	Disk quota file is not active
SS$_RADRMOD	Condition	Reserved addressing fault
SS$_RDDELDATA	Success	Sector contained deleted data address mark
SS$_REJECT	Severe	Network connect rejected
SS$_RELINK	Severe	Obsolete image header - please relink
SS$_REMOTE	Success	Assignment completed on remote node
SS$_REMRSC	Severe	Resource error at remote node
SS$_RESIGNAL	Warning	Resignal condition to next handler
SS$_RESULTOVF	Severe	Resultant string overflow
SS$_ROPRAND	Condition	Reserved operand fault
SS$_SECTBLFUL	Severe	Section table (process/global) full
SS$_SHARTOOBIG	Severe	New version of shareable image too big - relink all images
SS$_SHMGSNOTMAP	Severe	Shared memory global section not mapped during creation
SS$_SHMNOTCNCT	Severe	Shared memory not connected
SS$_SSFAIL	Condition	System service failure exception
SS$_SUBRNG	Condition	Subscript range trap
SS$_SUPERSEDE	Success	Logical name superseded
SS$_SUSPENDED	Severe	Process suspended or in miscellaneous wait state
SS$_SYSVERDIF	Success	Privilege removed - system version mismatch - please relink
SS$_TAPEPOSLOST	Severe	Magnetic tape position lost
SS$_TBIT	Condition	Tbit pending fault
SS$_THIRDPARTY	Severe	Logical link disconnected by a third party
SS$_TIMEOUT	Severe	Device timeout
SS$_TOOMANYLNAM	Severe	Logical name translation exceeded allowed depth
SS$_TOOMANYVER	Warning	Too many higher file versions
SS$_TOOMUCHDATA	Severe	Too much optional or interrupt message data
SS$_UNASEFC	Severe	Unassociated event flag cluster
SS$_UNREACHABLE	Severe	Node is known but unreachable
SS$_UNSAFE	Severe	Drive unsafe
SS$_UNWIND	Warning	Unwind currently in progress
SS$_UNWINDING	Warning	Unwind already in progress
SS$_VASFULL	Severe	Virtual address space full

Status Code	Type	Meaning
SS$_VECFULL	Severe	Privileged vector limit of 42 exceeded
SS$_VECINUSE	Severe	AST vector already enabled
SS$_VOLINV	Severe	Volume invalid
SS$_WAITUSRLBL	Warning	Waiting for user labels
SS$_WASCLR	Success	Previous state was clear
SS$_WASECC	Success	Successful transfer; no data check
SS$_WASSET	Success	Previous state was set
SS$_WRITLCK	Severe	Write lock error
SS$_WRONGACP	Severe	Wrong ACP for device

APPENDIX B

PROGRAM EXAMPLES

This appendix presents three VAX-11 MACRO programs: ORION, CYGNUS, and LYRA. These programs do not perform any useful work; they are intended only to illustrate how to call various system services.

Each program is preceded by an introduction identifying the services it uses and the main functions it performs. In addition, the program themselves contain many comments related to specific data definitions and portions of code.

To help you locate the system service calls in the programs, the macros are printed in red.

B.1 ORION PROGRAM EXAMPLE

The program ORION uses the following system services:

```
$ASSIGN (Assign I/O Channel)
$OUTPUT (form of Queue I/O Request and Wait For Event Flag)
$NUMTIM (Convert Binary Time to Numeric Time)
$BINTIM (Convert ASCII String to Binary Time)
$SETIMR (Set Timer)
$WAITFR (Wait for Single Event Flag)
$READEF (Read Event Flags)
$SETPRN (Set Process Name)
```

This sample program illustrates:

1. Assigning an I/O channel to a terminal and writing messages to the terminal. The device name is specified by the logical name TERMINAL. Before ORION is run, the logical name must be assigned an equivalence device name.

2. Using the $NUMTIM system service to find out whether the current time is before or after noon. A call to $SETIMR is made conditionally if the time is prior to noon.

3. How to obtain a delta time value in the system format to use as input to the Set Timer ($SETIMR) system service.

4. Calls to the Set Timer system service.

   a. Event flag - The $SETIMR call is followed by a wait for the specified event flag. When the timer expires, the program calls $READEF and displays the current status of the event flag cluster.

b. AST routine - one AST routine is for a delta time interval. The other (conditional) is for an absolute time. In either case, the program continues execution and will be interrupted when the timer requests are processed.

5. An example of terminal input. The program prompts for a character string to be used as the process name of the current process. Then it uses this name as input to the $SETPRN system service.

```
        .TITLE  ORION SYSTEM SERVICES TEST
        .IDENT  /01/

; Macro library calls

        $IODEF                          ;Define I/O function codes
        $SSDEF                          ;Define system status values
        $READEFDEF                      ;Define offsets for $READEF

; Local macro defined in private macro library

;       MESSAGE                         ;Output messages formatted by FAO

        .MACRO  MESSAGE
                $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
                BSBW    ERROR
        .ENDM   MESSAGE

; Read-only data program section

        .PSECT  RODATA,NOWRT,NOEXE

; Local Read/Write Data

TTNAME: .ASCID /TERMINAL/                       ;Terminal logical name

; FAO control strings and data for timer (AST and event flag) tests

ASCNOON: .ASCID /-- 12:00:00.00/        ;Noon in ASCII format

TENSEC: .ASCID /0 00:00:10/             ;Ten seconds delta time in ASCII format

DISPLAYEFN:                             ;Display cluster contents
        .ASCID /CLUSTER 2 CONTENTS: !XL/

TIMSTR:                                 ;Display message after event flag wait
         .ASCID @!/TIMER ENTRY PROCESSED; CLUSTER 2 = !XL@

NOONMSG:                                ;Display message at noon
        .ASCIC  /I'M YOUR TIME AST ROUTINE; IT'S NOON.../

SECMSGDESC:                             ;Display message from AST routine
        .ASCID @!/TIME AST ROUTINE; DELTA TIME !%T@

TWENTY: .LONG   -10*1000*1000*20,-1     ;20 seconds delta time
```

```
; Announcement messages

FAOSTR:                                 ;Master control string
        .ASCID @!/ORION: !AC @  ;Name, message


; Announcement messages and lengths for outputting

HELLO:  .ASCII  /HELLO...MY NAME IS ORION.../
HELLOLEN:
        .LONG   HELLOLEN-HELLO

TIMERMSG:
        .ASCII  /BEGINNING TIMER TESTS.../
TIMERLEN:
        .LONG   TIMERLEN-TIMERMSG

EFNWAITMSG:
        .ASCII  /TIMER SET; WAIT TEN SECONDS/
EFNWAITLEN:
        .LONG   EFNWAITLEN-EFNWAITMSG

ASTWAITMSG:
        .ASCII  /TIMER SET; AST IN 20 SECONDS/
ASTWAITLEN:
        .LONG   ASTWAITLEN-ASTWAITMSG


; Prompt for terminal input

PROMPT: .ASCII  /ENTER 1-15 CHARACTER NAME FOR PROCESS:/
PROMPTLEN:
        .LONG   PROMPTLEN-PROMPT


; Error message control strings

; ERRSTR    formats error message if a system service fails
; IOERRSTR  formats error message if I/O fails
; BADASTSTR formats error message if error in AST routine

ERRSTR:
        .ASCID @!/SYSTEM SERVICE ERROR AT APP. !XL R0=!XL@

IOERRSTR:
        .ASCID @!/I/O ERROR; IOSB !XW@

BADASTSTR:
        .ASCID /BAD AST PARAMETER  !UL/


WAKEUP: .ASCII /AWAKENED.../
WAKEUPLEN: .LONG WAKEUPLEN-WAKEUP


; Read/write data

        .PSECT  RWDATA,RD,WRT,NOEXE

; FAO control string and buffer for all announcement messages

FAODESC:
        .LONG   80                      ;Descriptor for FAO output buffer
        .LONG   FAOBUF                  ;Address of buffer
```

```
FAOBUF: .BLKB   80                      ;FAO buffer
FAOLEN: .WORD   0                       ;Length of final string, always
        .WORD   0                       ;Need longword for $OUTPUT


; Buffer to format messages from AST routine; a separate output buffer
; ensures that if the AST is delivered while another message is being
; written into the FAO output buffer, no data or message will be lost.

FASTDESC:
        .LONG   80                      ;Descriptor for FAO output buffer
        .LONG   FASTBUF
FASTBUF: .BLKB  80                      ;FAO buffer
FASTLEN: .WORD  0                       ;Length of final string, always
        .WORD   0                       ;Need longword for $OUTPUT


; Receive channel number assigned to terminal and I/O status here

TTCHAN: .BLKW   1                       ;Terminal channel

TTIOSB:                                 ;IOSB for terminal input
        .BLKW   1                       ;Return status
TTLEN:  .BLKW   1                       ;Length of I/O
        .BLKL   1                       ;Device char


; Argument list for $NAME_G form of a system service call

READLST:
        $READEF EFN=32,STATE=EFNTEST


; Buffer to obtain numeric values of components of time. Since
; the only field of interest is the hours field, the remaining
; fields in the buffer are not formatted.

TIMES:  .BLKW   3                       ;Year, month, day
HOURS:  .BLKW   1                       ;Current time in hours
        .BLKW   3                       ;Remainder of buffer

; Buffer for terminal input (will create input descriptor for
; $SETPRN system service)

NAMEDESC:                               ;Descriptor setup
        .LONG   15                      ;Initial size of buffer
        .LONG   NAME                    ;Address of buffer
NAME:   .BLKB   15                      ;Name string here


;Fields for timer tests

NOON:   .BLKQ   1               ;will contain 12:00 noon in system format

TEN:    .BLKQ   1               ;Will contain 10 second delta time

EFNTEST:
        .LONG   0               ;Receive status of event flags
EFNTEST2:
        .LONG   0               ;Status after timer test


; Longword to save PC on entry to error handling subroutine
```

```
SAVEPC: .BLKL   1


; Code begins here.

        .PSECT  TIMER,EXE,NOWRT
.ENTRY  ORION,^M<R2,R3,R4,R5,R6>        ;Entry mask


; Assign an I/O channel to the device specified by the logical name
; TERMINAL and issue a message indicating we're off and running.
; Do not perform normal error checking here: instead, let the
; command interpreter issue a message based on the status in R0
; if the channel assignment fails.

SETUP:
        $ASSIGN_S DEVNAM=TTNAME,CHAN=TTCHAN
        BLBS    R0,10$                  ;All okay, continue
        RET                             ;Otherwise exit with status in R0

10$:    $OUTPUT CHAN=TTCHAN,BUFFER=HELLO,LENGTH=HELLOLEN
        BSBW    ERROR


; Call Read Event Flags to get status of event flags before beginning
; tests and use FAO to output the contents of local event flag cluster 2

        $READEF_G READLST
        $FAO_S  CTRSTR=DISPLAYEFN,OUTBUF=FAODESC,OUTLEN=FAOLEN,-
                P1=EFNTEST
        MESSAGE

; Announce start of timer tests

TIMETEST:
        $OUTPUT CHAN=TTCHAN,BUFFER=TIMERMSG,LENGTH=TIMERLEN
        BSBW    ERROR


; Call $NUMTIM to find out if it is currently AM or PM. If
; the program is being run in the AM (any time), we'll call
; $SETIMR to notify us via an AST when the time rolls over
; to afternoon. If it's already PM, skip this setting of
; the timer.

        $NUMTIM_S TIMBUF=TIMES
        BSBW    ERROR
        CMPW    HOURS,#12               ;Before or afternoon?
        BGEQ    10$                     ;After, skip setting timer


; Fall through here: format ASCII string representing 12 noon
; into system quadword time format and call $SETIMR with
; the address of AST service routine to handle timer requests.

        $BINTIM_S TIMBUF=ASCNOON,TIMADR=NOON    ;Get binary noon time
        BSBW    ERROR                   ;Error check

        $SETIMR_S DAYTIM=NOON,ASTADR=TIMEAST,REQIDT=#12
        BSBW    ERROR                   ;Error check


; Now, get a delta time of 10 seconds formatted into a quadword
```

```
10$:    $BINTIM_S TIMBUF=TENSEC,TIMADR=TEN      ;Get binary delta time
        BSBW    ERROR                   ;Error check
        $SETIMR_S EFN=#33,DAYTIM=TEN    ;Set timer (ten seconds)
        BSBW    ERROR                   ;Error check


; Announce wait for event flag and wait; then read the
; event flag cluster and output its contents

        $OUTPUT CHAN=TTCHAN,BUFFER=EFNWAITMSG,LENGTH=EFNWAITLEN
        $WAITFR_S EFN=#33               ;Now wait
        BSBW    ERROR                   ;Error check


; Update argument list for $READEF and then call it with new address
; to write the cluster into. When complete, format a message and
; display the contents of the cluster.

        MOVAL   EFNTEST2,READLST+READEF$_STATE
        $READEF_G READLST
        BSBW    ERROR                   ;Error check
        $FAO_S CTRSTR=TIMSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=EFNTEST2
        BSBW    ERROR                   ;Error check
        MESSAGE


; Announce setting of timer with AST in 20 seconds (using
; alternate method of coding delta time). Then, set timer
; and continue.

        $OUTPUT CHAN=TTCHAN,BUFFER=ASTWAITMSG,LENGTH=ASTWAITLEN

        $SETIMR_S DAYTIM=TWENTY,ASTADR=TIMEAST,REQIDT=#20
        BSBW    ERROR                   ;Error check


; Issue a prompt for terminal input: request a name for the current
; process and then use the character string entered as the process
; name.

RDNAME:
        $OUTPUT CHAN=TTCHAN,BUFFER=PROMPT,LENGTH=PROMPTLEN
        BSBW    ERROR           ;Error check

        $INPUT CHAN=TTCHAN,BUFFER=NAME,LENGTH=NAMEDESC,-
                IOSB=TTIOSB
        BSBW    ERROR

        CMPW    TTIOSB,#SS$_NORMAL      ;I/O successful?
        BEQL    10$                     ;Yes, go on
        $FAO_S  CTRSTR=IOERRSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=TTIOSB
        MESSAGE
        BRW     RDNAME                  ;Go try again
10$:    MOVZWL  TTLEN,NAMEDESC          ;Update descriptor length
        $SETPRN_S PRCNAM=NAMEDESC       ;Set process name
        BSBW    ERROR


; Hibernate. When ORION is run interactively, the terminal is dormant.
; When the AST for the Set Timer service is delivered, ORION
; will awaken long enough to execute the AST service routine and
```

```
; then resume execution.

; If ORION is run in a subprocess, wakeups can be scheduled for
; delta time intervals. Each time it is awakened, ORION displays a
; message and then resumes hibernating.

HIB:    $HIBER_S                            ;For now
        $OUTPUT CHAN=TTCHAN,BUFFER=WAKEUP,LENGTH=WAKEUPLEN
        BRB     HIB
        RET


; AST routine to handle timer requests

TIMEAST:
        .WORD   0               ;Entry mask for timer AST routine
        CMPL    #12,4(AP)       ;Is it noon AST?
        BEQL    10$             ;Yes, go do it
        CMPL    #20,4(AP)       ;Is it delta time AST?
        BEQL    20$             ;Yes, go do that
        BRW     30$             ;Neither, issue error message

; Format message for noon AST

10$:    $FAO_S  CTRSTR=FAOSTR,OUTBUF=FASTDESC,OUTLEN=FASTLEN,P1=#NOONMSG
        BSBW    ERROR                       ;Error  check
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        BSBW    ERROR                       ;Error check
        RET

; Format message for 20 second AST

20$:    $FAO_S  CTRSTR=SECMSGDESC,OUTBUF=FASTDESC,OUTLEN=FASTLEN,-
                P1=#TWENTY
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        RET

; Format message if spurious AST

30$:    $FAO_S  CTRSTR=BADASTSTR,OUTLEN=FASTLEN,OUTBUF=FASTDESC,-
                P1=4(AP)
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        RET


; Error handling routine: checks status code in R0.
; If low bit set, returns to mainline routine. Otherwise,
; displays approximate PC and R0 when system service call
; encounters an error and issues RET that causes image exit.

ERROR:
        BLBC    R0,10$                  ;If error, branch
        RSB                             ;Otherwise, continue

; Use FAO to format output error message

10$:    MOVL    (SP),SAVEPC
        $FAO_S  CTRSTR=ERRSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=SAVEPC,P2=R0
        BLBC    R0,END
        $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
END:    RET
        .END    ORION
```

B.2 CYGNUS PROGRAM EXAMPLE

The program CYGNUS uses the following system services:

```
$TRNLOG - Translate Logical Name
$ASSIGN - Assign I/O Channel
$DCLEXH - Declare Exit Handler
$CREMBX - Create Mailbox
$GETCHN - Get I/O Channel Device Information
$CREPRC - Create Process
$FAO    - Formatted ASCII Output
$QIO    - Queue I/O Request
$CRELOG - Create Logical Name
$WAKE   - Wake Process
$SETSFM - Set System Service Failure Exception Mode
$WAITFR - Wait for Single Event Flag
$DELLOG - Delete Logical Name
$DASSGN - Deassign I/O Channel
```

This sample program illustrates:

1. Assigning a channel to the current output device by translating the logical name SYS$OUTPUT.
2. Declaring an exit handler to receive control at image exit. The exit handler ensures that the image exits in a graceful manner.
3. Creating a mailbox and using the $GETCHN system service to obtain the unit number.
4. Creating a subprocess and using the mailbox created as a termination mailbox. When the subprocess terminates, an AST service routine interprets the message.
5. Placing names in the group logical name table.
6. Waking a hibernating subprocess. The subprocess created by this program places itself in hibernation after getting started. When awakened, it translates the logical names placed in the group logical name table.

```
        .IDENT /01/

; System macro definitions required by CYGNUS

        $SSDEF                  ;Define status codes for returns
        $IODEF                  ;Define I/O functions codes for $QIO
        $MSGDEF                 ;Define names for mailbox messages
        $PQLDEF                 ;Define names for quota list
        $ACCDEF                 ;Define names for termination message
        $DIBDEF                 ;Define names for device information buffer


; Local macros:

;        MESSAGE,  to output messages formatted by FAO

        .MACRO  MESSAGE
                $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
                BSBW    ERROR
        .ENDM   MESSAGE
```

```
;       GRPNAME, to place logical name/equivalence name
;       pairs in the group logical name table with $CRELOG and
;       do error checking.

        .MACRO  GRPNAME LOGICAL,EQUAL
                $CRELOG_S TBLFLG=#1,LOGNAM=LOGICAL,EQLNAM=EQUAL
                BSBW    ERROR
        .ENDM   GRPNAME


; Read-only data program section

        .PSECT  RODATA,NOWRT,NOEXE


; Descriptor for input logical name

OUTPUT: .ASCID /SYS$OUTPUT/


; Buffers for announcement messages and lengths

HELLO:  .ASCID /CYGNUS...HELLO/
HELLOLEN:
        .LONG   HELLOLEN-HELLO

BYE:    .ASCII  /CYGNUS EXIT HANDLER.../
BYELEN: .LONG   BYELEN-BYE


; Control strings for output messages formatted by FAO and associated
; counted ASCII strings to insert in messages

PRCSTR:
        .ASCID /LYRA CREATED, PID !XL/  ;display PID of subprocess

ASTERRSTR:
        .ASCID @!/MAILBOX MESSAGE HAS !AC !XW@

IOERR:  .ASCIC  'I/O ERROR'             ;I/O error in AST routine
IDERR:  .ASCIC  /BAD MSG ID/            ;Mailbox message not termination message

PIDERRSTR:
        .ASCID @!/SPURIOUS PROCESS ID !XL IN DELETION MAILBOX@

DONESTR:
        .ASCID @!/LYRA COMPLETED; STATUS !XL TIME !%T@
BADEXSTR:
        .ASCID @!/EXIT DUE TO ERROR !XL@


; Descriptor to define name of image for subprocess to execute.

LYRAEXE:
        .ASCID /LYRA.EXE/


; Quota list for subprocess: defines minimal quotas required for
; for the subprocess to execute and ensures that the creating
; image will have sufficient quotas to continue.

QLIST:  .BYTE   PQL$_BYTLM              ;Buffer quota
```

```
        .LONG   1024
        .BYTE   PQL$_FILLM              ;Open file quota
        .LONG   3
        .BYTE   PQL$_PGFLQUOTA          ;Paging file quota
        .LONG   256
        .BYTE   PQL$_PRCLM              ;Subprocess quota
        .LONG   1
        .BYTE   PQL$_TQELM              ;Timer queue quota
        .LONG   3
        .BYTE   PQL$_LISTEND


; Logical name/equivalence name pairs for group table.
; Note that one of the names is recursive in the table.

ORION:  .ASCID /ORION/
HUNTER: .ASCID /HUNTER/
PEGASUS:.ASCID /PEGASUS/
HORSE:  .ASCID /HORSE/
LYRA:   .ASCID /LYRA/
HARP:   .ASCID /HARP/
CYG:    .ASCID /CYGNUS/
SWAN:   .ASCID /SWAN/
DUCK:   .ASCID /UGLY DUCKLING/
TALE:   .ASCID /FAIRY TALE!/


; Read/write data program section

        .PSECT  RWDATA,RD,WRT,NOEXE

TTCHAN: .BLKW   1                       ;Channel number of terminal


; Output buffer to receive physical terminal name

TTNAME: .LONG   63                      ;Descriptor length
TTADDR: .LONG   TT                      ;Address of buffer
TT:     .BLKB   63                      ;Maximum logical name length


; Termination control block

EXITBLOCK:                              ;Exit control block
        .BLKL   1                       ;System uses this for pointer
        .LONG   EXITRTN                 ;Address of routine
        .LONG   2                       ;Number of arguments for handler
        .LONG   STATUS                  ;Address to store status
ERRPC:  .BLKL   1                       ;Store PC (if error)
STATUS: .BLKL   1                       ;Status code at exit


; Fields used for termination mailbox creation, message buffering

EXCHAN: .BLKW   1                       ;Channel number of mailbox
EXITBUF:                                ;Descriptor for channel data
        .LONG   ENDBUF-BBUF             ;Length of buffer
        .LONG   BBUF                    ;Address of buffer
BBUF:   .BLKL   DIB$K_LENGTH
ENDBUF:
MBXIOSB:                                ;I/O status block
        .BLKW   1                       ;Status of I/O completion
MBLEN:  .BLKW   1                       ;Length of operation here
MBPID:  .BLKL   1                       ;PID of process deleted
```

```
EXITMSG:                                ;Buffer for mailbox message
        .BLKB   ACC$K_TERMLEN

; Receive PID of subprocess here

LYRAPID:
        .BLKL   1

; Output buffers for strings formatted by FAO

FAODESC:                                ;Descriptor for output buffer
        .LONG   80                      ;80-character buffer
        .LONG   FAOBUF                  ;Address
FAOBUF: .BLKB   80                      ;Buffer
FAOLEN: .BLKW   1                       ;Receive length here
        .BLKW   1                       ;Need longword for $QIO

; Need separate FAO buffers for use in AST routine to ensure
; that data doesn't get clobbered asynchronously

FASTDESC:
        .LONG   80                      ;Length
        .LONG   FASTBUF                 ;Address
FASTBUF:.BLKB   80                      ;Buffer
FASTLEN:.BLKW   1                       ;Get length
        .BLKW   1                       ;Need longword for $QIO


; Program code begins here.

        .PSECT  CODE,EXE,RD,NOWRT
CYGNUS::
        .WORD   0                       ;Entry mask

; First, translate logical name SYS$OUTPUT to find name of
; current output device. If the image is run interactively,
; its equivalence name is system-defined, and will contain
; a 4-byte header. The program must check for the header and update
; the descriptor so the device name will be valid for calling $ASSIGN.

        $TRNLOG_S LOGNAM=OUTPUT,RSLLEN=TTNAME,RSLBUF=TTNAME
        BSBW    ERROR
        CMPB    TT,#^X1B                ;First byte escape?
        BNEQ    10$                     ;No, go ahead
        SUBL    #4,TTNAME               ;Subtract 4 from length of name
        ADDL    #4,TTADDR               ;Add 4 to address in descriptor


; Call $ASSIGN to assign an I/O channel and issue message verifying
; successful initialization

10$:    $ASSIGN_S DEVNAM=TTNAME,CHAN=TTCHAN
        BSBW    ERROR                   ;Error check

        $OUTPUT CHAN=TTCHAN,BUFFER=HELLO,LENGTH=HELLOLEN
        BSBW    ERROR


; Declare exit handler to do cleanup operations
```

```
        $DCLEXH_S DESBLK=EXITBLOCK
        BSBW    ERROR


; Create a mailbox for subprocess termination message, then
; get the unit number of the mailbox by doing a $GETCHN

MAILBOX:
        $CREMBX_S CHAN=EXCHAN,MAXMSG=#120,BUFQUO=#240,PROMSK=#0
        BSBW    ERROR
        $GETCHN_S CHAN=EXCHAN,PRIBUF=EXITBUF
        BSBW    ERROR


; Create the subprocess. Since the logical name SYS$OUTPUT
; has already been translated, the same equivalence name can be
; given to LYRA as its logical output device.
; LYRA will be able to assign a channel to this device as well.
; The MBXUNT argument specifies the name of the mailbox just
; created; the mailbox will receive a message when LYRA exits.

PROCESS:
        $CREPRC_S IMAGE=LYRAEXE,PIDADR=LYRAPID,-
                MBXUNT=BBUF+DIB$W_UNIT,-
                OUTPUT=TTNAME,QUOTA=QLIST
        BSBW    ERROR


; If okay, format an output message showing the process id...

        $FAO_S  CTRSTR=PRCSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=LYRAPID
        BSBW    ERROR
        $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
        BSBW    ERROR


; Queue an I/O request to the mailbox with an AST
; to receive notification when LYRA completes.

        $QIO_S  EFN=#4,CHAN=EXCHAN,FUNC=#IO$_READVBLK,-
                ASTADR=EXITAST,IOSB=MBXIOSB,-
                P1=EXITMSG,P2=#ACC$K_TERMLEN
        BSBW    ERROR


; Place names in the group logical name table using the macro GRPNAME.
; It will be LYRA's task, when awakened, to translate these
; names and display the results at the terminal.
; Note that translation of the name CYGNUS will require
; recursive translation.

PUT_NAMES:
        GRPNAME ORION,HUNTER

        GRPNAME PEGASUS,HORSE

        GRPNAME LYRA,HARP

        GRPNAME CYG,SWAN

        GRPNAME SWAN,DUCK

        GRPNAME DUCK,TALE
```

```
; After placing names in the table, wake LYRA, who has been hibernating,
; to perform the logical name translation.

        $WAKE_S PIDADR=LYRAPID
        BSBW    ERROR
        RET                     ;All finished


; AST service routine to read the termination mailbox.
; In this example, only one message is actually expected in the mailbox
; but the program performs all the following checks:

;  1. That the I/O completed successfully.
;  2. That the message in the mailbox is a process termination message.
;  3. That the process being deleted is the subprocess created.

; This service routine enables system service failure exception
; mode as an error handling device: if a system service
; call fails, an exception condition will occur. CYGNUS
; does not declare a condition handler, so the image
; will be forced to terminate, and the system will display
; pertinent information about the exception condition.

EXITAST:
        .WORD   0                       ;Entry mask
        $SETSFM_S ENBFLG=#1             ;Enable SSFAIL exceptions


; Check IOSB to ensure that I/O completed successfully

        CMPW    MBXIOSB,#SS$_NORMAL     ;Check that I/O was successful
        BEQL    20$                     ;Okay, go on
        $FAO_S  CTRSTR=ASTERRSTR,-      ;Otherwise, format error msg
                OUTLEN=FASTLEN,OUTBUF=FASTDESC-
                P1=#IOERR, -            ;I/O error
                P2=MBXIOSB              ;Display IOSB
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        BRW     50$                     ;Return


; Check message type field in mailbox message to ensure that the message
; is a process termination message.

20$:    CMPW    EXITMSG+ACC$W_MSGTYP,#MSG$DELPROC ;Check message identification
        BEQL    30$                     ;Okay, go on
        $FAO_S  CTRSTR=ASTERRSTR,-      ;Otherwise, format error message
                OUTLEN=FASTLEN,OUTBUF=FASTDESC,-
                P1=#IDERR, -            ;Invalid PID error
                P2=EXITMSG+ACC$W_MSGTYP ;Print message type code
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        BRW     50$                     ;Return


; Compare the second longword in the IOSB with the PID returned
; by $CREPRC to ensure that the termination message is for LYRA.

30$:    CMPL    LYRAPID,MBPID           ;LYRA deletion?
        BNEQ    35$                     ;Yes, go on
        BRW     40$
35$:
        $FAO_S  CTRSTR=PIDERRSTR,-      ;Otherwise, format error message
                OUTLEN=FASTLEN,OUTBUF=FASTDESC,-
```

```
                P1=MBPID                ;Display spurious PID
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
        BRW     50$                     ;Return


; Format an output message indicating LYRA's final exit status
; and the time of day at which LYRA terminated.

40$:    $FAO_S CTRSTR=DONESTR, -        ;Format message telling of LYRA's demise
                OUTLEN=FASTLEN,OUTBUF=FASTDESC,-
                P1=EXITMSG+ACC$L_FINALSTS, - ;Get status code
                P2=#EXITMSG+ACC$Q_TERMTIME   ;and time of deletion
        $OUTPUT CHAN=TTCHAN,BUFFER=FASTBUF,LENGTH=FASTLEN
50$:    $SETSFM_S ENBFLG=#0             ;Disable exceptions
        RET                             ;Return


; This is the exit handler for CYGNUS. It receives control
; when CYGNUS exits, either normally, or as a result of
; an error condition.

EXITRTN:
        .WORD   0                       ;Entry mask
        $OUTPUT CHAN=TTCHAN,BUFFER=BYE,LENGTH=BYELEN
        BSBW    ERROR
        BLBS    STATUS,20$              ;Normal exit, continue

; If error, format error message using argument list in
; exit control block

10$:    $FAO_S CTRSTR=BADEXSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                P1=STATUS,P2=ERRPC
        BSBW    ERROR
        $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN


; Common code for both normal and error exit: wait for subprocess
; to terminate (if it hasn't already), then delete all names
; from the group logical name table.

20$:    $WAITFR_S EFN=#4                ;Wait for termination message
        BSBW    ERROR
30$:    $DELLOG_S TBLFLG=#1             ;Delete all names
        BSBW    ERROR
        $DASSGN_S CHAN=EXCHAN           ;Deassign mailbox channel
        BSBW    ERROR
        MOVL    STATUS,R0               ;Restore saved status code
        RET                             ;Exit with status


; Common error handling routine. This routine checks the
; status code in R0; if success, returns to mainline of
; program. If there is an error, the PC is placed in the exit
; control block so that exit routine can format and display
; an error message.

ERROR:
        BLBC    R0,10$                  ;Check status code
        RSB                             ;Low bit set, go back
10$:    MOVL    (SP),ERRPC              ;Store PC
        RET                             ;RET will cause image exit
        .END CYGNUS
```

B.3 LYRA PROGRAM EXAMPLE

The program LYRA uses the following system services:

```
        $TRNLOG - Translate Logical Name
        $ASSIGN - Assign I/O Channel
        $HIBER  - Hibernate
        $FAOL   - Formatted ASCII Output with List Parameter
```

LYRA is the subprocess created by CYGNUS. After assigning a channel to its current output device, LYRA hibernates. When awakened by CYGNUS, LYRA translates the logical names placed in the group logical name table by CYGNUS, and displays the results of the translations on the terminal.

When LYRA exits, a termination message is sent to the mailbox specified by CYGNUS.

```
        .IDENT  /01/


; Macro library call

        $SSDEF                          ;Define system status values


; Local macro

;  MESSAGE,  to output messages formatted by FAO

        .MACRO  MESSAGE
                $OUTPUT CHAN=TTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
                BSBW    ERROR
        .ENDM   MESSAGE


; Local data program section starts here

        .PSECT  RODATA,NOWRT,NOEXE


; Logical name of logical output device

OUTPUT: .ASCID /SYS$OUTPUT/


; Announcement messages

HELLO:  .ASCII  /LYRA: INITIALIZING...AND SO TO SLEEP/
HELLOLEN:
        .LONG   HELLOLEN-HELLO

WAKEMSG:
        .ASCII  /LYRA: OKAY, WILL DO LOGICAL NAME TRANSLATION.../
WAKELEN:
        .LONG   WAKELEN-WAKEMSG


; FAO control string for logical name output message

LOGNAMSTR:
        .ASCID @!/LYRA: !AS IS A !AS@
```

```
; Error message control string

ERRSTR:
        .ASCID @!/LYRA: SYSTEM SERVICE ERROR AT APP. !XL R0=!XL@


; Logical names to be translated

ORIONLOG:
        .ASCID /ORION/

CYGNUSLOG:
        .ASCID /CYGNUS/

LYRALOG:
        .ASCID /LYRA/

PEGASUSLOG:
        .ASCID /PEGASUS/


; Read/write data program section starts here

        .PSECT  RWDATA,RD,WRT,NOEXE


; Output buffer for all output formatted by FAO

FAOLEN: .WORD   0                       ;Length of final string, always
        .WORD   0                       ;Need longword for $OUTPUT
FAODESC:
        .LONG   80
        .LONG   FAOBUF
FAOBUF: .BLKB   80


; Word to receive channel number of terminal

OUTCHAN:        .BLKW   1


; Buffers to maintain logical name/equivalence name pairs
; in routine that performs logical name translation

LOGBUFA:
        .LONG   63
        .LONG   BUFA
BUFA:   .BLKB   63
LOGBUFB:
        .LONG   63
        .LONG   BUFB
BUFB:   .BLKB   63

LOGLEN: .LONG   0                       ;Save length of equivalence name


; Parameter list for call to FAOL (used by translate routine)

TLIST:
TLOGNAM:
        .LONG   0                       ;Address of logical name descriptor
TEQLNAM:
        .LONG   0                       ;Address of equivalence descriptor
```

```
SAVER3: .LONG   0                       ;Save register contents for switch

; Longword to store the PC when a system service call results in an
; error. LYRA checks the low bit of R0 following each service call.
; If set, LYRA continues; otherwise, it saves the PC and branches
; to an error handling routine that displays the saved PC and the
; contents of R0.

ERRPC:  .LONG   0                       ;For address of SSFAIL


; Code begins here.

        .PSECT  CODE,EXE,RD,NOWRT
        .ENABL  LSB
LYRA::
        .WORD   ^M<R2,R3,R4,R5,R6>      ;Entry mask

; Assign channel to device referred to by logical name
; SYS$OUTPUT. This name was placed in the logical name
; table by CYGNUS (it is also CYGNUS's logical output device).

20$:    $ASSIGN_S DEVNAM=OUTPUT,CHAN=OUTCHAN
        BLBS    R0,30$
        RET                             ;Exit with status if ASSIGN fails
30$:    $OUTPUT CHAN=OUTCHAN,BUFFER=HELLO,LENGTH=HELLOLEN
        BLBS    R0,40$
        MOVAL   30$,ERRPC
        BRW     ERROR

40$:    $HIBER_S
        BLBS    R0,50$
        MOVAL   40$,ERRPC
        BRW     ERROR

50$:    $OUTPUT CHAN=OUTCHAN,BUFFER=WAKEMSG,LENGTH=WAKELEN
        BLBS    R0,60$
        MOVAL   50$,ERRPC
        BRW     ERROR

60$:

; When awakened, begin translating logical names. To translate the
; names, place address of a logical name descriptor in R2 and then
; go to the subroutine that performs the translation. Repeat for
; each logical name to translate.

        MOVAL   ORIONLOG,R2
        JSB     TRANSLATE
        MOVAL   CYGNUSLOG,R2
        JSB     TRANSLATE
        MOVAL   LYRALOG,R2
        JSB     TRANSLATE
        MOVAL   PEGASUSLOG,R2
        JSB     TRANSLATE

; All finished, return

        RET


        .ENABL LSB
; Subroutine to translate and print logical names:
```

```
; On entry to this subroutine,
; R2 = address of logical name to translate
; It uses: R3 to hold address of final result buffer
;          R4 to hold address of intermediate buffer

TRANSLATE:
        MOVAL   LOGBUFA,R3              ;Get addresses of buffers
        MOVAL   LOGBUFB,R4


; Initial translation places resultant equivalence name in buffer  pointed
; to by R3

10$:    $TRNLOG_S LOGNAM=(R2),RSLLEN=LOGLEN,RSLBUF=(R3)
        BLBS    R0,30$
        MOVAL   10$,ERRPC
        BRW     ERROR


; Place length of equivalence name in first word of descriptor and use this
; descriptor as input for next translation. If SS$_NOTRAN is returned,
; then there was no recursion of name. If not, update registers to
; provide input and output descriptors for translation and repeat
; translation until SS$_NOTRAN is returned.

30$:    MOVZWL  LOGLEN,(R3)             ;Fix length in buffer
        $TRNLOG_S LOGNAM=(R3),RSLLEN=LOGLEN,RSLBUF=(R4)
        BLBS    R0,40$
        MOVAL   30$,ERRPC
        BRW     ERROR

40$:    CMPW    R0,#SS$_NOTRAN          ;Final?
        BEQL    50$                     ;Yes, go print
        MOVL    R3,SAVER3               ;Otherwise, switch
        MOVL    R4,R3
        MOVL    SAVER3,R4
        MOVZWL  #63,(R4)                ;Restore length
        BRB     30$                     ;Try again


; Place addresses of logical name and equivalence names in FAO parameter list
; and call FAO to format output message, then output the message.

50$:    MOVL    R2,TLOGNAM
        MOVL    R3,TEQLNAM
        $FAOL_S CTRSTR=LOGNAMSTR,OUTLEN=FAOLEN,OUTBUF=FAODESC,-
                PRMLST=TLIST
        BLBS    R0,60$
        MOVAL   50$,ERRPC
        BRW     ERROR
60$:    $OUTPUT CHAN=OUTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
        BLBS    R0,70$
        MOVAL   60$,ERRPC
        BRW     ERROR
70$:    MOVL    #63,LOGBUFA
        MOVL    #63,LOGBUFB
        RSB                             ;To main routine


; Error-handling routine:
; This routine uses the saved PC and R0 to format a message describing
; the conditions under which a call to a system service failed.

ERROR:
```

```
$FAO_S   CTRSTR=ERRSTR,OUTBUF=FAODESC,OUTLEN=FAOLEN,-
         P1=ERRPC,P2=R0
$OUTPUT  CHAN=OUTCHAN,BUFFER=FAOBUF,LENGTH=FAOLEN
RET
.END     LYRA
```

APPENDIX C

QUICK REFERENCE SUMMARY OF SYSTEM SERVICES

C.1 VAX-11 MACRO FORMS

C.1.1 $name_G Form

Format

$name_G label

label

Address of argument list; argument list may be created with $name macro form.

$name Macro Format

label: $name argl ,... ,argn

label

Symbolic address of the generated argument list.

name

Macro name.

argl-argn

Arguments to be placed in successive longwords in the argument list. A longword of zeros is generated for a nonspecified argument. Arguments can be specified (1) in positional order, with commas indicating no specified arguments; or (2) using keyword = argument. If keywords are used, arguments can be specified in any order.

Argument List Offset Names

The $name macro automatically defines symbolic names for argument list of offsets. The offset names can also be defined with the $name DEF. The symbolic names defined are:

name$_NARGS

Number of arguments in list.

name$_keyword

Symbolic name for offset of each argument in list.

C.1.2 $name_S Form

Format

$name_S argl ,... ,argn

argl - argn

Arguments for macro instruction.

Arguments can be specified (1) in positional order, with commas indicating nonspecified arguments, or (2) using keyword=argument. If keywords are used, arguments can be specified in any order.

C.2 SYSTEM SERVICE MACROS

Adjust Outer Mode Stack Pointer

```
$ADJSTK [acmode] ,[adjust] ,newadr
```

acmode = access mode for which to adjust stack pointer

adjust = 16-bit signed adjustment value

newadr = address of longword to store updated value

Adjust Working Set Limit

```
$ADJWSL [pagcnt] ,[wsetlm]
```

pagcnt = number of pages to add to working set (if positive). Number of pages to subtract from working set (if negative).

wsetlm = address of longword to receive new working set limit, or current working set limit if pagcnt not specified.

Allocate Device

```
$ALLOC devnam ,[phylen] ,[phybuf] ,[acmode]
```

devnam = address of device name or logical name string descriptor

phylen = address of word to receive length of physical name

phybuf = address of physical name buffer descriptor

acmode = access mode associated with allocated device

Associate Common Event Flag Cluster

```
$ASCEFC  efn ,name ,[prot] ,[perm]
```

efn = number of any event flag in the cluster with which to associate

name = address of the text name string descriptor

prot = protection indicator for the cluster
0 -> default, any process in group
1 -> only owner's UIC

perm = permanent indicator
0 -> temporary cluster
1 -> permanent cluster

Convert Binary Time to ASCII String

$ASCTIM [timlen] ,timbuf ,[timadr] ,[cvtflg]

timlen = address of a word to receive the number of characters inserted into the output buffer.

timbuf = address of a quadword descriptor describing the buffer to receive the converted time.

timadr = address of the quadword containing the 64-bit time to be converted to ASCII. If 0, use current time.

cvtflg = conversion indicator
0 -> return full date and time
1 -> return converted time only

Assign I/O Channel

$ASSIGN devnam ,chan ,[acmode] ,[mbxnam]

devnam = address of device name or logical name string descriptor

chan = address of word to receive channel number assigned

acmode = access mode associated with channel

mbxnam = address of mailbox logical name string descriptor, if mailbox associated with device

Convert ASCII String to Binary Time

$BINTIM timbuf ,timadr

timbuf = address of string descriptor for ASCII time string

timadr = address of quadword to receive 64-bit binary time value

Absolute time strings are specified in the format:

dd-mmm-yyyy hh:mm:ss.cc

Delta time strings are specified in the format:

dddd hh:mm:ss.cc

Broadcast

$BRDCST msgbuf ,[devnam]

msgbuf = address of message buffer string descriptor

devnam = terminal device name string descriptor. If 0, send message to all terminals. If first word in descriptor is 0, send message to all allocated terminals.

Cancel I/O on Channel

```
$CANCEL  chan
```

chan = number of the channel on which I/O is to be canceled

Cancel Exit Handler

```
$CANEXH  [desblk]
```

desblk = address of exit control block describing exit handler to be deleted. If 0, delete all.

Cancel Timer Request

```
$CANTIM  [reqidt] ,[acmode]
```

reqidt = request identification for request to be canceled. If 0, all requests canceled.

acmode = access mode of requests to be canceled

Cancel Wakeup

```
$CANWAK  [pidadr] ,[prcnam]
```

pidadr = address of process identification of process for which wakeups are to be canceled

prcnam = address of process name string descriptor

Clear Event Flag

```
$CLREF efn
```

efn = number of event flag to be cleared

Change to Executive Mode

```
$CMEXEC  routin ,[arglst]
```

routin = address of the routine to be executed in executive mode

arglst = address of argument list to be supplied to the routine

Change to Kernel Mode

```
$CMKRNL  routin ,[arglst]
```

routin = address of routine to be executed in kernel mode

arglst = address of argument list to be supplied to routine

Contract Program/Control Region

```
$CNTREG  pagcnt ,[retadr] ,[acmode] ,[region]

pagcnt = number of pages to be deleted from end of region

retadr = address of 2-longword array to receive virtual
         addresses of starting and ending page of deleted area

acmode = access mode for which service is performed

region = region indicator
         0 -> program (P0) region
         1 -> control (P1) region
```

Create Logical Name

```
$CRELOG  [tblflg] ,lognam ,eqlnam ,[acmode]

tblflg = logical name table number
         0 -> system (default)
         1 -> group table
         2 -> process table

lognam = address of logical name string descriptor

eqlnam = address of equivalence name string descriptor

acmode = access mode for logical name (process table only)
```

Create Mailbox and Assign Channel

```
$CREMBX [prmflg] ,chan ,[maxmsg] ,[bufquo] ,[promsk] ,[acmode]
       ,[lognam]

prmflg = permanent flag
         0 -> temporary mailbox (default)
         1 -> permanent mailbox

chan   = address of word to receive channel assigned

maxmsg = maximum message size that may be received by mailbox

bufquo = number of bytes of dynamic memory that can be used to
         buffer mailbox messages

promsk = protection mask for mailbox

acmode = access mode of created mailbox

lognam = address of logical name string descriptor for mailbox
```

Create Process

```
$CREPRC  [pidadr]   ,[image]   ,[input]   ,[output]
         ,[error]   ,[prvadr]   ,[quota]   ,[prcnam]
         ,[baspri] ,[uic] ,[mbxunt] ,[stsflg]
```

pidadr = address of longword in which to return process identification of created process

image = address of string descriptor for image name

input = address of string descriptor for SYS$INPUT logical name

output = address of string descriptor for SYS$OUTPUT logical name

error = address of string descriptor for SYS$ERROR logical name

prvadr = address of quadword privilege list

quota = address of quota list

prcnam = address of string descriptor for process name

baspri = base priority (0-31) to set for new process (macro default = 2)

uic = user identification code. If 0, create a subprocess

mbxunt = mailbox unit for termination message

stsflg = status and mode flag bits

Bit	Meaning
0	disable resource wait mode
1	enable system service failure exception mode
2	inhibit process swapping
3	disable accounting messages
4	batch process
5	cause created process to hibernate
6	allow login without authorization file check
7	process is a network connect object

Create Virtual Address Space

```
$CRETVA  inadr ,[retadr] ,[acmode]
```

inadr = address of 2-longword array containing starting and ending virtual address of pages to be created

retadr = address of a 2-longword array to receive starting and ending virtual address of pages actually created

acmode = access mode for the new pages (protection is read/write for acmode and more privileged modes)

Create and Map Section

$CRMPSC [inadr] ,[retadr] ,[acmode] ,[flags] ,[gsdnam] ,[ident] ,[relpag] ,[chan] ,[pagcnt] ,[vbn] ,[prot] ,[pfc]

inadr = address of 2-longword array containing starting and ending virtual addresses of space into which section is to be mapped

retadr = address of 2-longword array to receive addresses actually mapped

acmode = access mode of owner of pages

flags = section characteristics

Flag	Meaning
SEC$M_GBL	Global section
SEC$M_CRF	Copy-on-reference pages
SEC$M_DZRO	Demand zero pages
SEC$M_EXPREG	Find first available space
SEC$M_PERM	Permanent section
SEC$M_PFNMAP	Page frame section
SEC$M_SYSGBL	System global section
SEC$M_WRT	Read/write section

gsdnam = address of global section name string descriptor

ident = address of quadword containing version identification and match control

relpag = relative page number within section to begin mapping

chan = number of channel on which file is accessed

pagcnt = number of pages in section

vbn = virtual block number of beginning of section or physical page frame number of beginning of section

prot = protection mask

pfc = page fault cluster size

Disassociate Common Event Flag Cluster

$DACEFC efn

efn = number of any event flag in the cluster to be disassociated

Deallocate Device

$DALLOC [devnam] ,[acmode]

devnam = address of device name string descriptor. If 0, deallocate all devices.

acmode = access mode associated with device

Deassign I/O Channel

```
$DASSGN  chan

chan   = number of channel to be deassigned
```

Declare AST

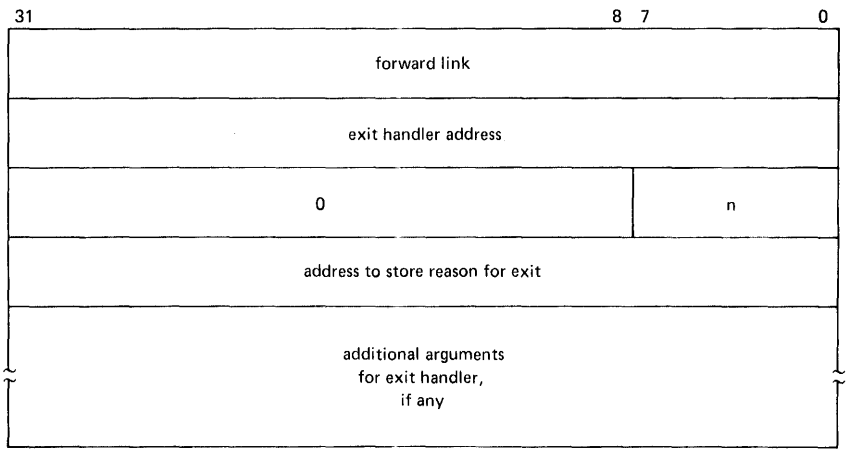
```
$DCLAST  astadr ,[astprm] ,[acmode]

astadr = address of entry mask of AST routine

astprm = value to be passed to AST routine as an argument

acmode = access mode for which the AST is to be declared
```

Declare Change Mode or Compatibility Mode Handler

```
$DCLCMH  addres ,[prvhnd] ,[type]

addres = address of change mode or compatibility mode handler

prvhnd = address of longword to receive previous handler
         address

type   = handler type indicator
           0 -> change mode handler for current mode
           1 -> compatibility mode handler
```

Declare Exit Handler

```
$DCLEXH  desblk

desblk = address of exit control block containing:
```



Delete Logical Name

```
$DELLOG  [tblflg] ,[lognam] ,[acmode]

tblflg = logical name table number
         0 -> system
         1 -> group
         2 -> process

lognam = address of logical name string descriptor. If 0,
         delete all names in the specified table.

acmode = access mode of logical name (process table only)
```

Delete Mailbox

```
$DELMBX  chan

chan   = channel number assigned to the mailbox
```

Delete Process

```
$DELPRC  [pidadr] ,[prcnam]

pidadr = address of longword containing process identification
         of process to be deleted

prcnam = address of string descriptor for process name of
         process to be deleted.
```

Delete Virtual Address Space

```
$DELTVA  inadr ,[retadr] ,[acmode]

inadr  = address of 2-longword array containing starting and
         ending virtual addresses of pages to delete

retadr = address of 2-longword array to receive starting and
         ending addresses of pages actually deleted

acmode = access mode for which service is performed
```

Delete Global Section

```
$DGBLSC  [flags] ,gsdnam ,[ident]

flags  = type of section
         0 -> group global section
         SEC$M_SYSGBL -> system global section

gsdnam = address of global section name string descriptor

ident  = address of quadword containing version identification
         and match control
```

Delete Common Event Flag Cluster

```
$DLCEFC  name

name   = address of text name string descriptor of permanent
         cluster
```

Exit

```
$EXIT    [code]

code   = longword to be saved in process header as completion
         status of current image (macro default = 1)
```

Expand Program/Control Region

```
$EXPREG  pagcnt ,[retadr] ,[acmode] ,[region]

pagcnt = number of pages to add to end of specified region

retadr = address of 2-longword array to receive virtual
         addresses of starting and ending pages of expanded
         region

acmode = access mode of the new pages

region = region indicator
         0 -> expand program (P0) region
         1 -> expand program (P1) region
```

Formatted ASCII Output

```
$FAO     ctrstr ,[outlen] ,outbuf ,[p1] ,[p2]...[pn]

ctrstr = address of string descriptor for ASCII control string

outlen = address of word in which to store output string
         length

outbuf = address of output buffer string descriptor

p1...  = variable number of arguments to FAO
```

Formatted ASCII Output With List Parameter

```
$FAOL    ctrstr ,[outlen] ,outbuf ,prmlst

ctrstr = address of string descriptor for control string

outlen = address of word to receive output string length

outbuf = address of output buffer string descriptor

prmlst = address of a list of longword parameters
```

Force Exit

```
$FORCEX  [pidadr] ,[prcnam] ,[code]

pidadr = address of process identification of process to be
         forced to exit

prcnam = address of process name string descriptor for forced
         process

code   = longword completion status for Exit service
```

Get I/O Channel Information

$GETCHN chan ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf]

chan = number of a channel assigned to the device

prilen = address of word to receive length of primary buffer

pribuf = address of primary buffer descriptor

scdlen = address of word to receive length of secondary buffer

scdbuf = address of secondary buffer descriptor

Get I/O Device Information

$GETDEV devnam ,[prilen] ,[pribuf] ,[scdlen] ,[scdbuf]

devnam = address of device name or logical name string descriptor

prilen = address of word to receive length of primary buffer

pribuf = address of primary buffer descriptor

scdlen = address of word to receive length of secondary buffer

scdbuf = address of secondary buffer descriptor

Get Job/Process Information

$GETJPI [efn] ,[pidadr] ,[prcnam] ,itmlst ,[iosb], [astadr], [astprm]

efn = event flag number of flag to be set at request completion

pidadr = address of process identification

prcnam = address of process name string descriptor

itmlst = address of a list of item descriptors

iosb = address of a quadword I/O status block

astadr = address of entry mask of AST routine

astprm = value to be passed to AST routine as an argument

Get Message

$GETMSG msgid ,msglen ,bufadr ,[flags] ,[outadr]

msgid = identification of message to be retrieved

msglen = address of a word to receive length of string returned

bufadr = address of buffer descriptor of buffer to receive string

flags = flag bits for message content (macro default = 15)

Bit	Value	Meaning
0	1	Include text
	0	Do not include text
1	1	Include identifier
	0	Do not include identifier
2	1	Include severity
	0	Do not include severity
3	1	Include component
	0	Do not include component

outadr = address of 4-byte array to receive the following values:

Byte	Contents
0	Reserved
1	Count of FAO arguments
2	User value
3	Reserved

Get Time

$GETTIM timadr

timadr = address of a quadword to receive 64-bit current time value

Hibernate

$HIBER_S

$INPUT Macro

$INPUT chan ,length ,buffer ,[iosb] ,[efn]

chan = number of the channel on which I/O is to be performed

length = length of the input buffer

buffer = address of the input buffer

iosb = address of quadword I/O status block

efn = event flag to set on completion (default = 0)

Lock Pages in Memory

$LCKPAG inadr ,[retadr] ,[acmode]

inadr = address of 2-longword array containing starting and ending addresses of pages to be locked

retadr = address of 2-longword array to receive addresses of pages actually locked

acmode = access mode to check against the owner of the pages

Lock Pages in Working Set

$LKWSET inadr ,[retadr] ,[acmode]

inadr = address of 2-longword array containing starting and ending virtual addresses of pages to be locked

retadr = address of a 2-longword array to receive starting and ending virtual addresses of pages actually locked

acmode = access mode to be checked against the page owner

Map Global Section

$MGBLSC inadr ,[retadr] ,[acmode] ,[flags] ,gsdnam ,[ident] ,[relpag]

inadr = address of 2-longword array containing starting and ending addresses of pages to be mapped

retadr = address of 2-longword array to receive virtual addresses of pages mapped

acmode = access mode of owner of mapped pages

flags = flags overriding default section characteristics

Flag	Meaning
SEC$M_WRT	Read/write section
SEC$M_SYSGBL	System global section
SEC$M_EXPREG	Find first available space

gsdnam = address of global section name descriptor

ident = address of quadword containing version identification and match control

relpag = relative page number within global section

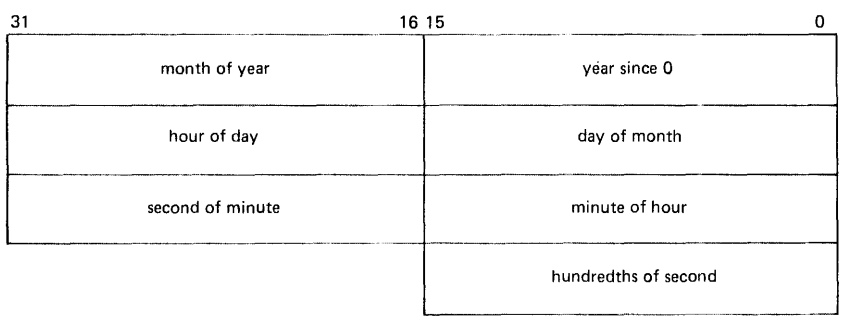
Convert Binary Time to Numeric Time

$NUMTIM timbuf ,[timadr]

timbuf = address of a 7-word buffer to receive numeric time information

timadr = address of a quadword containing the 64-bit time. If 0, use current time

Buffer format:



$OUTPUT Macro

```
$OUTPUT  chan, length, buffer, [iosb], [efn]

chan   = channel on which I/O is directed

length = length of the output buffer

buffer = address of the output buffer

iosb   = address of quadword I/O status block

efn    = event flag number to set on completion (default = 0)
```

Purge Working Set

```
$PURGWS  inadr

inadr  = address of 2-longword array containing  starting  and
         ending addresses of pages to be removed
```

Put Message

```
$PUTMSG msgvec ,[actrtn] ,[facnam]

msgvec = address of message argument vector

actrtn = address of entry mask of action routine

facnam = address of facility name string descriptor
```

Queue I/O Request

```
$QIO   [efn] ,chan ,func ,[iosb] ,[astadr] ,[astprm]
$QIOW  ,[p1] ,[p2] ,[p3] ,[p4] ,[p5] ,[p6]

efn    = number of event flag to set on completion

chan   = number of channel on which I/O is directed

func   = function code specifying action to be performed

iosb   = address of quadword I/O status block to receive final
         completion status information

astadr = address of entry mask of AST routine

astprm = value to be passed to AST routine as argument

p1...  = optional device- and function-specific parameters
```

Queue I/O Request and Wait for Event Flag

```
See QIO for argument description
```

Read Event Flag

```
$READEF  efn ,state

efn    = event flag number of any flag in the cluster to be
         read

state  = address of a longword to receive current state of all
         flags in the cluster
```

Resume Process

```
$RESUME  [pidadr] ,[prcnam]

pidadr = address of process identification of process whose
         execution is to be resumed

prcnam = address of name string descriptor of process whose
         execution is to be resumed
```

Schedule Wakeup

```
$SCHDWK  [pidadr] ,[prcnam] ,daytim ,[reptim]

pidadr = address of process identification of process to be
         awakened

prcnam = address of name string descriptor of process to be
         awakened

daytim = address of quadword containing time to wake

reptim = address of quadword containing repeat time interval
```

Set AST Enable

```
$SETAST  enbflg

enbflg = AST enable indicator
         0 -> disable ASTs for caller at current access mode
         1 -> enable ASTs for caller at current access mode
```

Set Event Flag

```
$SETEF  efn

efn    = event flag number of flag to set
```

Set Exception Vector

```
$SETEXV  [vector] ,[addres] ,[acmode] ,[prvhnd]

vector = vector number
         0 -> modify primary vector
         1 -> modify secondary vector
         2 -> modify last chance vector

addres = exception handler address (0 indicates deassign
         vector)

acmode = access mode for which vector is set

prvhnd = address of longword to receive previous handler
         address
```

Set System Time

$SETIME [timadr]

timadr = address of quadword containing new system time in 64-bit format. If 0, recalibrate system time using hardware time-of-year clock.

Set Timer

$SETIMR [efn] ,daytim ,[astadr] ,[reqidt]

efn = event flag to set when timer expires

daytim = address of quadword containing 64-bit time value

astadr = address of entry mask of AST routine

reqidt = request identification of this timer request

Set Power Recovery AST

$SETPRA astadr ,[acmode]

astadr = address of power recovery AST routine

acmode = access mode of AST

Set Priority

$SETPRI [pidadr] ,[prcnam] ,pri ,[prvpri]

pidadr = address of process identification of process whose priority is to be set

prcnam = address of name string descriptor of process whose priority is to be set

pri = new base priority for the process (0 - 15 are timesharing; 16 - 31 are real-time)

prvpri = address of longword to receive previous base priority

Set Process Name

$SETPRN [prcnam]

prcnam = address of the process name string descriptor

Set Protection on Pages

```
$SETPRT  inadr ,[retadr] ,[acmode] ,prot ,[prvprt]

inadr  = address of 2-longword array containing starting and
         ending virtual addresses of pages for which to change
         protection

retadr = address of 2-longword array to receive starting and
         ending addresses of pages that had their protection
         changed

acmode = access mode of request

prot   = new protection

prvprt = address of byte to receive previous protection of
         last page changed
```

Set Privileges

```
$SETPRV [enbflg] ,[prvadr] ,[prmflg] ,[prvprv]

enbflg = enable indicator
         0 -> disable specified privileges
         1 -> enable specified privileges

prvadr = 64-bit mask defining the privileges to be enabled or
         disabled

prmflg = permanent indicator
         0 -> enable or disable temporarily
         1 -> enable or disable permanently

prvprv = address of quadword buffer to receive previous
         privilege mask
```

Set Resource Wait Mode

```
$SETRWM  [watflg]

watflg = wait indicator
         0 -> wait for resources
         1 -> return failure status immediately
```

Set System Service Failure Mode

```
$SETSFM  [enbflg]

enbflg = enable indicator
         0 -> disable generation of exceptions on
              system service failures
         1 -> generate exceptions for system service
              failures
```

Set Process Swap Mode

```
$SETSWM  [swpflg]

swpflg = swap indicator
         0 -> enable swapping
         1 -> disable swapping (lock in balance set)
```

Send Message to Accounting Manager

```
$SNDACC  msgbuf ,[chan]

msgbuf = address of message buffer string descriptor

chan   = number of channel assigned to mailbox to receive
         reply
```

Send Message to Error Logger

```
$SNDERR msgbuf

msgbuf = address of message buffer string descriptor
```

Send Message to Operator

```
$SNDOPR  msgbuf ,[chan]

msgbuf = address of message buffer string descriptor

chan   = number of channel assigned to mailbox to receive
         reply
```

Send Message to Symbiont Manager

```
$SNDSMB  msgbuf ,[chan]

msgbuf = address of message buffer string descriptor

chan   = number of channel assigned to mailbox to receive
         reply
```

Suspend Process

```
$SUSPND  [pidadr] ,[prcnam]

pidadr = address of process identification of process to be
         suspended

prcnam = address of name string descriptor of process to be
         suspended
```

Translate Logical Name

$TRNLOG lognam ,[rsllen] ,rslbuf ,[table] ,[acmode] ,[dsbmsk]

lognam = address of logical name string descriptor

rsllen = address of word to receive length of resultant name string

rslbuf = address of descriptor pointng to buffer to hold result string (equivalence name)

table = address of byte to receive logical name table number

acmode = address of byte to receive access mode of entry (process table only)

dsbmsk = table search disable mask

Bit Set	Meaning
0	Do not search system table
1	Do not search group table
2	Do not search process table

Unlock Pages From Memory

$ULKPAG inadr ,[retadr] ,[acmode]

inadr = address of 2-longword array containing starting and ending virtual addresses of pages to be unlocked

retadr = address of a 2-longword array to receive starting and ending virtual addresses of pages actually unlocked

acmode = access mode to check against the owner of the pages

Unlock Pages From Working Set

$ULWSET inadr ,[retadr] ,[acmode]

inadr = address of 2-longword array containing starting and ending virtual addresses of pages to be unlocked

retadr = address of a 2-longword array to receive starting and ending virtual addresses of pages actually unlocked

acmode = access mode to check against the owner of the pages

Unwind Call Stack

$UNWIND [depadr] ,[newpc]

depadr = address of longword containing number of logical frames (depth) to unwind call stack

newpc = address to be given control when the unwind is complete

Update Section File on Disk

```
$UPDSEC inadr ,[retadr] ,[acmode] ,[updflg] ,[efn] ,[iosb]
        ,[astadr] ,[astprm]
```

inadr = address of 2-longword array containing starting and ending addresses of the pages to be potentially written

retadr = address of 2-longword array to receive addresses of the first and last page queued in the first I/O request

acmode = access mode on behalf of which the service is performed

updflg = update indicator for read/write global sections
0 -> write all read/write pages in the section
1 -> write all pages modified by the caller

efn = number of event flag to set when the section file is updated

iosb = address of quadword I/O status block

astadr = address of entry mask of an AST service routine

astprm = AST parameter to be passed to the AST service routine

Wait for Single Event Flag

```
$WAITFR  efn
```

efn = event flag number to wait for

Wake

```
$WAKE  [pidadr] ,[prcnam]
```

pidadr = address of process identification of process to be awakened

prcnam = address of name string descriptor of process to be awakened

Wait for Logical AND of Event Flags

```
$WFLAND  efn ,mask
```

efn = event flag number of any flag within the cluster

mask = 32-bit mask of flags that must be set

Wait for Logical OR of Event Flags

```
$WFLOR  efn ,mask
```

efn = event flag number of any flag within the cluster

mask = 32-bit mask of flags, any of which must be set

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