
OpenVMS Programming Concepts Manual, Volume II

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Intended Audience

This manual is intended for system and application programmers. It presumes that its readers have some familiarity with the OpenVMS programming environment, derived from the *OpenVMS Programming Environment Manual* and OpenVMS high-level language documentation. The *OpenVMS Programming Environment Manual* has been archived but is available on the OpenVMS Documentation CD_ROM.

Document Structure

The printed copy of the *OpenVMS Programming Concepts Manual* is a two volume manual. The second volume contains three parts; the three parts are as follows:

- OpenVMS Programming Interfaces: Calling a System Routine
- I/O, System and Programming Routines
- Appendixes

The chapters in Volume II provide information about the programming features of the OpenVMS operating system. A list of the chapters and a summary of their content are as follows:

- Chapter 17, Call Format to OpenVMS Routines, describes the format used to document system routine calls and explains where to find and how to interpret information about routine calls.
- Chapter 18, Basic Calling Standard Conventions, describes the concepts and conventions used by common languages to invoke routines and pass data between them.
- Chapter 19, Calling Run-Time Library Routines, describes a set of language-independent routines that establishes a common run-time environment for user programs.
- Chapter 20, Calling System Services, describes the system services available to application and system programs for use at run time.
- Chapter 21, STARLET Structures and Definitions for C Programmers, describes the libraries that contain C header files for routines.
- Chapter 22, Run-Time Library Input/Output Operations, describes the different I/O programming capabilities provided by the run-time library.
- Chapter 23, System Service Input/Output Operations, describes how to use system services to perform input and output operations.

- Chapter 24, *Using Run-Time Library Routines to Access Operating System Components*, describes the run-time library (RTL) routines that allow access to various operating system components.
- Chapter 25, *Using Cross-Reference Routines*, describes how cross-reference routines that are contained in a separate, shareable image are capable of creating a cross-reference analysis of symbols.
- Chapter 26, *Shareable Resources*, describes the techniques available for sharing data and program code among programs.
- Chapter 27, *System Time Operations*, describes the system time format, and the manipulation of date/time and time conversion. It further describes how to obtain and set the current date and time, how to set and cancel timer requests, and how to schedule and cancel wakeups. The Coordinated Universal Time (UTC) system is also described.
- Chapter 28, *File Operations*, describes file attributes, strategies to access files, and file protection techniques.
- Chapter 29, *Using the Distributed Transaction Manager*, describes the use of the DECdtm system services to ensure the integrity and consistency of distributed transactions by implementing a two-phase commit protocol.
- Chapter 30, *Creating User-Written System Services*, describes how to create user-written system services with privileged shareable images for both VAX systems and Alpha systems.
- Chapter 31, *System Security Services*, describes the system services that establish protection by using identifiers, rights databases, and access control entries. This chapter also describes how to modify a rights list as well as check access protection.
- Chapter 32, *Logical Name and Logical Name Tables*, describes how to create and use logical name services, how to use logical and equivalence names, and how to add and delete entries to a logical name table.
- Chapter 33, *Image Initialization*, describes how to use the LIB\$INITIALIZE routine to initialize an image.
- Appendix A, *Generic Macros for Calling System Services*, describes the use of generic macros to specify argument lists with appropriate symbols and conventions in the system services interface to MACRO assembles.
- Appendix B, *OpenVMS Data Types*, describes the data types that provide compatibility between procedure calls that support many different high-level languages.
- Appendix C, *Distributed Name Service*, describes the Digital Distributed Name Service (DECdns) Clerk by introducing the functions of the DECdns (SYSSDNS) system service and various run-time library routines.

Related Documents

For a detailed description of each run-time library and system service routine mentioned in this manual, see the *OpenVMS Run-Time Library* documentation and the *OpenVMS System Services Reference Manual*.

You can find additional information about calling OpenVMS system services and Run-Time Library routines in your language processor documentation. You may also find the following documents useful:

- *OpenVMS DCL Dictionary*
- *OpenVMS User's Manual*
- *Guide to OpenVMS File Applications*
- *OpenVMS Guide to System Security*
- *DECnet for OpenVMS Networking Manual*
- OpenVMS Record Management Services documentation
- *OpenVMS Utility Routines Manual*
- *OpenVMS I/O User's Reference Manual*

For additional information about OpenVMS products and services, access the following World Wide Web address:

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If you need help deciding which documentation best meets your needs, call 800-282-6672.

Conventions

The following conventions are used in this manual:

- | | |
|--|--|
| Ctrl/ <i>x</i> | A sequence such as Ctrl/ <i>x</i> indicates that you must hold down the key labeled Ctrl while you press another key or a pointing device button. |
| PF1 <i>x</i> | A sequence such as PF1 <i>x</i> indicates that you must first press and release the key labeled PF1 and then press and release another key or a pointing device button. |
| Return | In examples, a key name enclosed in a box indicates that you press a key on the keyboard. (In text, a key name is not enclosed in a box.)

In the HTML version of this document, this convention appears as brackets, rather than a box. |

...	A horizontal ellipsis in examples indicates one of the following possibilities: <ul style="list-style-type: none"> • Additional optional arguments in a statement have been omitted. • The preceding item or items can be repeated one or more times. • Additional parameters, values, or other information can be entered.
.	A vertical ellipsis indicates the omission of items from a code example or command format; the items are omitted because they are not important to the topic being discussed.
()	In command format descriptions, parentheses indicate that you must enclose choices in parentheses if you specify more than one.
[]	In command format descriptions, brackets indicate optional choices. You can choose one or more items or no items. Do not type the brackets on the command line. However, you must include the brackets in the syntax for OpenVMS directory specifications and for a substring specification in an assignment statement.
	In command format descriptions, vertical bars separate choices within brackets or braces. Within brackets, the choices are optional; within braces, at least one choice is required. Do not type the vertical bars on the command line.
{ }	In command format descriptions, braces indicate required choices; you must choose at least one of the items listed. Do not type the braces on the command line.
bold text	This typeface represents the introduction of a new term. It also represents the name of an argument, an attribute, or a reason.
<i>italic text</i>	Italic text indicates important information, complete titles of manuals, or variables. Variables include information that varies in system output (Internal error <i>number</i>), in command lines (<i>/PRODUCER=name</i>), and in command parameters in text (where <i>dd</i> represents the predefined code for the device type).
UPPERCASE TEXT	Uppercase text indicates a command, the name of a routine, the name of a file, or the abbreviation for a system privilege.
Monospace text	Monospace text indicates code examples and interactive screen displays. <p>In the C programming language, monospace type in text identifies the following elements: keywords, the names of independently compiled external functions and files, syntax summaries, and references to variables or identifiers introduced in an example.</p>
-	A hyphen at the end of a command format description, command line, or code line indicates that the command or statement continues on the following line.
numbers	All numbers in text are assumed to be decimal unless otherwise noted. Nondecimal radices—binary, octal, or hexadecimal—are explicitly indicated.

Part I

OpenVMS Programming Interfaces: Calling a System Routine

This part of this second volume describes the basic calling format for OpenVMS routines and system services. It also describes the STARLET structures and definitions for C programmers.

Call Format to OpenVMS Routines

This chapter describes the format used to document system routine calls and explains where to find and how to interpret information about routine calls. Subsequent chapters provide more specific information about calling run-time library (RTL) routines and system services.

Note

The documentation format described in this chapter is generic; portions of it are used or not used, as appropriate, in the following OpenVMS manuals that document system routines:

OpenVMS System Services Reference Manual: A-GETUAI
OpenVMS System Services Reference Manual: GETUTC-Z
OpenVMS Run-Time Library manuals
OpenVMS Utility Routines Manual
OpenVMS Record Management Services Reference Manual

17.1 Overview

This chapter provides additional explanations for the following documentation categories for routines:

- Format
- Returns
- Arguments
- Condition values returned

However, some main categories in the routine format contain information requiring no explanation beyond that given in Table 17-1.

Call Format to OpenVMS Routines

17.1 Overview

Table 17–1 Main Headings in the Documentation Format for System Routines

Main Heading	Description
Routine Name	Always present. The routine entry point name appears at the top of the first page. It is usually followed by the English text name of the routine.
Routine Overview	Always present. Appears directly below the routine name and briefly explains what the routine does.
Format	Always present. Follows the routine overview and gives the routine entry point name and the routine argument list.
Returns	Always present. Follows the routine format and explains what information is returned by the routine.
Arguments	Always present. Follows the Returns heading and gives detailed information about each argument. If a routine takes no arguments, the word None appears.
Description	<p>Optional. Follows the Arguments heading and contains information about specific actions taken by the routine: interaction between routine arguments, if any; operation of the routine within the context of OpenVMS; user privileges needed to call the routine, if any; system resources used by the routine; and user quotas that might affect the operation of the routine.</p> <p>Note that any restrictions on the use of the routine are always discussed first in the Description section. For example, any required user privileges or necessary system resources are explained first.</p> <p>For some simple routines, a Description section is not necessary because the routine overview provides the needed information.</p>
Condition Values Returned	Always present. Follows the Description section and lists the condition values (typically status or completion codes) that are returned by the routine.
Example	<p>Optional. Follows the Condition Values Returned heading and contains one or more programming examples that illustrate how to use the routine, followed by an explanation.</p> <p>All examples under this heading are complete. They have been tested and should run when compiled (or assembled) and linked. Throughout the manuals that document system routines, examples are provided in as many different programming languages as possible.</p>

17.2 Format Heading

The following three types of information can be present in the format heading:

- Procedure call format
- Explanatory text
- Jump to Subroutine (JSB) format (VAX only)

On VAX processors, all system routines have a procedure call format, but few system routines have JSB formats. If a routine has a JSB format, the format always appears after the routine's procedure call format.

17.2.1 Procedure Call Format

Procedure call formats can appear in many forms. The following four formats illustrate the meaning of syntactical elements, such as brackets and commas. General rules of syntax governing how to use procedure call formats are shown in Table 17–2.

Table 17–2 General Rules of Syntax for Procedure Call Formats

Element	Syntax Rule
Entry point names	Entry point names are always shown in uppercase characters.
Argument names	Argument names are always shown in lowercase characters.
Spaces	One or more spaces are used between the entry point name and the first argument, and between each argument.
Braces ({})	Braces surround two or more arguments. You must choose one of the arguments.
Brackets ([])	Brackets surround optional arguments. Note that commas can also be optional (see the comma element). Note that programming language syntax for optional arguments differs between languages. Refer to your language user's guide for more information.
Commas (,)	Between arguments, the comma always follows the space. If the argument is optional, the comma might appear either inside or outside the brackets, depending on the position of the argument in the list and on whether surrounding arguments are optional or required.
Null arguments	<p>A null argument is a placeholder argument. It is used for one of the following reasons: (1) to hold a place in the argument list for an argument that has not yet been implemented by Compaq but might be in the future; or (2) to mark the position of an argument that was used in earlier versions of the routine but is not used in the latest version (upward compatibility is thereby ensured because arguments that follow the null argument in the argument list keep their original positions). A null argument is always given the name nullarg.</p> <p>In the argument list constructed when a procedure is called, both null arguments and omitted optional arguments are represented by argument list entries containing the value 0. The programming language syntax required to produce argument list entries containing 0 differs from language to language. See your language user's guide for language-specific syntax.</p>

Format 1 This format illustrates the standard representation of optional arguments and best describes the use of commas as delimiters. Arguments enclosed within square brackets are optional. In most languages, if an optional argument other than a trailing optional argument is omitted, you must include a comma as a delimiter for the omitted argument.

ROUTINE_NAME *arg1*[, [*arg2*][, *arg3*]]

Typically, OpenVMS RMS system routines use this format when a maximum of three arguments appear in the argument list.

Call Format to OpenVMS Routines

17.2 Format Heading

Format 2 When the argument list contains three or more optional arguments, the syntax does not provide enough information. If you omit the optional arguments **arg3** and **arg4** and specify the trailing argument **arg5**, you must use commas to delimit the positions of the omitted arguments.

ROUTINE_NAME *arg1, [arg2], nullarg, [arg3], [arg4], arg5*

Typically, system services, utility routines, and run-time library routines contain call formats with more than three arguments.

Format 3 In the following call format, the trailing four arguments are optional as a group; that is, you specify either **arg2**, **arg3**, **arg4**, and **arg5**, or none of them. Therefore, if you do not specify the optional arguments, you need not use commas to delimit unoccupied positions.

However, if you specify a required argument or a separate optional argument after **arg5**, you must use commas when **arg2**, **arg3**, **arg4**, and **arg5** are omitted.

ROUTINE_NAME *arg1[, arg2, arg3, arg4, arg5]*

Format 4 In the following example, you can specify **arg2** and omit **arg3**. However, whenever you specify **arg3**, you *must* specify **arg2**.

ROUTINE_NAME *arg1[, arg2[, arg3]]*

17.2.2 JSB Call Format (VAX only)

The JSB call format indicates that the named routine is called using the VAX JSB instruction. The routine returns using Return from Subroutine (RSB). You can use the JSB call format with only the VAX MACRO and VAX BLISS languages.

Explanatory Text

Explanatory text might follow the procedure call format or the JSB call format, or both. This text is present only when needed to clarify the format. For example, in the call format, you indicate that arguments are optional by enclosing them in brackets ([]). However, brackets alone cannot convey all the important information that might apply to optional arguments. For example, in some routines that have many optional arguments, if you select one optional argument, you must also select another optional argument. In such cases, text following the format clarifies this.

17.3 Returns Heading

The Returns heading contains a description of any information returned by the routine to the caller. A routine can return information to the caller in various ways. The following subsections discuss each possibility and then describe how this returned information is presented.

17.3.1 Condition Values Returned in a Register

Most routines return a condition value in register R0. This condition value contains various kinds of information, the most important for the caller (in bits <3:0>) being the completion status of the operation. You test the condition value to determine whether the routine completed successfully.

On Alpha processors, a 32-bit condition value is represented in the Alpha register sign-extended to 64 bits.

If you program in high-level languages for OpenVMS environments, the fact that status information is returned by means of a condition value and that it is returned in a hardware register is of little importance because you receive this status information in the return (or status) variable. The run-time environment established for the high-level language program allows the status information in R0 to be moved automatically to the user's return variable.

Nevertheless, for routines that return a condition value, the Returns heading in the documentation contains the following information:

```
OpenVMS usage: cond_value
type:          longword (unsigned)
access:        write only
mechanism:     by value
```

The **OpenVMS usage** entry specifies the OpenVMS data type of the information returned. Because a condition value in any OpenVMS operating system environment is returned in a specific condition value structure, the OpenVMS usage entry is **cond_value**.

The **type** entry specifies the standard data type of the information returned. Because the condition value structure is 32 bits, the type heading is **longword (unsigned)**.

The **access** entry specifies the way in which the called routine accesses the object. Because the called routine is returning the condition value, the routine writes the value into R0, so the access heading is **write only**.

The **mechanism** heading specifies the passing mechanism used by the called routine in returning the condition value. Because the called routine is writing the condition value directly into R0, the mechanism heading is **by value**. (If the called routine had written the address of the condition value into R0, the passing mechanism would have been **by reference**.)

Note that if a routine returns a condition value, another main heading in the documentation format (Condition Values Returned) describes the possible condition values that the routine can return.

17.3.2 Other Returned Values

If a routine returns actual data, the Returns heading in the documentation of that routine contains the following information (for example, from a math routine):

```
OpenVMS usage: floating_point
type:          G_floating
access:        write only
mechanism:     by value
```

In this mathematics routine notation, the OpenVMS data type is **floating_point** and the standard data type is **G_floating point**. The meaning of the contents of the access and mechanism headings is discussed in Sections 17.4.3 and 17.4.4.

The registers used to return values vary with the type of the result and the specific hardware environment. For more information, see the *OpenVMS Calling Standard*.

In addition, under the Returns heading, some text can be provided after the information about the type, access, and mechanism. This text explains other relevant information about what the routine is returning.

Call Format to OpenVMS Routines

17.3 Returns Heading

For example, because the routine is returning actual data in the VAX or Alpha registers, the registers cannot be used to convey completion status information. All routines that return actual data in VAX or Alpha registers must **signal** the condition value, which contains the completion status. Thus, the text under the Returns heading points out that the routine signals its completion status.

17.3.3 Condition Values Signaled

Although most routines return condition values, some routines choose to signal their condition values using the OpenVMS signaling mechanism. Routines can signal their completion status whether or not they are returning actual data in the hardware registers, but all routines that return actual data in the hardware registers must signal their completion status if they are to return this status information at all.

If a routine signals its completion status, text under the Returns heading explains this, and the Condition Values Signaled heading in the documentation format describes the possible condition values that the routine can signal.

Compaq's system routines never signal condition values indicating success. Only error condition values are signaled.

17.4 Arguments Heading

Detailed information about each argument is listed in the call format under the Arguments heading. Arguments are described in the order in which they appear in the call format. If the routine has no arguments, the word None appears.

The following format is used to describe each argument:

```
argument-name
OpenVMS usage:  OpenVMS data type
type:          argument data type
access:        argument access
mechanism:     argument passing mechanism
```

A paragraph of structured text describing the arguments follows the argument format along with additional information, if needed.

17.4.1 OpenVMS Usage Entry

The purpose of the OpenVMS usage entry is to facilitate the coding of source-language data type declarations in application programs. Ordinarily, the standard data type, discussed in Section 17.4.2, is sufficient to describe the type of data passed by an argument. However, within the OpenVMS operating system environment, many system routines contain arguments whose conceptual nature or complexity requires additional explanation. For instance, when an argument passes the name of an event flag, the type entry **longword (unsigned)** alone does not indicate the nature of the value. In this instance, an accompanying OpenVMS usage entry, denoting the OpenVMS data type **ef_number**, further explains the actual usage.

See Table B-1 for a list of the possible OpenVMS usage entries and their definitions. Refer to the appropriate language implementation table in Appendix B to determine the correct syntax of the type declaration in the language you are using.

Note that the OpenVMS usage entry is not a traditional data type (such as the standard data types of byte, word, longword, and so on). It is significant only within the context of the OpenVMS operating system and is intended solely to expedite data declarations within application programs.

17.4.2 Type Entry

In actuality, an argument does not have a data type; rather, the data specified by an argument has a data type. The argument is merely the vehicle for passing data to the called routine. Nevertheless, the phrase **argument data type** is used to describe the *standard data type of the data* specified by the argument.

Procedure calls result in the construction of an **argument list**. (This process is described in the *OpenVMS Calling Standard*.) An argument list is a sequence of entries together with a count of the number of entries.

On VAX systems, an argument list is represented as a vector of longwords, where the first longword contains the count and each remaining longword contains one argument.

On Alpha systems, an argument list is represented as quadword entities that comprise an **argument item sequence**, partly in hardware registers and (when there are more than six arguments) partly on the stack. The argument information (AI) register contains the argument count that specifies the number of 64-bit argument items.

When arguments are passed by descriptors, these standard data types are defined with symbolic codes. Table 17-3 lists the standard data types for VAX and Alpha systems that can appear for the type entry in an argument description, along with their symbolic code (DTYPE) used in argument descriptors.

For a detailed description of each of the following symbolic codes, see the *OpenVMS Calling Standard*.

Table 17-3 Standard Data Types and Their Descriptor Field Symbols

Data Type	Symbolic Code
Absolute date and time	DSC\$K_DTYPE_ADT
Byte integer (signed)	DSC\$K_DTYPE_B
Bound label value	DSC\$K_DTYPE_BLV
Bound procedure value ¹	DSC\$K_DTYPE_BPV
Byte (unsigned)	DSC\$K_DTYPE_BU
COBOL intermediate temporary	DSC\$K_DTYPE_CIT
D_floating	DSC\$K_DTYPE_D
D_floating complex	DSC\$K_DTYPE_DC
Descriptor	DSC\$K_DTYPE_DSC
F_floating	DSC\$K_DTYPE_F
F_floating complex	DSC\$K_DTYPE_FC
G_floating	DSC\$K_DTYPE_G
G_floating complex	DSC\$K_DTYPE_GC
H_floating ¹	DSC\$K_DTYPE_H
H_floating complex ¹	DSC\$K_DTYPE_HC
S_floating (32-bit IEEE) ²	DSC\$K_DTYPE_FS

¹VAX specific.

²Alpha specific.

(continued on next page)

Call Format to OpenVMS Routines

17.4 Arguments Heading

Table 17–3 (Cont.) Standard Data Types and Their Descriptor Field Symbols

Data Type	Symbolic Code
T_floating (64-bit IEEE) ²	DSC\$K_DTYPE_FT
X_floating (128-bit IEEE) ²	DSC\$K_DTYPE_FX
S_floating complex ²	DSC\$K_DTYPE_FSC
T_floating complex ²	DSC\$K_DTYPE_FTC
X_floating complex ²	DSC\$K_DTYPE_FXC
Longword integer (signed)	DSC\$K_DTYPE_L
Longword (unsigned)	DSC\$K_DTYPE_LU
Numeric string, left separate sign	DSC\$K_DTYPE_NL
Numeric string, left overpunched sign	DSC\$K_DTYPE_NLO
Numeric string, right separate sign	DSC\$K_DTYPE_NR
Numeric string, right overpunched sign	DSC\$K_DTYPE_NRO
Numeric string, unsigned	DSC\$K_DTYPE_NU
Numeric string, zoned sign	DSC\$K_DTYPE_NZ
Octaword integer (signed)	DSC\$K_DTYPE_O
Octaword (unsigned)	DSC\$K_DTYPE_OU
Packed decimal string	DSC\$K_DTYPE_P
Quadword integer (signed)	DSC\$K_DTYPE_Q
Quadword (unsigned)	DSC\$K_DTYPE_QU
Character string	DSC\$K_DTYPE_T
Aligned bit string	DSC\$K_DTYPE_V
Varying character string	DSC\$K_DTYPE_VT
Unaligned bit string	DSC\$K_DTYPE_VU
Word integer (signed)	DSC\$K_DTYPE_W
Word (unsigned)	DSC\$K_DTYPE_WU
Unspecified	DSC\$K_DTYPE_Z
Procedure entry mask ¹	DSC\$K_DTYPE_ZEM
Sequence of instruction ¹	DSC\$K_DTYPE_ZI

¹VAX specific.

²Alpha specific.

17.4.3 Access Entry

The access entry describes the way in which the called routine accesses the data specified by the argument, or **access method**. The following methods of access are most common:

- **Read only.** Data upon which a routine operates, or data needed by the routine to perform its operation, must be **read** by the called routine. Such data is also called **input** data. When an argument specifies input data, the access entry is read only.

The term **only** is present to indicate that the called routine does not both read and write (that is, **modify**) the input data. Thus, input data supplied by a variable is preserved when the called routine completes execution.

- Write only. Data that the called routine returns to the calling program must be **written** into a location where the calling program can access it. Such data is also called **output** data. When an argument specifies output data, the access entry is write only.

In this context, the term *only* is present to indicate that the called routine does not read the contents of the location either before or after it writes into the location.

- Modify. When an argument specifies data that is both read and written by the called routine, the access entry is modify. In this case, the called routine reads the input data, which it uses in its operation, and then overwrites the input data with the results (the output data) of the operation. Thus, when the called routine completes execution, the input data specified by the argument is lost.

Following is a complete list of access methods that can appear under the access entry in an argument description:

- Read only
- Write only
- Modify
- Function call (before return)
- JMP after unwind
- Call after stack unwind
- Call without stack unwind

For more information, see the *OpenVMS Calling Standard*.

17.4.4 Mechanism Entry

The way in which an argument specifies the actual data to be used by the called routine is defined in terms of the argument **passing mechanism**. There are three basic passing mechanism types:

- By value. When the argument in the argument list contains the actual data to be used by the routine, the actual data is said to be passed to the routine by value. In this case, the argument is the actual data.
- By reference. When the argument in the argument list contains the address of the data to be used by the routine, the data is said to be passed by reference. In this case, the argument is a pointer to the data.
- By descriptor. When the argument in the argument list contains the address of a descriptor, the data is said to be passed by descriptor. A descriptor consists of two or more longwords (depending on the type of descriptor used) that describe the location, length, and the OpenVMS standard data type of the data to be used by the called routine. In this case, the argument is a pointer to a descriptor that points to the actual data.

There are several kinds of descriptors. Each one contains a value, or **class**, in the fourth byte of the first longword. The class identifies the type of descriptor it is. Each class has a symbolic code.

Call Format to OpenVMS Routines

17.4 Arguments Heading

Table 17–4 lists the types of descriptors and their corresponding code names. See the *OpenVMS Calling Standard* for a detailed description of each descriptor class.

Table 17–4 Descriptor Classes of Passing Mechanisms

Passing Mechanism	Descriptor Symbolic Code
By descriptor, fixed-length (scalar)	DSC\$K_CLASS_S
By descriptor, dynamic string	DSC\$K_CLASS_D
By descriptor, array	DSC\$K_CLASS_A
By descriptor, procedure	DSC\$K_CLASS_P
By descriptor, decimal string	DSC\$K_CLASS_SD
By descriptor, noncontiguous array	DSC\$K_CLASS_NCA
By descriptor, varying string	DSC\$K_CLASS_VS
By descriptor, varying string array	DSC\$K_CLASS_VSA
By descriptor, unaligned bit string	DSC\$K_CLASS_UBS
By descriptor, unaligned bit array	DSC\$K_CLASS_UBA
By descriptor, string with bounds	DSC\$K_CLASS_SB
By descriptor, unaligned bit string with bounds	DSC\$K_CLASS_UBSB

17.4.5 Explanatory Text

For each argument, one or more paragraphs of explanatory text follow the OpenVMS usage, type, access, and mechanism entries. The first paragraph is highly structured and always contains information in the following sequence:

1. A sentence or a sentence fragment that describes (1) the nature of the data specified by the argument, and (2) the way in which the routine uses this data. For example, if an argument were supplying a number, which the routine converts to another data type, the argument description would contain the following sentence fragment:

Integer to be converted to an F_floating point number

2. A sentence that expresses the relationship between the argument and the data that it specifies. This relationship is the passing mechanism used to pass the data and, for a given argument, is expressed in one of the following ways:
 - a. If the passing mechanism is by value, the sentence should read as follows:

The **attrib** argument is a longword that contains (or is) the bit mask specifying the attributes.
 - b. If the passing mechanism is by reference, the sentence should read as follows:

The **objtyp** argument is the address of a longword containing a value indicating whether the object is a file or a device.
 - c. If the passing mechanism is by descriptor, the sentence should read as follows:

The **devnam** argument is the address of a string descriptor of a logical name denoting a device name.

3. Additional explanatory paragraphs that appear for each argument, as needed. For example, some arguments specify complex data consisting of many discrete fields, each of which has a particular purpose and use. In such cases, additional paragraphs provide detailed descriptions of each such field, symbolic names for the fields, if any, and guidance on their use.

17.5 Condition Values Returned Heading

A condition value is a longword that has the following uses on the OpenVMS VAX and OpenVMS Alpha systems:

- Indicates the success or failure of a called procedure
- Describes an exception condition when an exception is signaled
- Identifies system messages
- Reports program success or failure to the command level

The *OpenVMS Calling Standard* explains in detail the uses for the condition value and depicts its format and contents.

The Condition Values Returned heading describes the condition values that are returned by the routine when it completes execution without generating an exception condition. These condition values describe the completion status of the operation.

If a called routine generates an exception condition during execution, the exception condition is **signaled**; the exception condition is then **handled** by a condition handler (either user supplied or system supplied). Depending on the nature of the exception condition and on the condition handler, the called routine either continues normal execution or terminates abnormally.

If a called routine executes without generating an exception condition, the called routine returns a condition value in one or two of the following ways:

- Condition Values Returned
- Condition Values Returned in an I/O Status Block
- Condition Values Returned in a Mailbox
- Condition Values Signaled

The method used to return the condition value is indicated under the Condition Values Returned heading in the documentation of each routine. These methods are discussed individually in the following subsections.

Under these headings, a two-column list shows the symbolic code for each condition value the routine can return and an accompanying description. The description explains whether the condition value indicates success or failure and, if failure, what user action might have caused the failure and what to do to correct it. Condition values that indicate success are listed first.

Symbolic codes for condition values are defined by the system. Though the condition value consists of several fields, each of which can be interpreted individually for specific information, the entire condition value itself can be interpreted as an integer, and this integer has an equivalent symbolic code.

The three sections that follow discuss the ways in which the called routine returns condition values.

Call Format to OpenVMS Routines

17.5 Condition Values Returned Heading

17.5.1 Condition Values Returned

The possible condition values that the called routine can return in general register R0 are listed under the Condition Values Returned heading in the documentation. Most routines return a condition value in this way.

In the documentation of system services that complete asynchronously, both the Condition Values Returned and Condition Values Returned in the I/O Status Block headings are used. Under the Condition Values Returned heading, the condition values returned by the asynchronous service refer to the success or failure of the system service request—that is, to the status associated with the correctness of the syntax of the call, in contrast to the final status associated with the completion of the service operation. For asynchronous system services, condition values describing the success or failure of the actual service operation—that is, the final completion status—are listed under the Condition Values Returned in the I/O Status Block heading.

17.5.2 Condition Values Returned in an I/O Status Block

The possible condition values that the called routine can return in an I/O status block are listed under the Condition Values Returned in the I/O Status Block heading.

The routines that return condition values in the I/O status block are the system services that are completed asynchronously. Each of these asynchronous system services returns to the caller as soon as the service call is queued. This allows the continued use of the calling program during the execution of the service operations. System services that are completed asynchronously all have arguments that specify an I/O status block. When the system service operation is completed, a condition value specifying the completion status of the operation is written in the first word of this I/O status block.

Representing a condition value in a word-length field is possible for system services because the high-order segment of all system service condition values is 0. See **cond_value** in Table B-1 or Section 18.11 for the field detail of the condition value structure.

17.5.3 Condition Values Returned in a Mailbox

The possible condition values that the called routine can return in a mailbox are listed under the Condition Values Returned in a Mailbox heading.

Routines such as SYSSNDOPR that return condition values in a mailbox send information to another process to perform a task. The receiving process performs the action and returns the status of the task to the mailbox of the sending process.

17.5.4 Condition Values Signaled

The possible condition values that the called routine can signal (instead of returning them in R0) are listed under the Condition Values Signaled heading.

Routines that signal condition values as a way of indicating the completion status do so because these routines are returning actual data as the value of the routine.

As mentioned, the signaling of condition values occurs whenever a routine generates an exception condition, regardless of how the routine returns its completion status under normal circumstances.

Basic Calling Standard Conventions

The *OpenVMS Calling Standard* defines the concepts and conventions used by common languages to invoke routines and pass data between them. This chapter briefly describes the following calling standard conventions:

- Register usage
- Stack usage
- Argument list
- Argument passing
- Returns

Refer to the *OpenVMS Calling Standard* for more detail on calling conventions and for standards defining argument data types, descriptor formats, and procedures for condition handling and stack unwinding.

18.1 Hardware Registers

Registers in the hardware provide the necessary temporary storage for computation within OpenVMS software procedures. The number of registers available and their usage vary between the Alpha and VAX systems.

18.1.1 Register Usage for OpenVMS VAX

The calling standard defines several VAX registers and their use, as listed in Table 18–1.

Table 18–1 VAX Register Usage

Register	Use
PC	Program counter
SP	Stack pointer
FP	Current stack frame pointer
AP	Argument pointer
R1	Environment value (when necessary)
R0, R1	Function return value registers

By definition, any called routine can use registers R2 through R11 for computation and the AP register as a temporary register.

Basic Calling Standard Conventions

18.1 Hardware Registers

18.1.2 Register Usage for OpenVMS Alpha

On Alpha systems, there are two groups of 64-bit wide, general-purpose Alpha hardware registers:

- Integer
- Floating point

The first 32 general-purpose registers support integer processing; the second 32 support floating-point operations.

18.1.2.1 Integer Registers

The calling standard defines the Alpha general-purpose integer registers and their use, as listed in Table 18–2.

Table 18–2 Alpha Integer Registers

Register	Usage
R0	Function value register. A standard call that returns a nonfloating-point function must return the function result in this register. The register can be modified by the called procedure without being saved and restored.
R1	Conventional scratch register. In a standard call, this register can be modified by the called procedure without being saved and restored.
R2–15	Conventional saved registers. If a standard-conforming procedure modifies one of these registers, the procedure must save and restore it.
R16–21	Argument registers. Up to six nonfloating-point items of the argument list are passed in these registers and the registers can be modified by the called procedure without being saved and restored.
R22–24	Conventional scratch registers. The registers can be modified by the called procedure without being saved and restored.
R25	Argument information (AI) register. The register describes the argument list (see Section 18.4 for a detailed description) and can be modified by the called procedure without being saved and restored.
R26	Return address (RA) register. The return address must be passed in this register and can be modified by the called procedure without being saved and restored.
R27	Procedure value (PV) register. The procedure value of the procedure being called is passed in this register and can be modified by the called procedure without being saved and restored.
R28	Volatile scratch register. The contents of this register are always <i>unpredictable</i> after any external transfer of control either to or from a procedure.
R29	Frame pointer (FP). This register defines which procedure is the current procedure.
R30	Stack pointer (SP). This register contains a pointer to the top (start) of the current operating stack.
R31	ReadAsZero/Sink (RZ). Hardware defined: binary zero as a source operand, sink (no effect) as a result operand.

18.1.2.2 Floating-Point Registers

The calling standard defines the Alpha floating-point registers and their use, as listed in Table 18–3.

Table 18–3 Alpha Floating-Point Registers

Register	Usage
F0	Floating-point function value register. In a standard call that returns a floating-point result in a register, this register is used to return the real part of the result. The register can be modified by the called procedure without being saved and restored.
F1	Floating-point function value register. In a standard call that returns a complex floating-point result in registers, this register is used to return the imaginary part of the result. This register can be modified by the called procedure without being saved and restored.
F2–9	Conventional saved registers. If a standard-conforming procedure modifies one of these registers, the procedure must save and restore it.
F10–15	Conventional scratch registers. The registers can be modified by the called procedure without being saved and restored.
F16–21	Argument registers. Up to six floating-point arguments can be passed by value in these registers. These registers can be modified by the called procedure without being saved and restored.
F22–30	Conventional scratch registers. The registers can be modified by the called procedure without being saved and restored.
F31	ReadAsZero/Sink. Hardware defined: binary zero as a source operand, sink (no effect) as a result operand.

18.2 Stack Usage for Procedures

A **stack** is a last-in/first-out (LIFO) temporary storage area that the system allocates for every user process. The system keeps information about each routine call in the current image on the call stack. Then, each time you call a routine, the system creates a structure on the stack, defined as the **stack frame**.

Stack frames and call frames are synonymous. A call frame for each procedure has a specified format containing pointers and control information necessary in the transfer of control between procedures of a call chain. Stack frames (call frames) of standard calling procedures differ between Alpha and VAX systems.

18.2.1 Stack Procedure Usage for VAX

Figure 18–1 shows the format of the stack frame created for the called procedure by the CALLG or CALLS instruction. The stack frame (pointed to by SP) is in the context of the current procedure, and call frames (pointed to by FP) are the preserved stack frames of other active procedures in the call chain. The stack frame (call frame) for each procedure in the chain contains the following:

- A pointer to the call frame of the previous procedure call, defined as the frame pointer (FP).

Note that FP points at the condition handler longword at the beginning of the previous call frame. Unless the procedure has a condition handler, this longword contains all zeros. See the *OpenVMS Calling Standard* for more information on condition handlers.

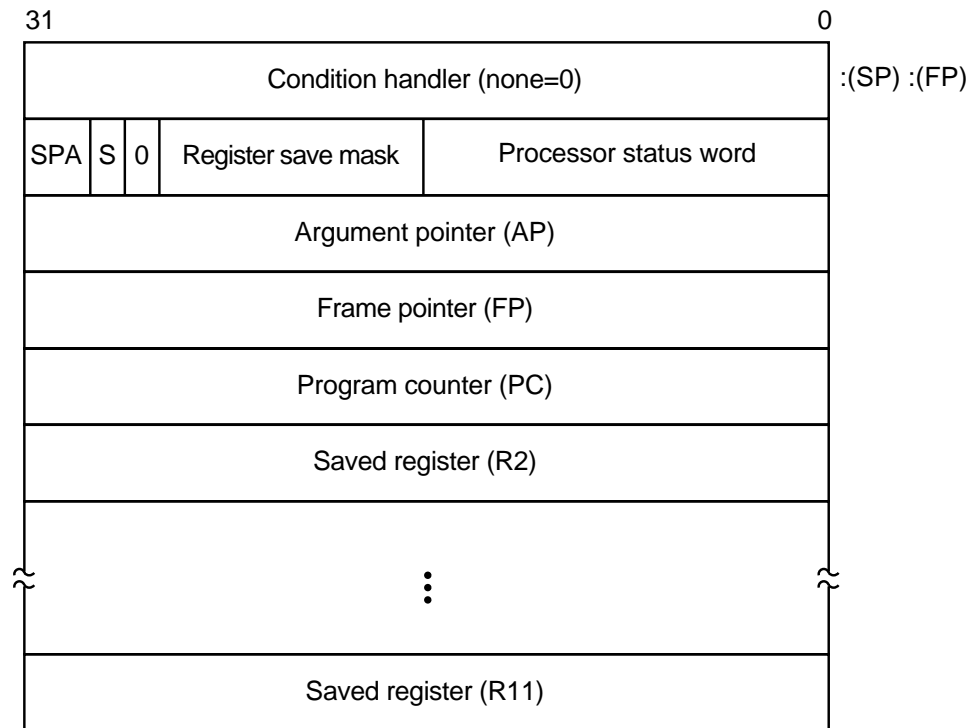
- The argument pointer (AP) of the previous routine call.

Basic Calling Standard Conventions

18.2 Stack Usage for Procedures

- The stored address (program count) of the point at which the routine was called. Specifically, this address is the program count from the program counter (PC) of the instruction following the call to the current routine.
- The contents of other general registers. Based on a register save mask specified in the control information of the second longword, the system restores the saved contents of the identified registers to the calling routine when control returns to it.

Figure 18–1 Call Frame Generated by CALLG and CALLS Instructions



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The contents of the stack located at addresses following the call frame belong to the calling program; they should not be read or written by the called procedure, except as specified in the argument list. The contents of the stack located at addresses lower than the call frame (at FP) belong to interrupt and exception routines; they are modified continually and unpredictably.

The called procedure allocates local storage by subtracting the required number of bytes from the stack provided on entry. This local storage is freed automatically by the RET instruction.

18.2.1.1 Calling Sequence

At the option of the calling procedure, the called procedure is invoked using the CALLG or CALLS instruction, as follows:

```
CALLG    arglst, procedure
CALLS    argcnt, procedure
```

CALLS pushes the argument count **argcnt** onto the stack as a longword and sets the argument pointer, AP, to the top of the stack. The complete sequence using CALLS follows:

```
push     argn
.
.
push     arg1
CALLS    #n, procedure
```

18.2.1.2 Call Frames on Return

If the called procedure returns control to the calling procedure, control must return to the instruction immediately following the CALLG or CALLS instruction. Skip returns and GOTO returns are allowed only during stack unwind operations.

The called procedure returns control to the calling procedure by executing the return instruction (RET).

Note that when a routine completes execution, the system uses the FP in the call frame of the current procedure to locate the frame of the previous procedure. The system then removes the stack frame of the current procedure from the stack.

18.2.2 Stack Procedure Usage for Alpha

On Alpha systems, when a standard procedure is called, the language compiler creates a stack frame for that procedure. The stack format of a stack frame procedure consists of a fixed part (the size of which is known at compile time) and an optional variable part. There are two basic types of stack frames:

- Fixed size
- Variable size

18.2.2.1 Fixed-Size Stack Frame

Figure 18–2 illustrates the format of the stack frame for a procedure with a fixed amount of stack. The SP register is the stack base pointer for a fixed-size stack. In this case, R29 (FP) typically contains the address of the procedure descriptor for the current procedure.

The optional parts of the stack frame are created only as required by the particular procedure. As shown in Figure 18–2, the field names within brackets are optional fields. The **fixed temporary locations** are optional sections of any stack frame that contain language-specific locations required by the procedure context of some high-level languages.

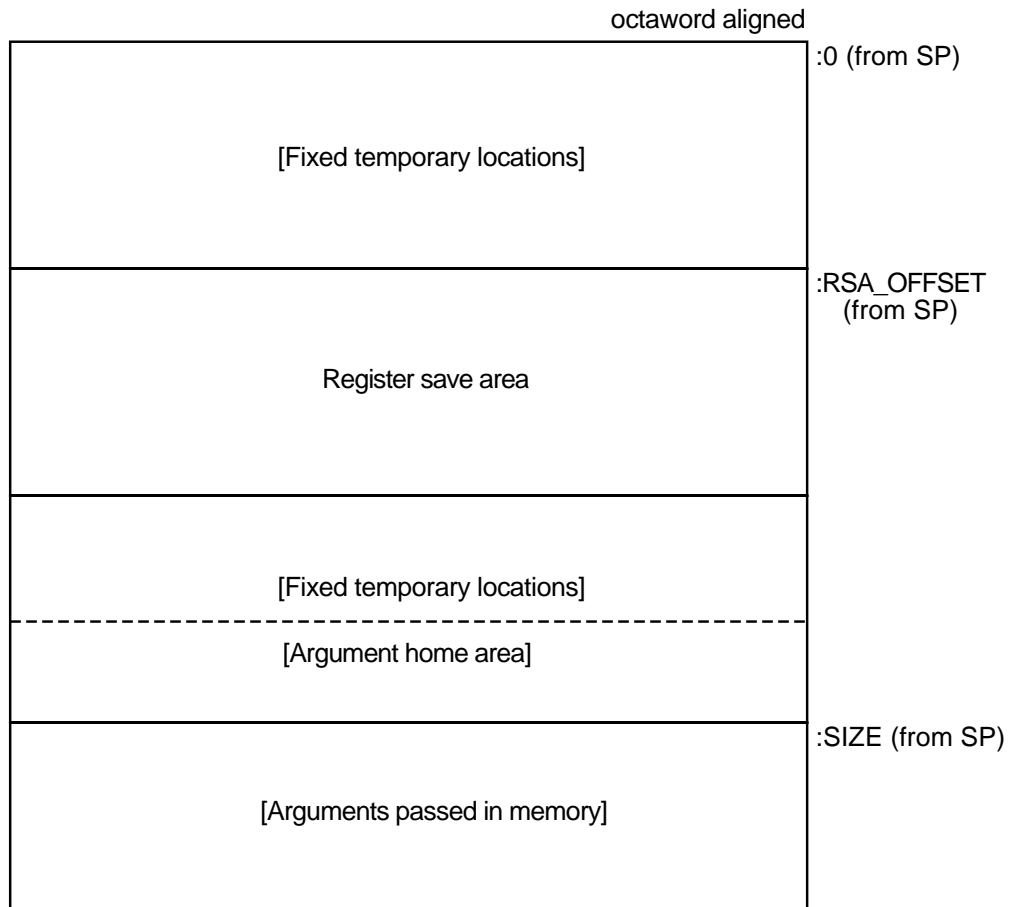
The **register save area** is a set of consecutive quadwords in which registers that are saved and restored by the current procedure are stored. The register save area (RSA) begins at the location pointed to by the RSA offset. The contents of the return address register (R26) are always saved in the first register field (SAVED_RETURN) of the register save area.

Basic Calling Standard Conventions

18.2 Stack Usage for Procedures

Use of the **arguments passed in memory** appending the end of the frame is described in Section 18.4. For more detail concerning the fixed-size stack frame, see the *OpenVMS Calling Standard*.

Figure 18–2 Fixed-Size Stack Frame Format



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18.2.2.2 Variable-Size Stack Frame

Figure 18–3 illustrates the format of the stack frame for procedures with a varying amount of stack when `PDSC$V_BASE_REG_IS_FP` is 1. In this case, R29 (FP) contains the address that points to the base of the stack frame on the stack. This frame-base quadword location contains the address of the current procedure's descriptor.

The optional parts of the stack frame are created as required by the particular procedure. As shown in Figure 18–3, field names within brackets are optional fields. The **fixed temporary locations** are optional sections of any stack frame that contain language-specific locations required by the procedure context of some high-level languages.

A compiler can use the **stack temporary area** pointed to by the SP base register for fixed local variables, such as constant-sized data items and program state, as well as for dynamically sized local variables. The stack temporary area may also be used for dynamically sized items with a limited lifetime, for example, a dynamically sized function result or string concatenation that cannot be directly

Basic Calling Standard Conventions

18.2 Stack Usage for Procedures

stored in a target variable. When a procedure uses this area, the compiler must keep track of its base and reset SP to the base to reclaim storage used by temporaries.

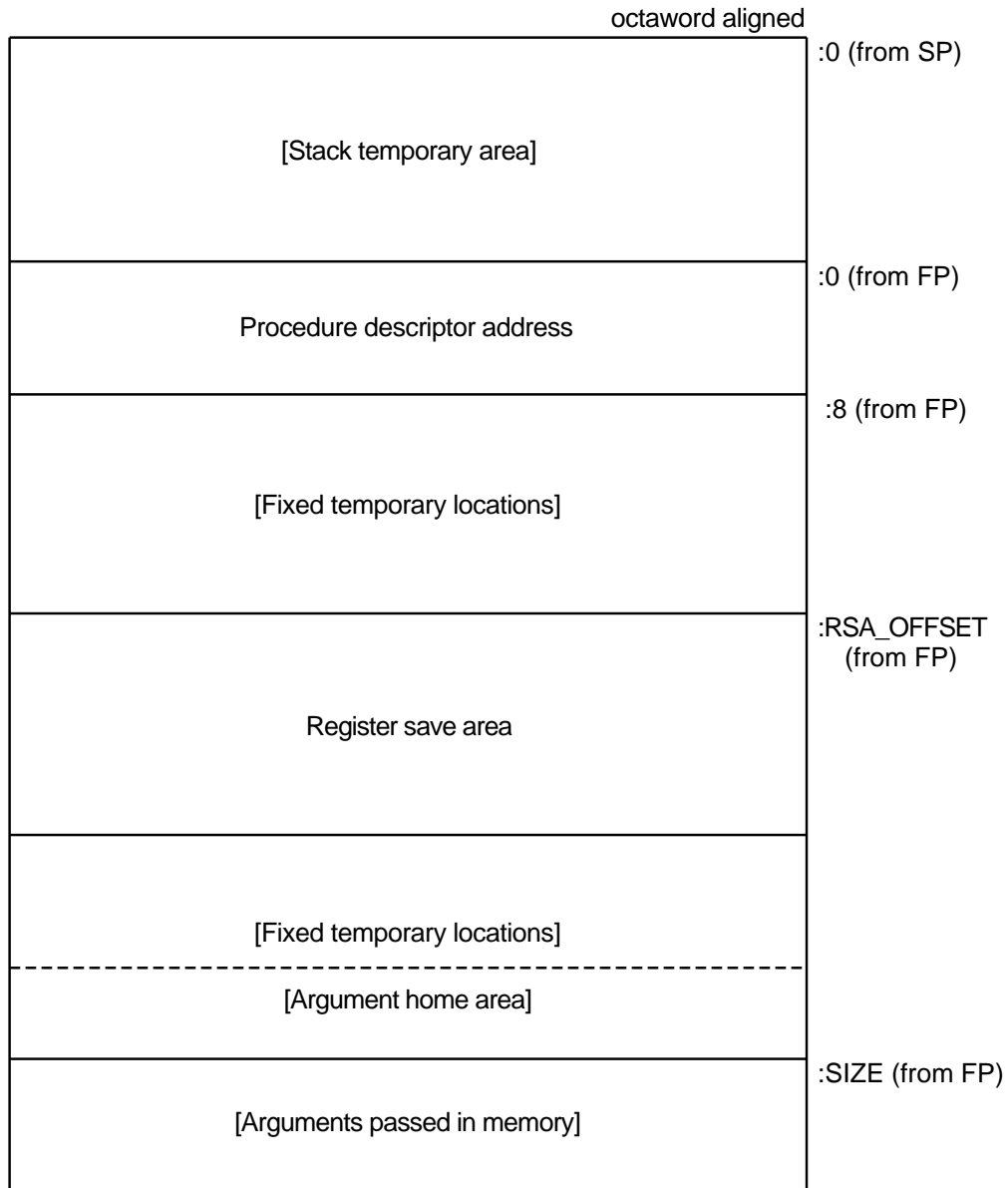
The **register save area** is a set of consecutive quadwords in which registers saved and restored by the current procedure are stored. The register save area (RSA) begins at the location pointed to by the offset PDSC\$W_RSA_OFFSET. The contents of the return address register (R26) is always saved in the first register field (SAVED_RETURN) of the register save area.

Use of the **arguments passed in memory** appending the end of the frame is described in Section 18.4. For more detail concerning the variable-size stack frame, see the *OpenVMS Calling Standard*.

Basic Calling Standard Conventions

18.2 Stack Usage for Procedures

Figure 18–3 Variable-Size Stack Frame Format



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18.3 Procedure Representation

A **procedure value** is an address value that represents a procedure.

On Alpha systems, the procedure value in R27 is the address of the procedure descriptor that describes that procedure. So any OpenVMS Alpha procedure can be invoked by calling the stored address at offset 8 from the procedure descriptor (PDSC) starting address (procedure value).

On VAX systems, the procedure value is the address of the procedure entry mask that begins the actual code sequence of the procedure.

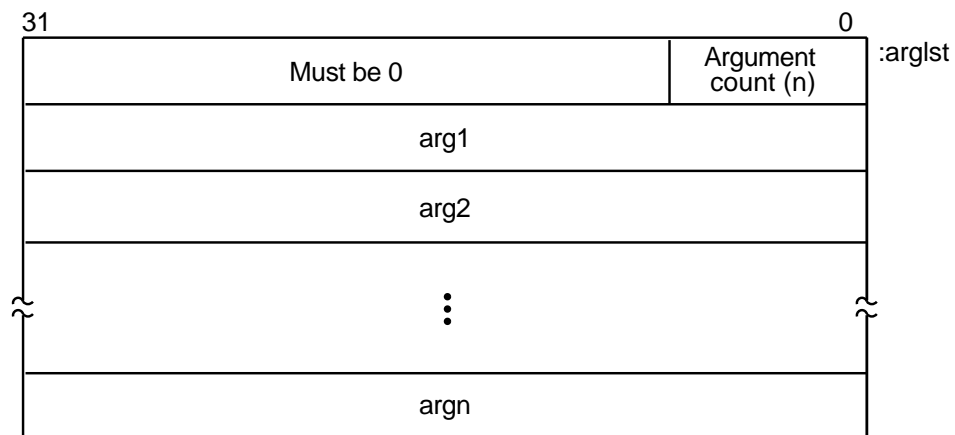
18.4 Argument List

The calling standard defines a data structure called the **argument list**. An argument list is a sequence of locations in memory that represents a routine parameter list and possibly includes a function value. You use an argument list to pass information to a routine and receive results.

On VAX systems, the first longword in an argument list (see Figure 18–4) stores the number of arguments (the argument count, *n*) as an unsigned integer value. The maximum argument count is 255. The remaining 24 bits of the first longword are reserved for use by Compaq and must be 0.

Both integer and floating-point values can be an argument passed in the argument list. Note that a 64-bit floating-point argument counts as 2 longword arguments in the list.

Figure 18–4 Structure of a VAX Argument List



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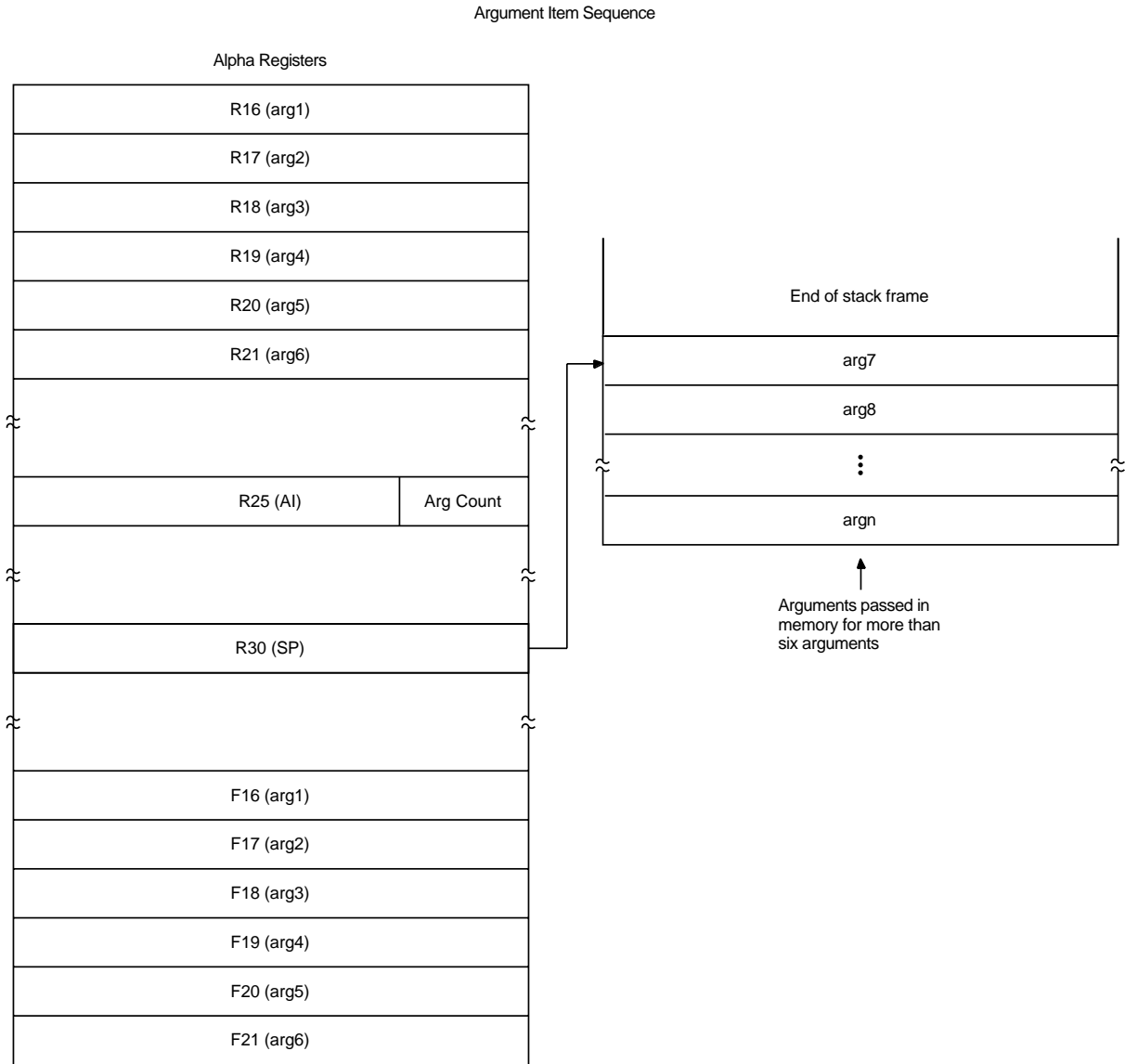
On Alpha systems, arguments are quadwords, and the calling program passes arguments in an **argument item sequence**. Each quadword in the sequence specifies a single argument. The argument item sequence is formed using R16–21 or F16–21 (a register for each argument). The argument item sequence can have a mix of integer and floating-point items that use both register types but must not repeat the same number. For example, an argument list might use R16, R17, F18, and R19. If there are more than six arguments, the argument items overflow to the end of the stack, as shown in Figure 18–5.

The calling procedure must pass to the called procedure information about the argument list. For high-level languages, this is performed by the language processor. In the argument information (AI) register (R25), the quadword format is the structure shown in Figure 18–6. The AI register contains the argument count in the first byte. Table 18–4 describes the argument information fields in detail.

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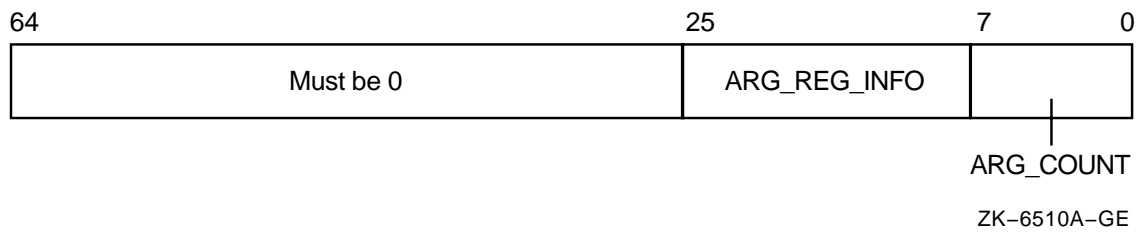
18.4 Argument List

Figure 18–5 Alpha Argument List Format



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Figure 18–6 Argument Information (AI) Register (R25) Format



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Table 18–4 Contents of the Argument Information (AI) Register (Alpha only)

Field Name	Contents																								
AISB_ARG_COUNT	Unsigned byte <7:0> that specifies the number of 64-bit argument items in the argument list (known as the argument count).																								
AISV_ARG_REG_INFO	An 18-bit vector field <25:8> divided into 6 groups of 3 bits that correspond to the 6 arguments passed in registers. These groups describe how each of the first six arguments are passed in registers with the first group <10:8> describing the first argument. The encoding for each group for the argument register usage follows:																								
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Value</th> <th style="text-align: left;">Name</th> <th style="text-align: left;">Meaning</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>AISK_AR_I64</td> <td>64-bit or 32-bit sign-extended to 64-bit argument passed in an integer register <i>or</i> Argument is not present.</td> </tr> <tr> <td>1</td> <td>AISK_AR_FF</td> <td>VAX F_floating argument passed in a floating register.</td> </tr> <tr> <td>2</td> <td>AISK_AR_FD</td> <td>VAX D_floating argument passed in a floating register.</td> </tr> <tr> <td>3</td> <td>AISK_AR_FG</td> <td>VAX G_floating argument passed in a floating register.</td> </tr> <tr> <td>4</td> <td>AISK_AR_FS</td> <td>IEEE S_floating argument passed in a floating register.</td> </tr> <tr> <td>5</td> <td>AISK_AR_FT</td> <td>IEEE T_floating argument passed in a floating register.</td> </tr> <tr> <td>6, 7</td> <td></td> <td>Reserved.</td> </tr> </tbody> </table>	Value	Name	Meaning	0	AISK_AR_I64	64-bit or 32-bit sign-extended to 64-bit argument passed in an integer register <i>or</i> Argument is not present.	1	AISK_AR_FF	VAX F_floating argument passed in a floating register.	2	AISK_AR_FD	VAX D_floating argument passed in a floating register.	3	AISK_AR_FG	VAX G_floating argument passed in a floating register.	4	AISK_AR_FS	IEEE S_floating argument passed in a floating register.	5	AISK_AR_FT	IEEE T_floating argument passed in a floating register.	6, 7		Reserved.
Value	Name	Meaning																							
0	AISK_AR_I64	64-bit or 32-bit sign-extended to 64-bit argument passed in an integer register <i>or</i> Argument is not present.																							
1	AISK_AR_FF	VAX F_floating argument passed in a floating register.																							
2	AISK_AR_FD	VAX D_floating argument passed in a floating register.																							
3	AISK_AR_FG	VAX G_floating argument passed in a floating register.																							
4	AISK_AR_FS	IEEE S_floating argument passed in a floating register.																							
5	AISK_AR_FT	IEEE T_floating argument passed in a floating register.																							
6, 7		Reserved.																							
Bits <63:26>	Reserved and must be 0.																								

18.5 Argument Passing Mechanisms

Each high-level language supported by OpenVMS provides a mechanism for passing arguments to a procedure. The specifics of the mechanism and the terminology used, however, vary from one language to another. For specific information, refer to the appropriate high-level language user's guide.

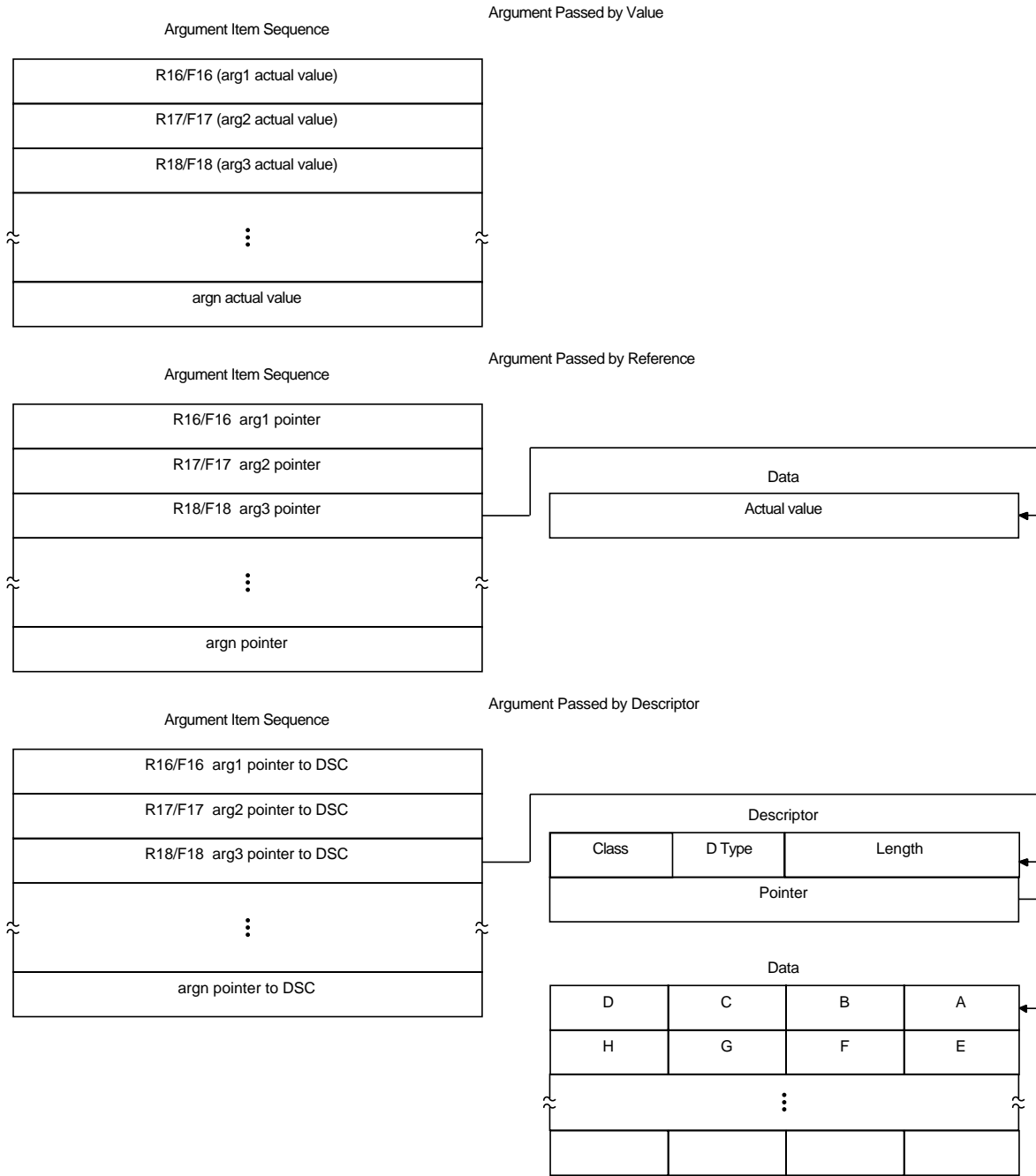
OpenVMS system routines are external procedures that accept arguments. The argument list contains the parameters that are passed to the routine. Depending on the passing mechanisms for these parameters, the forms of the arguments contained in the argument list vary. As shown in Figures 18–7 and 18–8, argument entries labeled **arg1** through **argn** are the actual parameters, which can be any of the following addresses or value:

- An uninterpreted 32-bit value on VAX or 64-bit value on Alpha systems is passed by value.
- An address of a data value is passed by reference.
- An address of a descriptor that contains a pointer to a data value is passed by descriptor (for example, a string might be the data value).

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18.5 Argument Passing Mechanisms

Figure 18–7 Alpha Procedure Argument-Passing Mechanisms



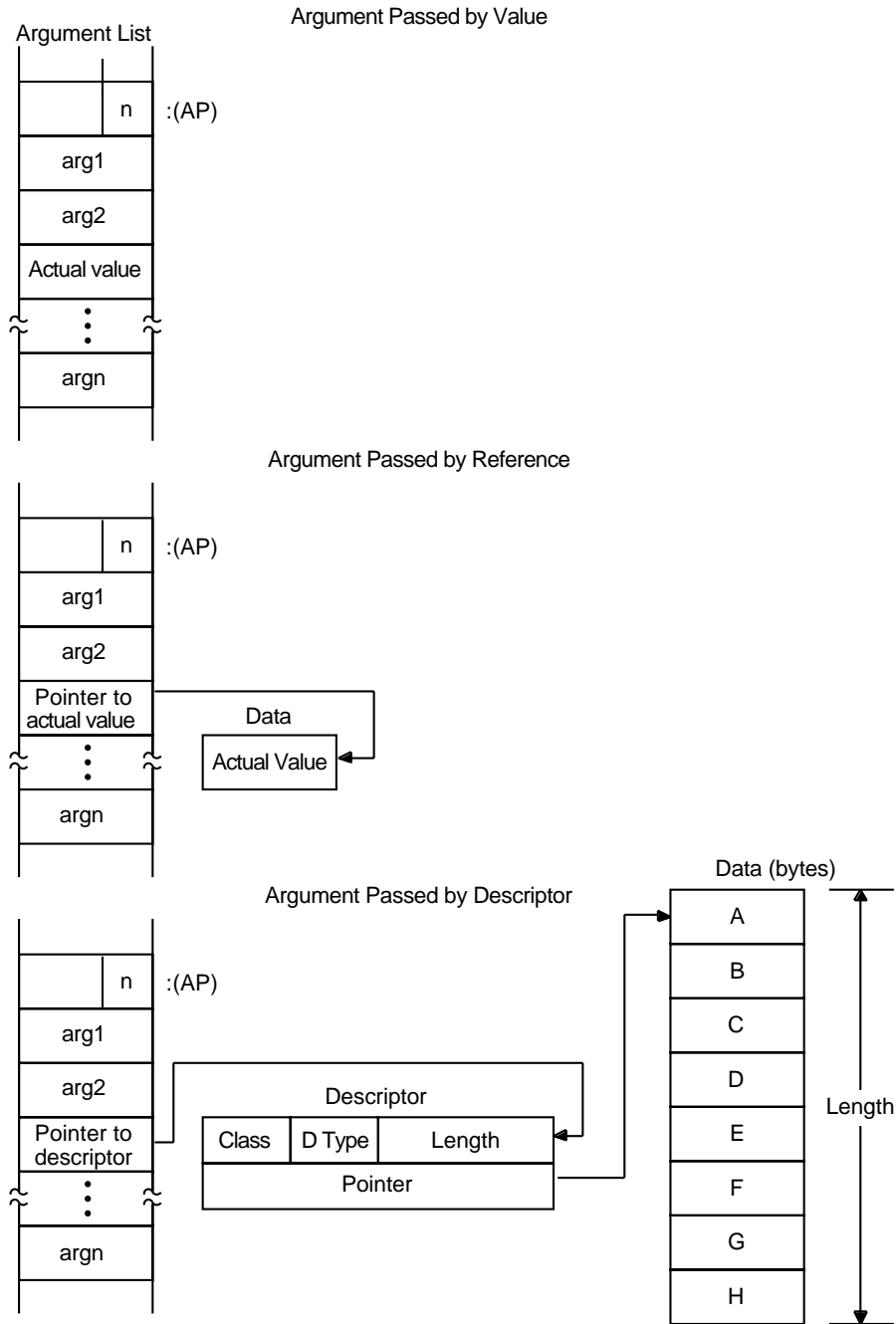
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OpenVMS programming reference manuals provide a description of each OpenVMS system routine that indicates how each argument is to be passed. Phrases such as “an address” and “address of a character string descriptor” identify reference and descriptor arguments, respectively. Terms like “Boolean value,” “number,” “value,” and “mask” indicate an argument that is passed by value.

Basic Calling Standard Conventions

18.5 Argument Passing Mechanisms

Figure 18–8 VAX Procedure Argument-Passing Mechanisms



Note: arg1, arg2, and argn can be passed by value, by reference, or by descriptor in any of these examples.

:(AP) = Argument pointer

n = Number of arguments

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18.5.1 Passing Arguments by Value

When your program passes an argument using the **by value** mechanism, the argument list entry contains either the actual uninterpreted 32-bit VAX value

Basic Calling Standard Conventions

18.5 Argument Passing Mechanisms

or a 64-bit Alpha value (zero- or sign-extended) of the argument. For example, to pass the constant 100 by value, the calling program puts 100 directly in the argument list or sequence. For more information about passing 64-bit Alpha values, refer to Chapter 11.

All high-level languages (except C) require you to specify the by-value mechanism explicitly when you call a procedure that accepts an argument by value. For example, FORTRAN uses the %VAL built-in function, while COBOL uses the BY VALUE qualifier on the CALL [USING] statement.

A FORTRAN program calls a procedure using the by-value mechanism as follows:

```
INCLUDE '($SSDEF)'  
CALL LIB$STOP (%VAL(SS$_INTOVF))
```

A BLISS program calls this procedure as follows:

```
LIB$SIGNAL (SS$_INTOVF)
```

The equivalent VAX MACRO code is as follows:

```
PUSHL    #SS$_INTOVF        ; Push longword by value  
CALLS   #1,G^LIB$SIGNAL    ; Call LIB$SIGNAL
```

A C language program calls a procedure using the by-value mechanism as follows:

```
#include <starlet.h>          /* Declare the function*/  
.  
.  
enum cluster0  
{  
    completion, breakdown, beginning  
} event;  
  
int status;  
event = completion;  
.  
.  
status = sys$setef(event);    /* Set event flag */
```

18.5.2 Passing Arguments by Reference

When your program passes arguments using the **by reference** mechanism, the argument list entry contains the address of the location that contains the value of the argument. For example, if variable *x* is allocated at location 1000, the argument list entry will contain 1000, the address of the value of *x*.

On Alpha processors, the address is sign-extended from 32 bits to 64 bits.

Most languages (but not C) pass scalar data by reference by default. Therefore, if you simply specify *x* in the CALL statement or function invocation, the language automatically passes the value stored at the location allocated to *x* to the OpenVMS system routine.

A VAX BLISS program calls a procedure using the by-reference mechanism as follows:

```
LIB$FLT_UNDER (%REF(1))
```


Basic Calling Standard Conventions

18.5 Argument Passing Mechanisms

The equivalent VAX MACRO code is as follows:

```
ONE:    .LONG    1                ; Longword value 1
        .
        .
        .
        PUSHAL  ONE                ; Push address of longword
        CALLS  #1,G^LIB$FLT_UNDER ; Call LIB$FLT_UNDER
```

A C language program calls a procedure using the by-reference mechanism as follows:

```
/* This program shows how to call system service SYS$READEF. */
#include <ssdef.h>
#include <stdio.h>
#include <starlet.h>      /* Declare the function */
main(void)
{
    /* Longword that receives the status *
     * of the event flag cluster      */
    unsigned cluster_status;
    int return_status;      /* Status: SYS$READEF      */
                                /* Argument values for SYS$READEF */
    enum cluster0
    {
        completion, breakdown, beginning
    } event;
        .
        .
        .
    event = completion;      /* Event flag in cluster 0 */
                                /* Obtain status of cluster 0. *
     * Pass value of event and *
     * address of cluster_status. */
    return_status = SYS$READEF(event, &cluster_status);
                                /* Check for successful call */
    if (return_status != SS$WASCLR && return_status != SS$WASSSET)
    {
        /* Handle the error here.      */
        .
        .
    }
    else
    {
        /* Check bits of interest in cluster_status here. */
        .
        .
    }
}
```

Basic Calling Standard Conventions

18.5 Argument Passing Mechanisms

18.5.3 Passing Arguments by Descriptor

When a procedure specifies that an argument is passed **by descriptor**, the argument list entry must contain the address of a descriptor for the argument. For more information about OpenVMS Alpha 64-bit descriptors, refer to Chapter 11.

On Alpha processors, the address is sign-extended from 32 bits to 64 bits.

This mechanism is used to pass more complicated data. For both Alpha and VAX systems, a descriptor includes at least the following fields:

Symbol	Description
DSC\$W_LENGTH	Length of data (or DSC\$W_MAXSTRLEN, maximum length, for varying strings)
DSC\$B_DTYPE	Data type
DSC\$B_CLASS	Descriptor class code
DSC\$A_POINTER	Address at which the data begins

The *OpenVMS Calling Standard* describes these fields in greater detail.

OpenVMS high-level languages include extensions for passing arguments by descriptor. When you specify by descriptor in these languages, the compiler creates the descriptor, defines its fields, and passes the address of the descriptor to the OpenVMS system routine. In some languages, by descriptor is the default passing mechanism for certain types of arguments, such as character strings. For example, the default mechanism for passing strings in BASIC is by descriptor.

```
100 COMMON STRING GREETING = 30
200 CALL LIB$PUT_SCREEN(GREETING)
```

The default mechanism for passing strings in COBOL, however, is by reference. Therefore, when passing a string argument to an OpenVMS system routine from a COBOL program, you must specify BY DESCRIPTOR for the string argument in the CALL statement.

```
CALL LIB$PUT_OUTPUT USING BY DESCRIPTOR GREETING
```

In VAX MACRO or BLISS, you must define the descriptor's fields explicitly and push its address onto the stack. Following is the VAX MACRO code that corresponds to the previous examples.

```
MSGDSC: .WORD LEN ; DESCRIPTOR: DSC$W_LENGTH
        .BYTE DSC$K_DTYPE_T ; DSC$B_DTYPE
        .BYTE DSC$K_CLASS_S ; DSC$B_CLASS
        .ADDRESS MSG ; DSC$A_POINTER

MSG: .ASCII/Hello/ ; String itself
LEN = .-MSG ; Define the length of the string

        .ENTRY EX1, ^M<>
        PUSHAQ MSGDSC ; Push address of descriptor
        CALLS #1, G^LIB$PUT_OUTPUT ; Output the string
        RET
        .END EX1
```

Basic Calling Standard Conventions 18.5 Argument Passing Mechanisms

The equivalent BLISS code looks like this:

```
MODULE BLISS1 (MAIN = BLISS1,      ! Example of calling LIB$PUT_OUTPUT
              IDENT = '1-001',
              ADDRESSING_MODE(EXTERNAL = GENERAL)) =
BEGIN
EXTERNAL ROUTINE
  LIB$STOP,          ! Stop execution via signaling
  LIB$PUT_OUTPUT;    ! Put a line to SYS$OUTPUT

FORWARD ROUTINE
  BLISS1 : NOVALUE;

LIBRARY 'SYS$LIBRARY:STARLET.L32';

ROUTINE BLISS1          ! Routine
  : NOVALUE =

  BEGIN

  !+
  ! Allocate the necessary local storage.
  !-
  LOCAL
    STATUS,          ! Return status
    MSG_DESC : BLOCK [8, BYTE]; ! Message descriptor

  BIND
    MSG = UPLIT('HELLO');

  !+
  ! Initialize the string descriptor.
  !-
  MSG_DESC [DSC$B_CLASS] = DSC$K_CLASS_S;
  MSG_DESC [DSC$B_DTYPE] = DSC$K_DTYPE_T;
  MSG_DESC [DSC$W_LENGTH] = 5;
  MSG_DESC [DSC$A_POINTER] = MSG;

  !+
  ! Put out the string. Test the return status.
  ! If it is not a success, then signal the RMS error.
  !-
  STATUS = LIB$PUT_OUTPUT(MSG_DESC);
  IF NOT .STATUS THEN LIB$STOP(.STATUS);
  END;          ! End of routine BLISS1
END            ! End of module BLISS1
ELUDOM
```

A C language program calls a procedure using the by-descriptor mechanism as follows:

```
/* This program shows a call to system service SYS$SETPRN. */
#include <ssdef.h>
#include <stdio.h>
#include <descrip.h> /* Define structures for descriptors */
#include starlet.h   /* Declare the function */

int main(void)
{
  int ret;          /* Define return status of SYS$SETPRN */
  struct dsc$descriptor_s name_desc; /* Name the descriptor */
  char *name = "NEWPROC"; /* Define new process name */
  .
  .
  .
  name_desc.dsc$w_length = strlen(name); /* Length of name without *
                                          * null terminator */
}
```

Basic Calling Standard Conventions

18.5 Argument Passing Mechanisms

```

name_desc.dsc$a_pointer = name; /* Put address of shortened string *
                               * in descriptor                */

name_desc.dsc$b_class = DSC$K_CLASS_S; /* String descriptor class */
name_desc.dsc$b_dtype = DSC$K_DTYPE_T; /* Data type: ASCII string */
.
.
.
ret = sys$setprn(&name_desc);

if (ret != SS$NORMAL) /* Test return status */
    fprintf(stderr, "Failed to set process name\n"),
    exit(ret);
.
.
}

```

18.6 Passing Scalars as Arguments

When you are passing an input scalar value to an OpenVMS system routine, you usually pass it either by reference or by value. You usually pass output scalar arguments by reference to OpenVMS system routines. An output scalar argument is the address of a location where some scalar output of the routine will be stored.

18.7 Passing Arrays as Arguments

Arrays are passed to OpenVMS system routines by reference or by descriptor.

Sometimes the routine knows the length and dimensions of the array to be received, as in the case of the table passed to LIB\$CRC_TABLE. Arrays such as this are normally passed by reference.

In other cases, the routine actually analyzes and operates on the input array. The routine does not necessarily know the length or dimensions of such an input array, so a descriptor is necessary to provide the information the routine needs to describe the array accurately.

18.8 Passing Strings as Arguments

Strings are passed by descriptor to OpenVMS system routines. Table 18–5 lists the string-passing descriptors recognized by a system routine.

Table 18–5 String-Passing Descriptors

Descriptor Function	Descriptor Class Code	Numeric Value
Unspecified	DSC\$K_CLASS_Z	0
Fixed length (string/scalar)	DSC\$K_CLASS_S	1
Dynamic	DSC\$K_CLASS_D	2
Array	DSC\$K_CLASS_A	4
Scaled decimal	DSC\$K_CLASS_SD	9
Noncontiguous array	DSC\$K_CLASS_NCA	10
Varying length	DSC\$K_CLASS_VS	11

An OpenVMS system routine writes strings according to the following types of semantics:

- Fixed length — Characterized by an address and a constant length
- Varying length — Characterized by an address, a current length, and a maximum length
- Dynamic — Characterized by a current address and a current length

18.9 Combinations of Descriptor Class and Data Type

Some combinations of descriptor class and data type are not permitted, either because they are not meaningful or because the calling standard does not recognize them. Possibly, the same function can be performed with more than one combination. This section describes the restrictions on the combinations of descriptor classes and data types. These restrictions help to keep procedure interfaces simple by allowing a procedure to accept a limited set of argument formats without sacrificing functional flexibility.

The tables in Figures 18–9, 18–10, and 18–11 show all possible combinations of descriptor classes and data types. For example, Figure 18–9 shows that your program can pass an argument to an OpenVMS system routine whose descriptor class is DSC\$K_CLASS_A (array descriptor) and whose data type is unsigned byte (DSC\$K_DTYPE_BU). The calling standard does not permit your program to pass an argument whose descriptor class is DSC\$K_CLASS_D (dynamic string) and whose data type is unsigned byte.

A descriptor with data type DSC\$K_DTYPE_DSC (24) points to a descriptor that has class DSC\$K_CLASS_D (2) and data type DSC\$K_DTYPE_T (14). All other class and data type combinations in the target descriptor are reserved for future definition in the standard.

The scale factor for DSC\$K_CLASS_SD is always a decimal data type. It does not vary with the data type of the data described by the descriptor.

For DSC\$K_CLASS_UBS and DSC\$K_CLASS_UBA, the length field specifies the length of the data field in bits. For example, if the data type is unsigned word (DSC\$K_DTYPE_WU), DSC\$W_LENGTH equals 16.

Basic Calling Standard Conventions

18.9 Combinations of Descriptor Class and Data Type

Figure 18–9 Atomic Data Types and Descriptor Classes

Data Type	Value	DSC\$K_CLASS											
		_S = 1	_D = 2	_V = 3	_A = 4	_P = 5	_SD = 9	_NCA = 10	_VS = 11	_VSA = 12	_UBS = 13	_UBA = 14	_BFA = 191
DSC\$K_DTYPE_Z	= 0	Yes	–	–	Yes	–	–	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_BU	= 2	Yes	–	–	Yes	Yes	–	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_WU	= 3	Yes	–	–	Yes	–	–	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_LU	= 4	Yes	–	–	Yes	–	–	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_QU	= 5	Yes	–	–	Yes	–	–	Yes	–	–	–	–	–
DSC\$K_DTYPE_OU	=25	Yes	–	–	Yes	–	–	Yes	–	–	–	–	–
DSC\$K_DTYPE_B	= 6	Yes	–	–	Yes	Yes	Yes	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_W	= 7	Yes	–	–	Yes	Yes	Yes	Yes	–	–	Yes	Yes	Yes
DSC\$K_DTYPE_L	= 8	Yes	–	–	Yes	Yes	Yes	Yes	–	–	Yes	Yes	Yes
DSC\$K_DTYPE_Q	= 9	Yes	–	–	Yes	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_O	=26	Yes	–	–	Yes	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_F	= 10	Yes	–	–	Yes	Yes	Yes	Yes	–	–	Yes	Yes	Yes
DSC\$K_DTYPE_D	= 11	Yes	–	–	Yes	Yes	Yes	Yes	–	–	–	–	Yes
DSC\$K_DTYPE_G	= 27	Yes	–	–	Yes	Yes	Yes	Yes	–	–	–	–	–
† DSC\$K_DTYPE_H	= 28	Yes	–	–	Yes	Yes	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_FC	= 12	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
DSC\$K_DTYPE_DC	= 13	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
DSC\$K_DTYPE_GC	= 29	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
† DSC\$K_DTYPE_HC	= 30	–	–	–	–	–	–	–	–	–	–	–	–
‡ DSC\$K_DTYPE_FS	= 52	Yes	–	–	Yes	Yes	Yes	Yes	–	–	Yes	Yes	Yes
‡ DSC\$K_DTYPE_FT	= 53	Yes	–	–	Yes	Yes	Yes	Yes	–	–	–	–	–
‡ DSC\$K_DTYPE_FSC	= 54	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
‡ DSC\$K_DTYPE_FTC	= 55	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
‡ DSC\$K_DTYPE_FX	= 57	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–
‡ DSC\$K_DTYPE_FXC	= 58	Yes	–	–	Yes	Yes	–	Yes	–	–	–	–	–

Yes	The calling standard allows this combination of class and data type.
–	The calling standard forbids the use of this combination of class and data type. Higher-level languages and their run-time support must conform to this restriction.
†	= VAX specific
‡	= Alpha specific

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18.9 Combinations of Descriptor Class and Data Type

Figure 18–10 String Data Types and Descriptor Classes

Data Type	Value	DSC\$K_CLASS											
		_S = 1	_D = 2	_V = 3	_A = 4	_P = 5	_SD = 9	_NCA = 10	_VS = 11	_VSA = 12	_UBS = 13	_UBA = 14	_BFA = 191
DSC\$K_DTYPE_V	= 1	Yes	–	–	Yes	–	–	Yes	–	–	Yes	Yes	–
DSC\$K_DTYPE_T	= 14	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DSC\$K_DTYPE_NU	= 15	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_NL	= 16	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_NLO	= 17	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_NR	= 18	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_NLR	= 19	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_NZ	= 20	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_P	= 21	Yes	–	–	–	–	Yes	Yes	–	–	–	–	–
DSC\$K_DTYPE_VT	= 37	–	–	–	–	–	–	–	Yes	Yes	–	–	–
DSC\$K_DTYPE_VU	= 34	*	*	*	*	*	*	*	*	*	*	*	*

Yes	The calling standard allows this combination of class and data type.
*	No valid interpretation exists for this combination.
–	The calling standard forbids the use of this combination of class and data type. Higher-level languages and their run-time support must conform to this restriction.

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Figure 18–11 Miscellaneous Data Types and Descriptor Classes

Data Type	Value	DSC\$K_CLASS											
		_S = 1	_D = 2	_V = 3	_A = 4	_P = 5	_SD = 9	_NCA = 10	_VS = 11	_VSA = 12	_UBS = 13	_UBA = 14	_BFA = 191
DSC\$K_DTYPE_ZI	= 22	Yes	–	–	–	–	*	–	–	–	–	–	–
DSC\$K_DTYPE_ZEM	= 23	Yes	–	–	–	–	*	–	–	–	–	–	–
DSC\$K_DTYPE_DSC	= 3	–	–	–	Yes	–	*	Yes	–	–	–	–	–
DSC\$K_DTYPE_BPV	= 32	Yes	–	–	–	–	*	Yes	–	–	–	–	–
DSC\$K_DTYPE_BLV	= 33	Yes	–	–	–	–	*	Yes	–	–	–	–	–

Yes	The calling standard allows this combination of class and data type.
*	No valid interpretation exists for this combination.
–	The calling standard forbids the use of this combination of class and data type. Higher-level languages and their run-time support must conform to this restriction.

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Basic Calling Standard Conventions

18.10 Return of the Function Value

18.10 Return of the Function Value

A function is a routine that returns a single value to the calling routine. The **function value** represents the value of the expression in the return statement. As specified by the calling standard, a function value may be returned as an actual value in R0.

On VAX systems, if the actual function value returned is greater than 32 bits, then both R0 and R1 should be used.

On Alpha systems, if the actual function returned is a floating-point value, the floating-point value is returned either in F0 or in both F0 and F1.

A standard function must return its function value by one of the following mechanisms:

- Immediate value
- Reference
- Descriptor

These mechanisms are the standard return convention because they support the language-independent data types. For information about condition values returned in R0, see Section 18.11.

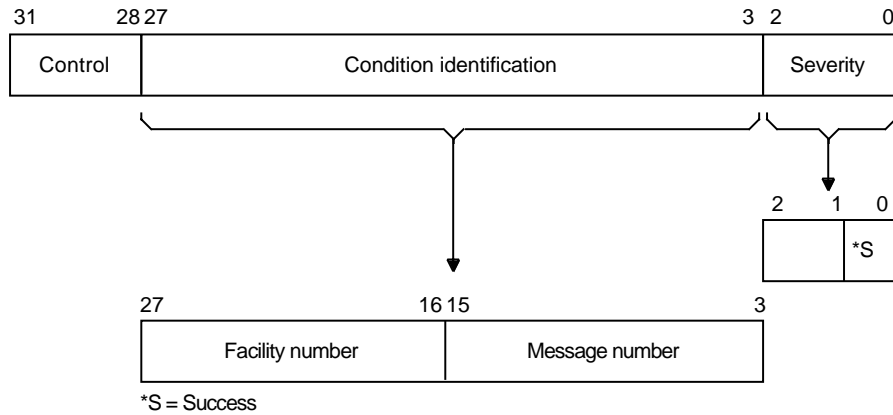
18.11 Return of the Condition Value

An OpenVMS system routine can indicate success or failure to the calling program by returning a condition value. In addition, an error condition to the calling program can return as a condition value in R0 or by error signaling.

A condition value in R0, also called a return status or completion code, is either a success (bit 0 = 1) value or an error condition (bit 0 = 0) value. In an error condition value, the low-order 3 bits specify the severity of the error (see Figure 18–12). Bits <27:16> contain the facility number, and bits <15:3> indicate the particular condition. Bits <31:28> are the control field. When the called procedure returns a condition value, the calling program can test R0 and choose a recovery path. A general guideline to follow when testing for success or failure is that all success codes have odd values and all error codes have even values.

Basic Calling Standard Conventions 18.11 Return of the Condition Value

Figure 18–12 Condition Value Format



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When the completion code is signaled, the calling program must establish a handler to get control and take appropriate action. (See the *OpenVMS Programming Concepts Manual* or the *OpenVMS Calling Standard* for a description of signaling and condition handling and for more information about the condition value.)

Calling Run-Time Library Routines

The OpenVMS Run-Time Library is a set of language-independent routines that establish a common run-time environment for user programs. The procedures ensure correct operation of complex language features and help enforce consistent operations on data across languages.

The *OpenVMS Calling Standard* describes the mechanisms used by OpenVMS languages for invoking routines and passing data between them. In effect, this standard describes the interface between your program and the run-time library routines that your program calls. This chapter describes the basic methods for coding calls to run-time library routines from an OpenVMS common language.

19.1 Overview

When you call a run-time library routine from your program, you must furnish whatever arguments the routine requires. When the routine completes execution, in most cases it returns control to your program. If the routine returns a status code, your program should check the value of the code to determine whether or not the routine completed successfully. If the return status indicates an error, you may want to change the flow of execution of your program to handle the error before returning control to your program.

When you log in, the operating system creates a process that exists until you log out. When you run a program, the system activates an executable image in your process. This image consists of a set of **user procedures**.

From the run-time library's point of view, user procedures are procedures that exist outside the run-time library and that can call run-time library routines. When you write a program that calls a run-time library routine, the run-time library views your program as a user procedure. User procedures also can call other user procedures that are either supplied by Compaq or written by you. Because an OpenVMS native-mode language compiler program exists outside the run-time library, compiler-generated programs that call any run-time library routine are also defined as a set of user procedures.

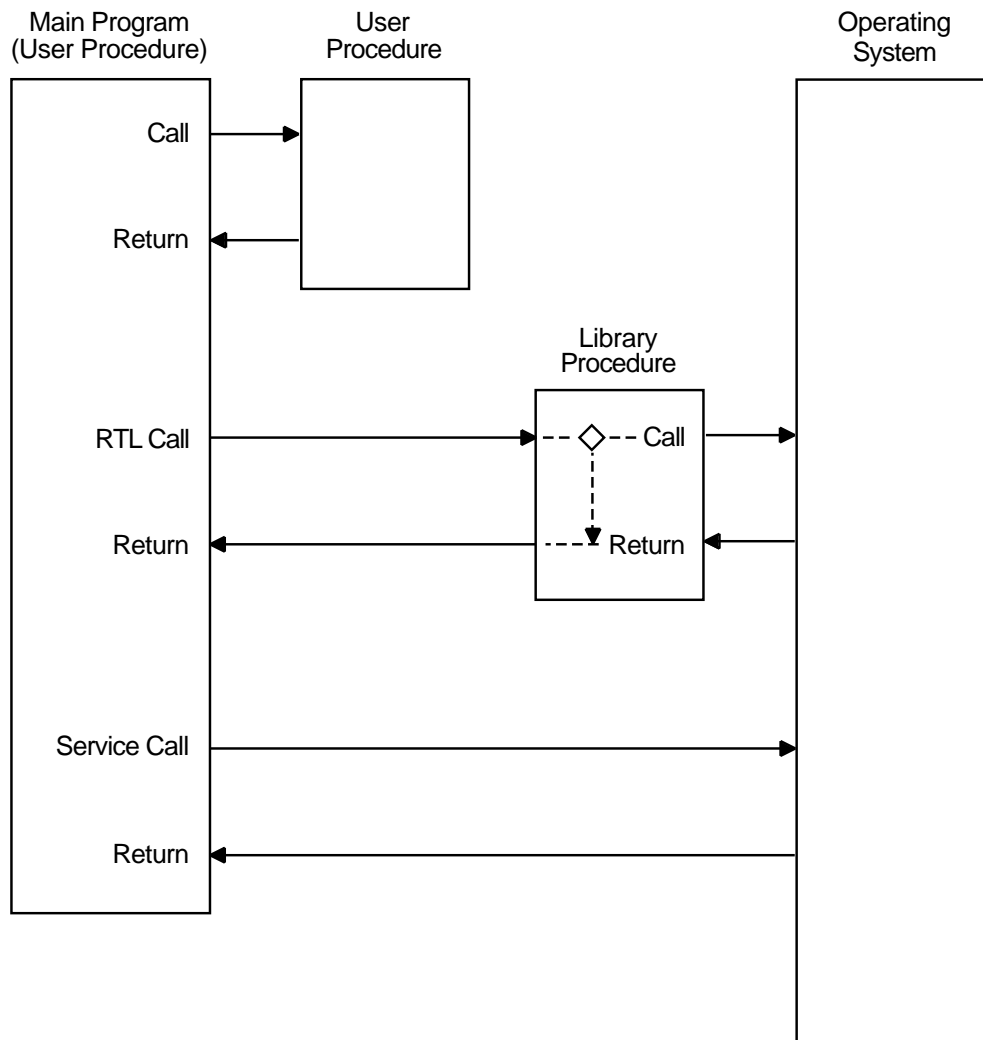
The **main program**, or **main procedure**, is the first user procedure that the system calls after calling a number of initialization procedures. A **user program** consists of the main program and all of the other user procedures that it calls.

Figure 19–1 shows the calling relationships among a main program, other user procedures, library routines, and the operating system. In this figure, Call indicates that the calling procedures requested some information or action; Return indicates that the called procedure returned the information to the calling procedure or performed the action.

Calling Run-Time Library Routines

19.1 Overview

Figure 19–1 Calling the Run-Time Library



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Although library routines can always call either other library routines or the operating system, they can call user procedures only in the following cases:

- When a user procedure establishes its own condition handler. For example, LIB\$SIGNAL operates by searching for and calling user procedures that have been established as condition handlers (see the *OpenVMS RTL Library (LIB\$) Manual* for more information).
- When a user procedure passes to a routine the address of another procedure that the library will call later. For example, when your program calls LIB\$SHOW_TIMER, you can pass the address of an action routine that LIB\$SHOW_TIMER will call to process timing statistics.

19.2 Call Instructions

Each run-time library routine requires a specific calling sequence. This calling sequence indicates the elements that you must include when calling the routine, and the order of those elements. The form of a calling sequence first specifies the type of call being made. A library routine can be invoked either by a CALL instruction or possibly by a JSB instruction (for VAX systems only) as follows:

- CALL — Call procedure from a high-level language
- CALLS — Call procedure with stack argument list instruction (VAX MACRO)
- CALLG — Call procedure with general argument list instruction (VAX MACRO)
- JSB — Jump to subroutine instruction (for VAX systems only)
- JSR — Jump to subroutine instruction (MACRO-64)

On VAX systems, the following restrictions apply to the different types of calls:

- High-level languages do not differentiate between CALLS and CALLG. They use a CALL statement or a function reference to invoke a run-time library routine.
- VAX MACRO does not differentiate between functions and subroutines in its CALLS and CALLG instructions.
- Only VAX MACRO and BLISS programs on VAX systems can explicitly access the JSB entry points that are provided for some routines in the run-time library. You cannot write a program to access the JSB entry points directly from a high-level language.

19.2.1 Facility Prefix and Routine Name

Each routine is identified by a unique entry point name consisting of the facility prefix (for example, MTH\$) and the procedure name (for example, MTH\$\$IN). Run-time library entry points follow the OpenVMS conventions for naming global symbols. A global entry point takes the following general form:

fac\$*symbol*

The elements that make up this format represent the following:

<i>fac</i>	A 2- or 3-character facility name
<i>symbol</i>	A 1- to 27-character symbol

The facility names are maintained in a systemwide Compaq registry. A unique, 12-bit facility number is assigned to each facility name for use in (1) condition value symbols, and (2) condition values in procedure return status codes, signaled conditions, and messages. The high-order bit of this number is 0 for facilities assigned by Compaq and 1 for those assigned by Application Project Services (APS) and customers. For further information, refer to the *OpenVMS Calling Standard*.

The run-time library facility names are as follows:

CVT\$	Convert routines
DTK\$	DECtalk routines
LIB\$	Library routines

Calling Run-Time Library Routines

19.2 Call Instructions

MTH\$	Mathematics routines
OTSS	General-purpose routines
PPL\$	Parallel processing routines
SMG\$	Screen management routines
STR\$	String-handling routines

19.2.2 The RTL Call Entry

Arguments passed to a routine must be listed in your call entry in the order shown in the format section of the routine description. Each argument has four characteristics: OpenVMS usage, data type, access type, and passing mechanism. These characteristics are described in Chapter 17.

Some arguments are optional. Optional arguments are indicated by brackets in the routine descriptions. When your program invokes a run-time library routine using a CALL entry point, you can omit optional arguments at the end of the argument list. If the optional argument is not the last argument in the list, you must either pass a zero by value or use a comma to indicate the place of the omitted argument. Some languages, such as C, require that you pass zero by value for trailing optional arguments. See your language processor documentation for further information.

On VAX systems, the calling program passes an argument list of longwords to a called routine; each longword in the argument list specifies a single argument. Note that a 64-bit floating-point argument would count as 2 longword arguments in the list.

On Alpha systems, the calling program passes arguments in an argument item sequence; each quadword in the sequence specifies a single argument item. Note that the argument item sequence is formed using R16–21 or F16–21 (a register for each argument). The argument item sequence can have a mix of integer and floating-point items that use both register types but must not repeat the same number.

In the Alpha and VAX environments, the called routine interprets each argument using one of three standard passing mechanisms: by value, by reference, or by descriptor. For more information on arguments, see Sections 18.4 and 18.5.

Optional arguments apply only to the CALL entry points. For example, the call format for a procedure with two optional arguments is as follows:

```
LIB$GET_INPUT get-str [,prompt-str] [,out-len]
```

A FORTRAN program could include any one of the following calls to this procedure:

```
INTEGER*4 STAT
.
.
.
STAT = LIB$GET_INPUT (GET_STR,PROMPT,LENGTH)
STAT = LIB$GET_INPUT (GET_STR,PROMPT)
STAT = LIB$GET_INPUT (GET_STR,PROMPT,)
STAT = LIB$GET_INPUT (GET_STR,,LENGTH)
STAT = LIB$GET_INPUT (GET_STR)
STAT = LIB$GET_INPUT (GET_STR,)
```

Calling Run-Time Library Routines 19.2 Call Instructions

```
STAT = LIB$GET_INPUT (GET_STR,%VAL(0))
```

The following examples illustrate the standard mechanism for calling an external procedure, subroutine, or function in most high-level languages.

BASIC

```
CALL LIB$MOVTC(SRC, FILL, TABLE, DEST)
STATUS = LIB$GET_INPUT(STRING, 'NAME:')
```

BLISS

```
LOCAL
MSG_DESC : BLOCK [8,BYTE];

MSG_DESC [DSC$B_CLASS] = DSC$K_CLASS_S;
MSG_DESC [DSC$B_DTYPE] = DSC$K_DTYPE_T;
MSG_DESC [DSC$W_LENGTH] = 5;
MSG_DESC [DSC$A_POINTER] = MSG;

STATUS = LIB$PUT_OUTPUT(MSG_DESC);
```

C

```
#include <lib$routines.h>
#include <descrip.h>

$DESCRIPTOR(name, "Name:");
struct dsc$descriptor_s string:
.
.
.
status = lib$get_input(&string, &name);
```

COBOL

```
CALL LIB$MOVTC USING BY DESCRIPTOR
SRC,
FILL,
TABLE,
DEST,
GIVING RET-STATUS.
```

FORTRAN

```
CALL LIB$MOVTC(SRC, FILL, TABLE, DEST)
STATUS = LIB$GET_INPUT(STRING, 'NAME:')
```

Pascal

```
RET_STATUS := LIB$MOVTC (SRC, FILL, TABLE, DEST);
```

PL/I

```
CALL LIB$MOVTC(SRC, FILL, TABLE, DEST);
STATUS = LIB$GET_INPUT(STRING, 'NAME:');
```

VAX MACRO

In VAX MACRO, a calling sequence takes one of three forms, as illustrated by the following examples:

```
CALLS      #2,G^LIB$GET_INPUT
CALLG      ARGLIST, G^LIB$GET_VM
JSB        G^MTH$SIN_R4
```

As these examples show, high-level languages use different forms of the call statement. Each language's user guide gives specific information about calling the run-time library from that language.

Calling Run-Time Library Routines

19.2 Call Instructions

19.2.2.1 JSB Call Entries (VAX Only)

On VAX systems, JSB entry point names follow the naming conventions explained in Section 19.2.1, except that they include a suffix indicating the number of the highest register accessed or modified. This suffix helps ensure that the calling program and the called routine agree on the number of registers that the called routine is going to change.

The following example illustrates the VAX MACRO code that invokes the library routine MTHSSIN_R4 by means of a JSB instruction. As indicated in the JSB entry point name, this routine uses R0 through R4.

```
JSB G^MTH$SIN_R4 ;F_floating sine uses R0 through R4
```

JSB entry points are available only to VAX MACRO and VAX BLISS programs. No VAX high-level language provides a mechanism for accessing JSB entry points.

19.2.3 Returns from an RTL Routine

On VAX systems, some run-time library routines return a function value. Typically on a VAX system, the return is in the form of a 32-bit value in register R0 or a 64-bit value in registers R0 and R1. In high-level languages, statuses or function return values in R0 appear as the function result. When a routine returns a function value in R0, it cannot also use R1 to return a status code. Therefore, such a procedure signals errors rather than returning a status. For more information, refer to the *OpenVMS Calling Standard* or the description of LIB\$SIGNAL in the *OpenVMS RTL Library (LIB\$) Manual*.

On Alpha systems, a standard function returns its function value in R0, F0, or F0 and F1. A function value of less than 64 bits returned by immediate value in R0 is zero-extended or sign-extended to a full quadword as required by the data type. Note that a floating function value is returned by immediate value in F0 or in F0 and F1.

19.2.3.1 Facility Return Status and Condition Value Symbols

Library return status and condition value symbols have the following general form:

fac\$_abcmnoxyz

The elements that make up this format represent the following:

<i>fac</i>	The 2- or 3-letter facility symbol
<i>abc</i>	The first 3 letters of the first word of the associated message
<i>mno</i>	The first 3 letters of the next word
<i>xyz</i>	The first 3 letters of the third word, if any

Articles and prepositions are not considered significant words in this format. If a significant word is only two letters long, an underscore is used to fill out the third space. Some examples follow. Note that, in most facilities, the normal or success symbol is an exception to the convention described here.

SS\$_NORMAL	Routine successfully completed
LIB\$_INSVIRMEM	Insufficient virtual memory
MTH\$_FLOOVEMAT	Floating overflow in mathematics library procedure
OTSS\$_FATINTERR	Fatal internal error in a language-independent support procedure

LIB\$_SCRBUFOVF

Screen buffer overflow

19.3 Calling a Library Procedure in VAX MACRO (VAX Only)

This section describes how to code MACRO calls to library routines using a CALLS, CALLG, or JSB instruction for VAX systems. The routine descriptions that appear later in this manual describe the entry points for each routine. You can use either a CALLS or a CALLG instruction to invoke a procedure with a CALL entry point. You must use a JSB instruction to invoke a procedure with a JSB entry point. All MACRO calls are explicitly defined.

19.3.1 VAX MACRO Calling Sequence

All run-time library routines have a CALL entry point. Some routines also have a JSB entry point. In MACRO, you invoke a CALL entry point with a CALLS or CALLG instruction. To access a JSB entry point, use a JSB instruction.

Arguments are passed to CALLS and CALLG entry points by a pointer to the argument list. The only difference between the CALLS and CALLG instructions is as follows:

- For CALLS, the calling procedure pushes the argument list onto the stack (in reverse order) before performing the call. The list is automatically removed from the stack upon return.
- For CALLG, the calling program specifies the address of the argument list, which can be anywhere in memory. This list remains in memory upon return.

Both of these instructions have the same effect on the called procedure.

JSB instructions execute faster than CALL instructions. They do not set up a new stack frame, do not change the enabling of hardware traps or faults, and do not preserve the contents of any registers before modifying them. For these reasons, you must be careful when invoking a JSB entry point in order to prevent the loss of information stored by the calling program.

Whichever type of call you use, the actual reference to the procedure entry point should use general-mode addressing (G^{\wedge}). This ensures that the linker and the image activator are able to locate the module within the shareable image.

In most cases, you have to tell a library routine where to find input values and store output values. You must select a data type for each argument when you code your program. Most routines accept and return 32-bit arguments.

For input arguments of byte, word, or longword values, you can supply a constant value, a variable name, or an expression in the run-time library routine call. If you supply a variable name for the argument, the data type of the variable must be as large as or larger than the data types that the called procedure requires. For example, if the called procedure expects a byte in the range 0 to 100, you can use a variable data type of a byte, word, or longword with a value between 0 and 100.

For each output argument, you must declare a variable of exactly the length required to avoid extraneous data. For example, if the called procedure returns a byte value to a word-length variable, the leftmost 8 bits of the variable <15:8> are not overwritten on output. Conversely, if a procedure returns a longword value to a word-length variable, it modifies variables in the next higher word.

Calling Run-Time Library Routines

19.3 Calling a Library Procedure in VAX MACRO (VAX Only)

19.3.2 VAX MACRO CALLS Instruction Example

Before executing a CALLS instruction, you must push the necessary arguments on the stack. Arguments are pushed in reverse order; the last argument listed in the calling sequence is pushed first. The following example shows how a MACRO program calls the procedure that allocates virtual memory in the program region for LIB\$GET_VM.

```
                .PSECT DATA      PIC,USR,CON,REL,GBL,NOSHR,NOEXE,RD,WRT,NOVEC
MEM:            .LONG      0                ; Longword to hold address of
                                                ; allocated memory
LEN:            .LONG      700             ; Number of bytes to allocate

                .PSECT CODE      PIC,USR,CON,REL,GBL,SHR,EXE,RD,NOWRT,NOVEC
                .ENTRY      PROG, ^M<>
                PUSHAL     MEM                ; Push address of longword
                                                ; to receive address of block
                PUSHAL     LEN                ; Push address of longword
                                                ; containing number of bytes
                                                ; desired
                CALLS      #2, G^LIB$GET_VM   ; Allocate memory
                BLBC      R0, 1$             ; Branch if memory not available
                RET
1$:             PUSHL      R0                ; Signal the error
                CALLS      #1, G^LIB$SIGNAL
                RET
                .END          PROG
```

Because the stack grows toward location 0, arguments are pushed onto the stack in reverse order from the order shown in the general format for the routine. Thus, the **base-address** argument, here called START, is pushed first, and then the **number-bytes** argument, called LEN. Upon return from LIB\$GET_VM, the calling program tests the return status (**ret-status**), which is returned in R0 and branches to an appropriate error routine if an error occurred.

19.3.3 VAX MACRO CALLG Instruction Example

When you use the CALLG instruction, the arguments are set up in any location, and the call includes a reference to the argument list. The following example of a CALLG instruction is equivalent to the preceding CALLS example.

```
ARGLST:
                .LONG      2                ; Argument list count
                .ADDRESS    LEN                ; Address of longword containing
                                                ; the number of bytes to allocate.
                .ADDRESS    START              ; Address of longword to receive
                                                ; the starting address of the
                                                ; virtual memory allocated.

LEN:            .LONG      20                ; Number of bytes to allocate
START:         .BLKL      1                ; Starting address of the virtual
                                                ; memory.

                CALLG     ARGLIST, G^LIB$GET_VM ; Get virtual memory
                BLBC     R0, ERROR            ; Check for error
                BRB      10$
```

Calling Run-Time Library Routines

19.3 Calling a Library Procedure in VAX MACRO (VAX Only)

19.3.4 VAX MACRO JSB Entry Points

A procedure's JSB entry point name indicates the highest numbered register that the procedure modifies. Thus, a procedure with a suffix R_n modifies registers R0 through R_n . (You should always assume that R0 and R1 are modified.) The calling program loads the arguments in the registers before the JSB instruction is executed.

A calling program must use a JSB instruction to invoke a run-time library routine by means of its JSB entry point. You pass arguments to a JSB entry point by placing them in registers in the following manner:

```
NUM:   .FLOAT      0.7853981          ; Constant P1/4
        MOVF       NUM, R0            ; Set up input argument
        JSB        G^MTH$SIN_R4      ; Call F_floating sine procedure
                                           ; Return with value in R0
```

In this example, R4 in the entry point name indicates that MTH\$SIN_R4 changes the contents of registers R0 through R4. The routine does not reference or change the contents of registers R5 through R11.

The entry mask of a calling procedure should specify all the registers to be saved if the procedure invokes a JSB routine. This step is necessary because a JSB procedure does not have an entry mask and thus has no way to specify registers to be saved or restored.

For example, consider program A calling procedure B by means of a CALL entry point.

- Procedure B modifies the contents of R2 through R6, so the contents of these registers are preserved at the time of the call.
- Procedure B then invokes procedure C by means of a JSB entry point.
- Procedure C modifies registers R0 through R7.
- When control returns to procedure B, R7 has been modified, but when procedure B passes control back to procedure A, it restores only R2 through R6. Thus, the contents of R7 are unpredictable, and program A does not execute as expected. Procedure B should be rewritten so that R2 through R7 are saved in procedure B's entry mask.

A similar problem occurs if the stack is unwound, because unwinding the stack restores the contents of registers for each stack frame as it removes the previous frame. Because a JSB entry point does not create a stack frame, the contents of the registers before the JSB instruction will not be restored unless they were saved in the entry mask of the calling program. You do this by naming the registers to be saved in the calling program's entry mask, so a stack unwind correctly restores all registers from the stack. In the following example, the function $Y=PROC(A,B)$ returns the value Y, where $Y = SIN(A)*SIN(B)$:

```
.ENTRY PROC, ^M <R2, R3, R4, R5>    ; Save R2:R5
MOVF   @4(AP), R0                    ; R0 = A
JSB    G^MTH$SIN_R4                  ; R0 = SIN(A)
MOVF   R0, R5                         ; Copy result to register
                                           ; not modified by MTH$SIN

MOVF   @8(AP), R0                    ; R0 = B
JSB    G^MTH$SIN_R4                  ; R0 = SIN(B)
MULF   R5, R0                         ; R0 = SIN(A)SIN(B)
RET                                         ; Return
```

Calling Run-Time Library Routines

19.3 Calling a Library Procedure in VAX MACRO (VAX Only)

19.3.5 Return Status

Your VAX MACRO program can test for errors by examining segments of the 32-bit status code returned by a run-time library routine.

To test for errors, check for a zero in bit 0 using a Branch on Low Bit Set (BLBS) or Branch on Low Bit Clear (BLBC) instruction.

To test for a particular condition value, compare the 32 bits of the return status with the appropriate return status symbol using a Compare Long (CMPL) instruction or the run-time library routine LIB\$MATCH_COND.

There are three ways to define a symbol for the condition value returned by a run-time library routine so that you can compare the value in R0 with a particular error code:

- Using the .EXTRN symbol directive. This causes the assembler to generate an external symbol declaration.
- Using the \$facDEF macro call. Calling the \$LIBDEF macro, for example, causes the assembler to define all LIB\$ condition values.
- By default. The assembler automatically declares the condition value as an external symbol that is defined as a global symbol in the run-time library.

The following example asks for the user's name. It then calls the run-time library routine LIB\$GET_INPUT to read the user's response from the terminal. If the string returned is longer than 30 characters (the space allocated to receive the name), LIB\$GET_INPUT returns in R0 the condition value equivalent to the error LIB\$_INPSTRTRU, 'input string truncated.' This value is defined as a global symbol by default. The example then checks for the specific error by comparing LIB\$_INPSTRTRU with the contents of R0. If LIB\$_INPSTRTRU is the error returned, the program considers that the routine executed successfully. If any other error occurs, the program handles it as a true error.

```

        $SSDEF                ; Define SS$ symbols
        $DSCDEF               ; Define DSC$ symbols
        .PSECT   $DATA
PROMPT_D:                ; Descriptor for prompt
        .WORD    PROMPT_LEN   ; Length field
        .BYTE    DSC$K_DTYPE_T ; Type field is text
        .BYTE    DSC$K_CLASS_S ; Class field is string
        .ADDRESS PROMPT       ; Address

PROMPT: .ASCII    /NAME: /    ; String descriptor
PROMPT_LEN = . - PROMPT     ; Calculate length of
                               ; string

STR_LEN = 30                ; Use 30-byte string
STRING_D:                ; Input string descriptor
        .WORD    STR_LEN     ; Length field
        .BYTE    DSC$K_DTYPE_T ; Type field in text
        .BYTE    DSC$K_CLASS_S ; Class field is string
        .ADDRESS STR_AREA    ; Address
STR_AREA: .BLKB   STR_LEN    ; Area to receive string

        .PSECT $CODE
        .ENTRY  START , ^M<>
        PUSHAQ PROMPT_D     ; Push address of prompt
                               ; descriptor
        PUSHAQ STRING_D     ; Push address of string
                               ; descriptor
```

19.3 Calling a Library Procedure in VAX MACRO (VAX Only)

```

CALLS #2 , G^LIB$GET_INPUT      ; Get input string
BLBS  R0 , 10$                  ; Check for success
CMPL  R0 , #LIB$_INPSTRTRU      ; Error: Was it
                                      ; truncated string?
BEQL  10$                        ; No, more serious error
PUSHL R0
CALLS #1 , G^LIB$SIGNAL
10$:  MOVL #SS$_NORMAL , R0      ; Success, or name too
                                      ; long
RET
.END  START

```

19.3.6 Function Return Values in VAX MACRO

Function values are generally returned in R0 (32-bit values) or R0 and R1 (64-bit values). A MACRO program can access a function value by referencing R0 or R0 and R1 directly. For functions that return a string, the address of the string or the address of its descriptor is returned in R0. If a function needs to return a value larger than 64 bits, it must return the value by using an output argument.

Note the following exceptions to these rules:

- JSB entry points in the MTH\$ facility return H_floating values in R0 through R3.
- One routine, MTH\$SINCOS, returns two function values: the sine and the cosine of an angle. Depending on the data type of the function values, the function values are returned in the following registers:

F_floating	R0 and R1
D_floating	R0 through R3
G_floating	R0 through R3
H_floating	R0 through R7

As in the case of output arguments, a variable declared to receive the function values must be the same length as the value.

19.4 Calling a Library Routine in BLISS

This section describes how to code BLISS calls to library routines. A called routine can return only one of the following:

- No value.
- A function value (typically, an integer or floating point number). For example, MTH\$SIN returns its result as an F_floating value in R0 on VAX systems or F0 on Alpha systems.

On Alpha processors, BLISS cannot access floating point registers.

- A return status (typically, a 32-bit condition value) indicating that the routine has either executed successfully or failed. For example, LIB\$GET_INPUT returns a return status in R0. If the routine executes successfully, it returns SSS\$_NORMAL; if not, it returns one of several possible error condition values. BLISS treats the return status like any other value.

Calling Run-Time Library Routines

19.4 Calling a Library Routine in BLISS

19.4.1 BLISS Calling Sequence

Scalar arguments are usually passed to run-time library routines by reference. Thus, when a BLISS program passes a variable, the variable appears with no preceding period in the procedure-call actual argument list. A constant value can be easily passed by using the %REF built-in function.

The following example shows how a BLISS program calls LIB\$PUT_OUTPUT. This routine writes a record at the user's terminal.

```
MODULE SHOWTIME(IDENT='1-1' %TITLE'Print time', MAIN=TIMEOUT)=
BEGIN
LIBRARY 'SYS$LIBRARY:STARLET'; ! Defines system services, etc.

MACRO
    DESC[]=%CHARCOUNT(%REMAINING), ! VAX string descriptor
    UPLIT BYTE(%REMAINING) %; ! definition
BIND
    FMTDESC=UPLIT( DESC('At the tone, the time will be ',
        %CHAR(7), '!%T' ));
EXTERNAL ROUTINE
    LIB$PUT_OUTPUT: ADDRESSING_MODE(GENERAL);
ROUTINE TIMEOUT
    =
    BEGIN
    LOCAL
        TIMEBUF: VECTOR[2], ! 64-bit system time
        MSGBUF: VECTOR[80,BYTE], ! Output message buffer
        MSGDESC: BLOCK[8,BYTE], ! Descriptor for message buffer
        RSLT: WORD; ! Length of result string

    !+
    ! Initialize the fields of the string descriptor.
    !-
        MSGDESC[DSC$B_CLASS]=DSC$K_CLASS_S;
        MSGDESC[DSC$B_DTYPE]=DSC$K_DTYPE_T;
        MSGDESC[DSC$W_LENGTH]=80;
        MSGDESC[DSC$A_POINTER]=MSGBUF[0]

        $GETTIM(TIMADR=TIMEBUF); ! Get time as 64-bit integer

        $FAOL(CTRSTR=FMTDESC, ! Format descriptor
            OUTLEN=RSLT, ! Output length (only a word!)
            OUTBUF=MSGDESC, ! Output buffer desc.
            PRMLST= %REF(TIMEBUF)); ! Address of 64-bit
            ! time block

        MSGDESC [DSC$W_LENGTH] = .RSLT; ! Modify output desc.
        RETURN (LIB$PUT_OUTPUT(MSGDESC); ! Return status
        END;
    END
ELUDOM
```

19.4.2 Accessing a Return Status in BLISS

BLISS accesses a function return value or condition value returned in R0 as follows:

```
STATUS = LIB$PUT_OUTPUT(MSG_DESC);
IF NOT .STATUS THEN LIB$STOP(.STATUS);
```

Calling Run-Time Library Routines

19.4 Calling a Library Routine in BLISS

19.4.3 Calling JSB Entry Points from BLISS

Many of the library mathematics routines have JSB entry points. You can invoke these routines efficiently from a BLISS procedure using LINKAGE and EXTERNAL ROUTINE declarations, as in the following example:

```
MODULE JSB_LINK (MAIN = MATH_JSB,          ! Example of using JSB linkage
                IDENT = '1-001',
                ADDRESSING_MODE(EXTERNAL = GENERAL)) =
BEGIN
LINKAGE
    LINK_MATH_R4 = JSB (REGISTER = 0; ! input reg
                       REGISTER = 0): ! output reg
                       NOPRESERVE (0,1,2,3,4)
                       NOTUSED (5,6,7,8,9,10,11);
EXTERNAL ROUTINE
    MTH$SIND_R4 : LINK_MATH_R4;
FORWARD ROUTINE
    MATH_JSB;
LIBRARY 'SYS$LIBRARY:STARLET.L32';
ROUTINE MATH_JSB =                                ! Routine
    BEGIN
    LOCAL
        INPUT_VALUE : INITIAL (%E'30.0'),
        SIN_VALUE;
    !+
    ! Get the sine of single floating 30 degrees. The input, 30 degrees,
    ! is passed in R0, and the answer, is returned in R0. Registers
    ! 0 to 4 are modified by MTH$SIND_R4.
    !-
        MTH$SIND_R4 (.INPUT_VALUE ; SIN_VALUE);
    RETURN SS$_NORMAL;
    END;                                ! End of routine
END                                     ! End of module JSB_LINK
ELUDOM
```

Calling System Services

The OpenVMS operating system kernel has many services that are made available to application and system programs for use at run time. These system services are procedures that the OpenVMS 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. The *OpenVMS Programming Concepts Manual* defines these functions further.

This chapter describes the basic methods and conventions for coding calls to system services from OpenVMS high-level languages or from an assembly language.

For more information about using the system services that support 64-bit addressing and to see example programs that demonstrate the use of these services, refer to Chapter 11.

20.1 Overview

System services are called by using the conventions of the *OpenVMS Calling Standard*. The programming languages that generate VAX or Alpha native mode instructions provide mechanisms for specifying the procedure calls.

When you call a system service from your program, you must furnish whatever arguments the routine requires. When the system service procedure completes execution, in most cases it returns control to your program. If the service returns a status code, your program should check the value of the code to determine whether or not the service completed successfully. If the return status indicates an error, you may want to change the flow of execution of your program to handle the error before returning control to your program.

When you write a program that calls a system service in the OpenVMS operating system, the operating system views your program as a user procedure. User procedures also can call other user procedures that are either supplied by Compaq or written by you. Because an OpenVMS native-mode language compiler program exists outside the operating system, compiler generated programs calling any system service are also defined as a set of user procedures.

If you program in a high-level language, refer to Chapter 21 for information about the `SYS$LIBRARY:SYS$LIB_C.TLB` file, which is an OpenVMS Alpha library of C header files.

For VAX MACRO, system service macros generate argument lists and CALL instructions to call system services. These macros are located in the system library (see `SYS$LIBRARY:STARLET.MLB`). When you assemble a source program, this library is searched automatically for unresolved references. (See Appendix A for further details.) Similar macros are available for VAX BLISS and are located in `SYS$LIBRARY:STARLET.REQ`.

Calling System Services

20.2 Preserving System Integrity

20.2 Preserving System Integrity

As described in the *OpenVMS Programming Concepts Manual* and the *OpenVMS System Services Reference Manual*, many system services are available and suitable for application programs, but the use of some of these powerful 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 (SYSSCREMBX) system service to create a permanent mailbox.

The various controls and restrictions applied to system service usage are described in this chapter. The Description section of each system service in the *OpenVMS System Services Reference Manual* lists any privileges and quotas necessary to use the service.

20.2.1 User Privileges

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

When you log in to the system, the privileges and quotas assigned to you are associated with the process created on your behalf. These privileges and quotas are applied to every image 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 the specific privilege required, the image is allowed to execute the system service; otherwise, a condition value indicating an error is returned.

For a list of privileges, see the description of the Create Process (\$CREPRC) system service in the *OpenVMS System Services Reference Manual*.

20.2.2 Resource Quotas

Many system services require certain system resources for execution. These resources include system dynamic memory and process quotas for I/O operations. 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 condition value may be returned.

20.2.3 Access Modes

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.

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.

Note that many system services use access modes to protect system resources, and thus employ a special convention for interpreting access mode arguments. You can specify an access mode using a numeric value or a symbolic name. Table 20–1 shows the access modes and their numeric values, symbolic names, and privilege ranks.

Table 20–1 OpenVMS System Access Modes

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

The symbolic names are defined by the symbolic definition macro SY\$PSLDEF.

System services that permit an access mode argument allow callers to specify only an access mode of equal or lesser privilege than the access mode from which the service was called. If the specified access mode is more privileged than the access mode from which the service was called, the less privileged access mode is always used.

To determine the mode to use, the operating system compares the specified access mode with the access mode from which the service was called. 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 mode is said to be **maximized**.

Because much of the code you write executes in user mode, you can omit the access mode argument. The argument value defaults to 0 (kernel mode), and when this value is compared with the value of the current execution mode (3, user mode), the higher value (3) is used.

20.3 System Service Call Entry

The Format section of each system service description in the *OpenVMS System Services Reference Manual* indicates the positional dependencies and keyword names of each argument, as shown in the following format:

```
$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**.

Arguments passed to a service must be listed in your call entry in the order shown in the Format section of the service description. Each argument has four characteristics: OpenVMS usage, data type, access type, and passing mechanism. These characteristics are described in Chapter 17.

Calling System Services

20.3 System Service Call Entry

The OpenVMS Alpha SYSSLIBRARY:SYSSLIB_C.TLB file contains C function prototypes for system services. These prototypes are documented in *OpenVMS System Services Reference Manual: A-GETUAI* and *OpenVMS System Services Reference Manual: GETUTC-Z*. For each prototype, the manuals provide the correct syntax (which shows the arguments the function accepts in the order in which it expects them), a description of each argument, and the type of data returned by the function.

Some arguments are optional. Optional arguments are indicated by brackets in the service descriptions. When your program invokes a system service by using a CALL entry point, you can omit optional arguments at the end of the argument list. If the optional argument is not the last argument in the list, you must either pass a zero by value or use a comma to indicate the place of the omitted argument. Some languages, such as C, require that you pass a zero by value for all trailing optional arguments. See your language processor documentation for further information.

In the call statement of a high-level language program, you must prefix the macro function service name with SYS (the system service facility prefix). For example, the call statement in a C program procedure that calls the SYS\$GETDVI system service with four arguments is as follows:

```
return_status = sys$getdvi( event_flagnum, channel, &devnam, &item_list,0,0,0);
```

Note that in C, you must not omit the optional trailing arguments and should pass a zero by value for these unused parameters. See your language processor documentation for further information.

The *OpenVMS System Services Reference Manual* provides a description of each service that indicates how each argument is to be passed. Phrases such as “an address” and “address of a character string descriptor” identify reference and descriptor arguments, respectively. Terms like “Boolean value,” “number,” “value,” or “mask” indicate an argument that is passed by value.

In the Alpha and VAX environments, the called routine interprets each argument using one of three standard passing mechanisms: by value, by reference, or by descriptor.

On VAX systems, the calling program passes an argument list of longwords to a called service; each longword in the argument list specifies a single argument.

On Alpha systems, the calling program passes arguments in an argument item sequence; each quadword in the sequence specifies a single argument item. Note that the argument item sequence is formed using R16–R21 or F16–F21 (a register for each argument).

For more detailed information on arguments lists and passing mechanisms, see Sections 18.4 and 18.5.

Some services also require service-specific data structures that either indicate functions to be performed or hold information to be returned. The *OpenVMS System Services Reference Manual* includes descriptions of these service-specific data structures. You can use this information and information from your programming language manuals to define such service-specific item lists.

20.4 System Service Completion

When a system service completes, control is returned to your program. You can specify how and when control is returned to your program by choosing synchronous or asynchronous forms of system services and by enabling process execution modes.

The following sections describe:

- When synchronous system services return control to your program
- When asynchronous system services return control to your program
- How you can synchronize the completion of asynchronous system services
- How control is returned to your program when special process execution modes are enabled

20.4.1 Asynchronous and Synchronous System Services

You can execute a number of system services either asynchronously or synchronously (such as, `SYSSGETJPI` and `SYSSGETJPIW` or `SYSS$ENQ` and `SYSS$ENQW`). The `W` at the end of the system service name indicates the synchronous version of the system service.

The asynchronous version of a system service queues a request and returns control to your program. You can perform operations while the system service executes; however, you should not attempt to access information returned by the service until you check for the system service completion.

Typically, you pass to an asynchronous system service an event flag and an I/O status block or a lock status block. When the system service completes, it sets the event flag and places the final status of the request in the status block. You use the `SYSS$SYNCH` system service to ensure that the system service has completed. You pass `SYSS$SYNCH` the event flag and the status block that you passed to the asynchronous system service; `SYSS$SYNCH` waits for the event flag to be set, then ensures that the system service (rather than some other program) sets the event flag by checking the status block. If the status block is still zero, `SYSS$SYNCH` waits until the status block is filled.

The synchronous version of a system service acts exactly as if you had used the asynchronous version followed immediately by a call to `SYSS$SYNCH`. If you omit the `efn` argument, the service uses event flag number 0 whether you use the synchronous or asynchronous version of a system service.

Example 20–1 illustrates the use of the `SYSS$SYNCH` system service to check the completion status of the asynchronous service `SYSS$GETJPI`.

Calling System Services

20.4 System Service Completion

Example 20–1 Example of SYS\$SYNCH System Service in FORTRAN

```
! Data structure for SYS$GETJPI
.
.
.
INTEGER*4 STATUS,
2      FLAG,
2      PID_VALUE
! I/O status block
INTEGER*2 JPISTATUS,
2      LEN
INTEGER*4 ZERO /0/
COMMON /IO_BLOCK/ JPISTATUS,
2      LEN,
2      ZERO
.
.
.
! Call SYS$GETJPI and wait for information
STATUS = LIB$GET_EF (FLAG)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

STATUS = SYS$GETJPI (%VAL(FLAG),
2      PID_VALUE,
2      ,
2      NAME_BUF_LEN,
2      JPISTATUS,
2      , )
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
.
.
.
STATUS = SYS$SYNCH (%VAL(FLAG),
2      JPISTATUS)
IF (.NOT. JPISTATUS) THEN
  CALL LIB$SIGNAL (%VAL(JPISTATUS))
END IF

END
```

20.4.2 System Service Resource Wait Mode

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 condition value. You can disable (and reenable) resource wait mode with the Set Resource Wait Mode (SYS\$SETRWM) system service.

If resource wait mode is disabled, it remains disabled until it is explicitly reenabled or until your process is deleted. For example, if your program has disabled resource wait mode and has exited to the DCL prompt, subsequent programs or utilities invoked by this process continue to run with resource wait mode disabled and might not perform properly because they are not prepared to handle a failure to obtain a resource. In this case, you should reenable the wait mode before your program exits to the DCL prompt.

How a program responds to the unavailability of a resource depends primarily on the application and the particular service 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 for the program to wait for the resource and the system service to complete.

20.4.3 Condition Values Returned from System Services

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 errors in the condition value.

Depending on your specific needs, you can test just the low-order bit, the low-order 3 bits, or the entire condition value, as follows:

- The low-order bit indicates successful (1) or unsuccessful (0) completion of the service.
- The low-order 3 bits, taken together, represent the severity of the error. Table 20–2 lists the possible severity code values returned.

For VAX MACRO, the symbolic definition macro SYSSSTSDEF defines the symbolic names. For the C programming language, the SSDEF.H file defines the symbolic names.

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

Table 20–2 Severity Codes of Condition Value Returned

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

Each numeric condition value has a unique symbolic name in the following format:

SS\$_code

where *code* is a mnemonic describing the return condition.

For example, the following symbol usually indicates a successful return:

SS\$_NORMAL

An example of an error return condition value is as follows:

SS\$_ACCVIO

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20.4 System Service Completion

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

The symbolic definitions for condition values are included in the default system library `SYSSLIBRARY:STARLET.OLB`. You can obtain a listing of these symbolic codes at assembly time by invoking the system macro `SYSSSDEF`. To check return conditions, use the symbolic names for system condition values.

The OpenVMS 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.

20.4.4 Testing the Condition Value

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). Condition values that are returned by system services can provide information and whether the service completed successfully. The condition value that usually indicates success is `SS$_NORMAL`, but others are defined. For example, the condition value `SS$_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 condition value, however, gives the program additional information.

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

The possible condition values that each service can return are described with the individual service descriptions in the *OpenVMS System Services Reference Manual*. When you write calls to system services, read the descriptions of the return condition values to determine whether you want the program to check for particular return conditions.

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 write tests for specific conditions.

For information about how to test for these codes, see the user's guide for your programming language.

20.4.5 Special Condition Values Using Symbolic Codes

Individual services have symbolic codes for special return conditions, argument list offsets, identifiers, and flags associated with these services. For example, the Create Process (`SYSSCREPRC`) system 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.

The `SYSSLIBRARY:SYSSLIB_C.TLB` file contains the C header files for OpenVMS Alpha C data structures and definitions. For more information about `SYSSLIBRARY:SYSSLIB_C.TLB`, refer to Chapter 21.

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.

Calling System Services

20.4 System Service Completion

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 can do the following:

1. Write a short VAX MACRO program containing the desired macros.
2. Assemble or compile the program and generate a listing. Using the listing, find the desired symbols and their hexadecimal values.
3. Define each symbol with its value within your source program.

For example, to use the Get Job/Process Information (\$GETJPI) system service to find out the accumulated CPU time (in 10-millisecond ticks) for a specified process, you must obtain the value associated with the item identifier JPI\$_CPUTIM. You can do this in the following way:

1. Create the following three-line VAX MACRO program (named JPIDEF.MAR here; you can choose any name you want):

```
.TITLE JPIDEF "Obtain values for $JPIDEF"  
$JPIDEF GLOBAL          ; These MUST be UPPERCASE  
.END
```

2. Assemble and link the program to create the file JPIDEF.MAP as follows:

```
$ MACRO JPIDEF  
$ LINK/NOEXE/MAP/FULL JPIDEF  
%LINK-W-USRTFR, image NL:[].EXE; has no user transfer address
```

The file JPIDEF.MAP contains the symbols defined by \$JPIDEF listed both alphabetically and numerically.

To compile the program to create the JPIDEF.MAP, enter the following:

```
$ MACRO/MIGRATION JPIDEF  
$ LINK/NOEXE/MAP/FULL JPIDEF  
%LINK-W-USRTFR, image NL:[].EXE; has no user transfer address
```

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

20.4.6 Testing the Return Condition Value for Assembly Languages

To check for successful completion after 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
```

Programs should not test for success by comparing the return status to SSS_NORMAL. A future release of OpenVMS may add new, alternate success codes to an existing service, causing programs that test for SSS_NORMAL to fail.

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

```
CMPL    #SS$_ILLEFC,R0      ; Is event flag number illegal?
```

Note that return condition values are always longword values; however, all system services always return the same value in the high-order word of all condition values returned in R0.

Calling System Services

20.4 System Service Completion

20.4.7 System Messages Generated by Condition Values

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 an unsuccessful status.

The following VAX MACRO code fragment 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
```

After a system service call, the BSBW instruction branches to 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 instruction 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 following message:

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

The keyword UNASEFC in the message corresponds to the condition value SSS_UNASEFC.

The following three severe errors generated by the calls, not the services, can be returned from calls to system services:

Error	Meaning
SSS_ACCVIO	The argument list cannot be read by the caller (using the \$name_G macro), and the service is not called. This meaning of SSS_ACCVIO is different from its meaning for individual services. When SSS_ACCVIO is returned from individual services, the service is called, but one or more arguments to the service cannot be read or written by the caller.
SSS_INSFARG	Not enough arguments were supplied to the service.
SSS_ILLSER	An illegal system service was called.

20.5 Program Examples with System Service Calls

This section provides code examples that illustrate the use of a system service call in the following programming languages:

Ada — Example 20-2
 BASIC — Example 20-3
 BLISS — Example 20-4
 C — Example 20-5
 COBOL — Example 20-6
 FORTRAN — Example 20-7
 Pascal — Example 20-8
 VAX MACRO — Example 20-9

Example 20-2 System Service Call in Ada

```
with SYSTEM, TEXT_IO, STARLET, CONDITION_HANDLING; ❶
procedure ORION is
  -- Declare variables to hold equivalence name and length
  --
  EQUIV_NAME: STRING (1..255); ❷
  pragma VOLATILE (EQUIV_NAME);
  NAME_LENGTH: SYSTEM.UNSIGNED_WORD;
  pragma VOLATILE (NAME_LENGTH);

  -- Declare itemlist and fill in entries.
  --
  ITEM_LIST: STARLET.ITEM_LIST_3_TYPE (1..2) := ❸
    (1 =>
      (ITEM_CODE => STARLET.LNM_STRING, ❹
       BUF_LEN   => EQUIV_NAME'LENGTH,
       BUF_ADDRESS => EQUIV_NAME'ADDRESS,
       RET_ADDRESS => NAME_LENGTH'ADDRESS),
      2 =>
      (ITEM_CODE => 0,
       BUF_LEN   => 0,
       BUF_ADDRESS => SYSTEM.ADDRESS_ZERO,
       RET_ADDRESS => SYSTEM.ADDRESS_ZERO));

  STATUS: CONDITION_HANDLING.COND_VALUE_TYPE; ❺
begin
  -- Translate the logical name
  --
  STARLET.TRNLNM ( ❻
    STATUS => STATUS,
    TABNAM => "LNM$FILE_DEV",
    LOGNAM => "CYGNUS",
    ITMLST => ITEM_LIST);

  -- Display name if success, else signal error
  --
  if not CONDITION_HANDLING.SUCCESS (STATUS) then ❼
    CONDITION_HANDLING.SIGNAL (STATUS);
  else
    TEXT_IO.PUT ("CYGNUS translates to "");
    TEXT_IO.PUT (EQUIV_NAME (1..INTEGER(NAME_LENGTH)));
    TEXT_IO.PUT_LINE ("");
  end if;
end ORION;
```

Calling System Services

20.5 Program Examples with System Service Calls

Ada Notes

- ❶ The **with** clause names the predefined packages of declarations used in this program. `SYSTEM` and `TEXT_IO` are standard Ada packages; `STARLET` defines the OpenVMS system service routines, data types, and constants; and `CONDITION_HANDLING` defines error-handling facilities.
- ❷ Enough space is allocated to `EQUIV_NAME` to hold the longest possible logical name. `NAME_LENGTH` will receive the actual length of the translated logical name. The `VOLATILE` pragma is required for variables that will be modified by means other than an assignment statement or being an output parameter to a routine call.
- ❸ `ITEM_LIST_3_TYPE` is a predeclared type in package `STARLET` that defines the OpenVMS three-longword item list structure.
- ❹ The dollar-sign character is not valid in Ada identifiers; package `STARLET` defines the *fac\$* names by removing the dollar sign.
- ❺ `COND_VALUE_TYPE` is a predeclared type in package `CONDITION_HANDLING` that is used for return status values.
- ❻ System services are defined in package `STARLET` using names that omit the prefix `SYSS$`. The passing mechanisms are specified in the routine declaration in `STARLET`, so they need not be specified here.
- ❼ In this example, any failure status from the `SYSTRNLNM` service is signaled as an error. Other means of error recovery are possible; see your Ada language documentation for more details.

Calling System Services

20.5 Program Examples with System Service Calls

Example 20–3 System Service Call in BASIC

```

10 SUB ORION           ❶           ! Subprogram ORION
    OPTION TYPE=EXPLICIT           ! Require declaration of all
                                   ! symbols

    EXTERNAL LONG FUNCTION SYS$TRNLNM ! Declare the system service
    EXTERNAL WORD CONSTANT LNM$_STRING ! The request code that
                                       ! we will use

    DECLARE WORD NAMLEN,           ❷           ! Word to receive length
              LONG SYS_STATUS      ! Longword to receive status

    COMMON (BUF) STRING NAME_STRING = 255  ❸

    RECORD ITEM_LIST               ! Define item
                                   ! descriptor structure
        WORD BUFFER_LENGTH         ! The buffer length
        WORD ITEM                  ! The request code
        LONG BUFFER_ADDRESS        ! The buffer address
        LONG RETURN_LENGTH_ADDRESS ! The address of the return len
                                   ! word
        LONG TERMINATOR           ! The terminator
    END RECORD ITEM_LIST           ! End of structure definition

    DECLARE ITEM_LIST ITEMS        ! Declare an item list
    ITEMS::BUFFER_LENGTH = 255%    ! Initialize the item list
    ITEMS::ITEM = LNM$_STRING
    ITEMS::BUFFER_ADDRESS = LOC( NAME_STRING )
    ITEMS::RETURN_LENGTH_ADDRESS = LOC( NAMLEN )
    ITEMS::TERMINATOR = 0

    SYS_STATUS = SYS$TRNLNM( , 'LNM$FILE_DEV', 'CYGNUS', , ITEMS) ❹

    IF (SYS_STATUS AND 1%) = 0% ❺
    THEN
        ! Error path
    ELSE
        ! Success path
    END IF
END SUB

```

BASIC Notes

- ❶ The SUB statement defines the routine and its entry mask.
- ❷ The DECLARE WORD NAMLEN declaration reserves a 16-bit word for the output value.
- ❸ The COMMON (BUF) STRING NAME_STRING = 255 declaration allocates 255 bytes for the output data in a static area. The compiler builds the descriptor.
- ❹ The SYS\$ form invokes the system service as a function.
Enclose the arguments in parentheses and specify them in positional order only. Specify a comma for each optional argument that you omit (including trailing arguments).
- ❺ The input character string is specified directly in the system service call; the compiler builds the descriptor.
- ❻ The IF statement performs a test on the low-order bit of the return status. This form is recommended for all status returns.

Calling System Services

20.5 Program Examples with System Service Calls

Example 20–4 System Service Call in BLISS

```
MODULE ORION=
BEGIN
EXTERNAL ROUTINE
    ERROR_PROC: NOVALUE;                ! Error processing routine
LIBRARY 'SYS$LIBRARY:STARLET.L32';     ! Library containing OpenVMS
                                        ! macros (including $TRNLNM).
                                        ! This declaration
                                        ! is required.

GLOBAL ROUTINE ORION: NOVALUE=
    BEGIN
    OWN
        NAMBUF : VECTOR[255, BYTE],     ! Output buffer
        NAMLEN : WORD,                  ! Translated string length
        ITEMS  : BLOCK[16, BYTE]
            INITIAL(WORD(255,           ! Output buffer length
                    LNM$_STRING),      ! Item code
                    NAMBUF,           ! Output buffer
                    NAMLEN,           ! Address of word for
                                        ! translated
                                        ! string length
                                        ! List terminator
                    0);
    LOCAL
        STATUS;                          ! Return status from
                                        ! system service
    STATUS = $TRNLNM(TABNAM = %ASCID'LNM$FILE_DEV',
                    LOGNAME = %ASCID'CYGNUS',
                    ITMLST = ITEMS); ❶
    IF NOT .STATUS THEN ERROR_PROC(.STATUS); ❷
    END;
```

BLISS Notes

- ❶ The macro is invoked 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 the *OpenVMS System Services Reference Manual*.)
- ❷ The return status, which is assigned to the variable STATUS, is tested for TRUE or FALSE. FALSE (low bit = 0) indicates failure or warning.

Calling System Services

20.5 Program Examples with System Service Calls

Example 20–5 System Service Call in C

```
#include <starlet.h> ❶
#include <lib$routines.h>
#include <ssdef.h>
#include <lnmdef.h>
#include <descrip.h>
#include <stdio.h>

typedef struct {
    unsigned short buffer_length;
    unsigned short item_code;
    char *buffer_addr;
    short *return_len_addr;
    unsigned terminator;
} item_list_t;

main ()
{
    $DESCRIPTOR(table_name, "LNM$FILE_DEV");
    $DESCRIPTOR(log_name, "CYGNUS");
    char translated_name[255];
    int status;
    short return_length;
    item_list_t item_list;

    item_list.buffer_length = sizeof(translated_name); ❷
    item_list.item_code = LNM$string;
    item_list.buffer_addr = translated_name;
    item_list.return_len_addr = &return_length;
    item_list.terminator = 0;

    status = sys$trnlm(0, &table_name, &log_name, 0, &item_list); ❸

    if (!(status & 1)) ❹
        lib$signal(status);
    else
        printf("The logical name %s is equivalent to %*s\n",
            log_name.dsc$a_pointer,
            return_length,
            translated_name);
}
```

C Notes

- ❶ The C language header file `starlet.h` defines OpenVMS system services entry points. The file `lib$routines.h` declares the LIB\$ Run-Time Library routines.
- ❷ The structure of an item list entry is defined.
- ❸ The `$DESCRIPTOR` macro declares and initializes a character string descriptor. Here, two descriptors are created for use with the `sys$trnlm` system service.
- ❹ The function `sizeof` is used to obtain the size of the string. The returned length will be stored as a short integer in `return_length`.
- ❺ The `sys$trnlm` routine is defined in `starlet.h`.
- ❻ The IF statement performs a logical test following the function reference to determine whether the service completed successfully. If an error or warning occurs during the service call, the error is signaled.

Calling System Services

20.5 Program Examples with System Service Calls

Example 20–6 System Service Call in COBOL

```
IDENTIFICATION DIVISION.  
PROGRAM-ID. ORION. ❶  
ENVIRONMENT DIVISION.  
DATA DIVISION.  
WORKING-STORAGE SECTION.  
01 TABNAM PIC X(11) VALUE "LNM$FILE_DEV".  
01 CYGDES PIC X(6) VALUE "CYGNUS".  
01 NAMDES PIC X(255) VALUE SPACES. ❷  
01 NAMLEN PIC S9(4) COMP.  
01 ITMLIS.  
    02 BUFLen PIC S9(4) COMP VALUE 225.  
    02 ITMCOD PIC S9(4) COMP VALUE 2. ❸  
    02 BUFADR POINTER VALUE REFERENCE NAMDES.  
    02 RETLEN POINTER VALUE REFERENCE NAMLEN.  
    02 FILLER PIC S9(5) COMP VALUE 0.  
01 RESULT PIC S9(9) COMP. ❹  
  
PROCEDURE DIVISION.  
START-ORION.  
    CALL "SYS$STRNLNM" ❺  
        USING OMITTED  
            BY DESCRIPTOR TABNAM  
            BY DESCRIPTOR CYGDES ❻  
            OMITTED  
            BY REFERENCE ITMLIS  
        GIVING RESULT.  
    IF RESULT IS FAILURE ❼  
        GO TO ERROR-CHECK.  
    DISPLAY "NAMDES: ", NAMDES(1:NAMLEN).  
    GO TO THE-END.  
ERROR-CHECK.  
    DISPLAY "Returned Error: ", RESULT CONVERSION.  
THE-END.  
STOP RUN.
```

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 Enough bytes are allocated for the alphanumeric output data. The compiler generates a descriptor when you specify USING BY DESCRIPTOR in the CALL statement.
- ❸ The value of the symbolic code LNMSSTRING is 2. Section 20.4.5 explains how to obtain values for symbolic codes.
- ❹ This definition reserves a signed longword with COMP (binary) usage to receive the output value.
- ❺ The service is called by the SYSS form of the service name, and the name is enclosed in quotation marks.

Specify arguments in positional order only, with the USING statement. You cannot omit arguments; if you are accepting the default for an argument, you must pass the default value explicitly (OMITTED 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

Calling System Services

20.5 Program Examples with System Service Calls

(by reference), or through association with the last specified mechanism (thus, the last two arguments in the example are implicitly passed by value).

- ⑥ The input string is defined as alphanumeric (ASCII) data. The compiler generates a descriptor when you specify USING BY DESCRIPTOR in the CALL statement.
- ⑦ The IF statement tests RESULT for a failure status. In this case, control is passed to the routine ERROR-CHECK.

Example 20–7 System Service Call in FORTRAN

```

SUBROUTINE ORION
IMPLICIT NONE                ! Require declaration of all symbols
INCLUDE '($SYSSRVNAM)'       ! Declare system service names ①
INCLUDE '($LNMDEF)'         ! Declare $TRNLNM item codes
INCLUDE '(LIB$ROUTINES)'    ! Declare LIB$ routines

STRUCTURE /ITEM_LIST_3_TYPE/ ! Structure of item list ②
  INTEGER*2 BUFLen          ! Item buffer length
  INTEGER*2 ITMCOd          ! Item code
  INTEGER*4 BUFADR          ! Item buffer address
  INTEGER*4 RETADR          ! Item return length address
END STRUCTURE
RECORD /ITEM_LIST_3_TYPE/ ITEMLIST(2) ! Declare itemlist

CHARACTER*255 EQUIV_NAME    ! For returned equivalence name
INTEGER*2 NAMLEN            ! For returned name length
VOLATILE EQUIV_NAME,NAMLEN ③

INTEGER*4 STATUS            ! For returned service status ④

! Fill in itemlist
!
ITEMLIST(1).ITMCOd = LNM$_STRING
ITEMLIST(1).BUFLen = LEN(EQUIV_NAME) ⑤
ITEMLIST(1).BUFADR = %LOC(EQUIV_NAME)
ITEMLIST(1).RETA DR = %LOC(NAMLEN)
ITEMLIST(2).ITMCOd = 0          ! For terminator
ITEMLIST(2).BUFLen = 0

! Call SYS$TRNLN
!
STATUS = SYS$TRNLNM (,          ! ATTR omitted ⑥
  1      'LNM$FILE_DEV', ! TABNAM
  2      'CYGNUS',       ! LOGNAM
  3      ,                ! ACMODE omitted
  4      ITEMLIST)       ! ITMLST

! Check return status, display translation if successful
!
IF (.NOT. STATUS) THEN ⑦
  CALL LIB$SIGNAL(%VAL(STATUS))
ELSE
  WRITE (*,*) 'CYGNUS translates to: "',
  1      EQUIV_NAME(1:NAMLEN), ' "'
END IF
END

```

FORTTRAN Notes

- ① The module \$SYSSRVNAM in the FORTRAN system default library FORSYSDEF.TLB contains INTEGER and EXTERNAL declarations for each of the system services, so you need not explicitly provide these declarations in your program. Module \$LNMDEF defines constants and data structures used

Calling System Services

20.5 Program Examples with System Service Calls

when calling the logical name services, and module LIB\$ROUTINES contains declarations for the LIB\$ Run-Time Library routines.

- ② The structure of an OpenVMS 3-longword item list is declared and then used to define the record variable ITEM_LIST. The second element will be used for the terminator.
- ③ The VOLATILE declaration is required for variables that are modified by means other than a direct assignment or as an argument in a routine call.
- ④ Return status variables should always be declared as longword integers.
- ⑤ The LEN intrinsic function returns the allocated length of EQUIV_NAME. The %LOC built-in function returns the address of its argument.
- ⑥ By default, FORTRAN passes arguments by reference, except for strings which are passed by CLASS_S descriptor. Arguments are omitted in FORTRAN by leaving the comma as a placeholder. All arguments must be specified or explicitly omitted.
- ⑦ A condition value can be tested for success or failure by a true/false test. For more information on testing return statuses, see the OpenVMS FORTRAN documentation.

Calling System Services

20.5 Program Examples with System Service Calls

Example 20–8 System Service Call in Pascal

```
[INHERIT('SYS$LIBRARY:STARLET', ❶
        'SYS$LIBRARY:PASCAL$LIB_ROUTINES')]
PROGRAM ORION (OUTPUT);

TYPE
  Item_List_Cell = RECORD CASE INTEGER OF ❷
    1:( { Normal Cell }
        Buffer_Length : [WORD] 0..65535;
        Item_Code     : [WORD] 0..65535;
        Buffer_Addr    : UNSIGNED;
        Return_Addr   : UNSIGNED
        );
    2:( { Terminator }
        Terminator    : UNSIGNED
        );
  END;

  Item_List_Template(Count:INTEGER) = ARRAY [1..Count] OF Item_List_Cell;

VAR
  Item_List      : Item_List_Template(2);
  Translated_Name : [VOLATILE] VARYING [255] OF CHAR; ❸
  Status         : INTEGER;

BEGIN
  { Specify the buffer to return the translation } ❹
  Item_List[1].Buffer_Length := SIZE(Translated_Name.Body);
  Item_List[1].Item_Code    := LNM$_String;
  Item_List[1].Buffer_Addr  := IADDRESS(Translated_Name.Body);
  Item_List[1].Return_Addr  := IADDRESS(Translated_Name.Length);

  { Terminate the item list }
  Item_List[2].Terminator := 0;

  { Translate the CYGNUS logical name }
  Status := $trnlm(Tabnam := 'LNM$FILE_DEV', Lognam := 'CYGNUS', ❺
                  Itmlst := Item_List);
  IF NOT ODD(Status) ❻
  THEN
    LIB$SIGNAL(Status)
  ELSE
    WRITELN('CYGNUS is equivalent to ',Translated_Name);
  END.
```

Pascal Notes

- ❶ The Pascal environment file STARLET.PEN defines OpenVMS system services, data structures and constants. PASCAL\$LIB_ROUTINES declares the LIB\$ Run-Time Library routines.
- ❷ The structure of an item list entry is defined using a variant record type.
- ❸ The VARYING OF CHAR type is a variable-length character string with two components: a word-integer length and a character string body, which in this example is 255 bytes long. The VOLATILE attribute is required for variables that are modified by means other than a direct assignment or as an argument in a routine call.
- ❹ The functions SIZE and IADDRESS obtain the allocated size of the string body and the address of the string body and length. The returned length will be stored into the length field of the varying string Translated_Name, so that it will appear to be the correct size.

Calling System Services

20.5 Program Examples with System Service Calls

- ⑤ The definition of the SYS\$STRNLNM routine in STARLET.PEN contains specifications of the passing mechanism to be used for each argument; thus, it is not necessary to specify the mechanism here.
- ⑥ The IF statement performs a logical test following the function reference to see if the service completed successfully. If an error or warning occurs during the service call, the error is signaled.

Example 20–9 System Service Call in VAX MACRO

```

CYGDES: .ASCID /CYGNUS/ ① ; Descriptor for CYGNUS string
TBLDES: .ASCID /LNM$FILE_DEV/ ② ; Logical name table
NAMBUF: .BLKB 255 ③ ; Output buffer
NAMLEN: .BLKW 1 ④ ; Word to receive length
ITEMS: .WORD 255 ; Output buffer length
        .WORD LNM$STRING ; Item code
        .ADDRESS - ; Output buffer
            NAMBUF
        .ADDRESS - ; Return length
            NAMLEN
        .LONG 0 ; List terminator
        .
        .
        .ENTRY ORION,0 ⑤ ; Routine entry point & mask
STRNLNM_S - ⑥
            TABNAM=TBLDES, -
            LOGNAM=CYGDES, -
            ITMLST=ITEMS
BLBC RO,ERROR ⑦ ; Check for error
        .
        .
        .END

```

VAX MACRO Notes

- ① The input character string descriptor argument is defined using the .ASCID directive.
- ② The name of the table to search is defined using the .ASCID directive.
- ③ Enough bytes to hold the output data are allocated for an output character string argument.
- ④ The MACRO directive .BLKW reserves a word to hold the output length.
- ⑤ A routine name and entry mask show the beginning of executable code in a routine or subroutine.
- ⑥ A macro name that has the suffix _S or _G calls the service.

You can specify arguments either by keyword (as in this example) or by positional order. (Keyword names correspond to the names of the arguments shown in lowercase in the system service format descriptions in the *OpenVMS System Services Reference Manual*.) If you omit any optional arguments (if you accept the defaults), you can omit them completely if you specify arguments by keyword. If you specify arguments by positional order, however, you must specify the comma for each missing argument.

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

Calling System Services

20.5 Program Examples with System Service Calls

- ⑦ The BLBC instruction causes a branch to a subroutine named ERROR (not shown) if the low bit of the condition value 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.

STARLET Structures and Definitions for C Programmers

This chapter describes the libraries that contain C header files for routines supplied by the OpenVMS Alpha operating system.

21.1 SYS\$STARLET_C.TLB Equivalency to STARLETSD.TLB

The SYS\$STARLET_C.TLB file, which was introduced in OpenVMS Alpha Version 1.0, contains all the .H files that provide STARLET functionality equivalent to STARLETSD.TLB. The file SYS\$STARLET_C.TLB, together with DECC\$RTLDEF.TLB that ships with the Compaq C Compiler, replaces VAXCDEF.TLB that previously shipped with the VAX C Compiler. DECC\$RTLDEF.TLB contains all the .H files that support the compiler and RTL, such as STDIO.H.

If you are running an application from a release prior to OpenVMS Alpha Version 1.0, the following differences may require source changes:

- RMS structures

Previously, the RMS structures FAB, NAM, RAB, XABALL, and so forth, were defined in the appropriate .H files as “struct RAB {...”, for example. The .H files supplied in OpenVMS Alpha Version 1.0 define them as “struct rabdef {...”. To compensate for this difference, lines of the form “#define RAB rabdef” have been added. However, there is one situation where a source change is required because of this change. If you have a private structure that contains a pointer to one of these structures and your private structure is defined (but not used) before the RMS structure has been defined, you will receive compile-time errors similar to the following:

```
%CC-E-PASNOTMEM, In this statement, "rab$b_rac" is not a member of "rab".
```

This error can be avoided by reordering your source file so that the RMS structure is defined before the private structure. Typically, this involves moving around “#include” statements.

- LIB (privileged interface) structures

Historically, three structures from LIB (NFBDEF.H, FATDEF.H, and FCHDEF.H) have been made available as .H files. These files were shipped as .H files in OpenVMS Alpha Version 1.0 and 1.5 (not in the new SYS\$STARLET_C.TLB). As of OpenVMS Alpha Version 1.0, the file SYS\$LIB_C.TLB, containing all LIB structures and definitions, has been added. These three .H files are now part of that .TLB and are no longer shipped separately. Source changes may be required, because no attempt has been made to preserve any existing anomalies in these files. The structures and definitions from LIB are for privileged interfaces only and are therefore subject to change.

STARLET Structures and Definitions for C Programmers

21.1 SYS\$STARLET_C.TLB Equivalency to STARLETSD.TLB

- Use of “variant_struct” and “variant_union”

In the new .H files, “variant_struct” and “variant_union” are always used; whereas previously some structures used “struct” and “union”. Therefore, the intermediate structure names cannot be specified when referencing fields within data structures.

For example, the following statement:

```
AlignFaultItem.PC[0] = DataPtr->afr$r_pc_data_overlay.afr$q_fault_pc[0];
```

becomes:

```
AlignFaultItem.PC[0] = DataPtr->afr$q_fault_pc[0];
```
- Member alignment

Each of the .H files in SYS\$STARLET_C.TLB saves and restores the state of “#pragma member_alignment”.
- Conventions

The .H files in SYS\$STARLET_C.TLB adhere to some conventions that were only partly followed in VAXCDEF.TLB. All constants (#defines) have uppercase names. All identifiers (routines, structure members, and so forth) have lowercase names. Where there is a difference from VAXCDEF.TLB, the old symbol name is also included for compatibility, but users are encouraged to follow the new conventions.
- Use of Librarian utility to access the .H files

During installation of OpenVMS Alpha Version 1.0, the contents of SYS\$STARLET_C.TLB are not extracted into the separate .H files. The Compaq C Compiler accesses these files from within SYS\$STARLET_C.TLB, regardless of the format of the #include statement. If you want to inspect an individual .H file, you can use the Librarian utility, as in the following example:

```
$ LIBRARY /EXTRACT=AFRDEF /OUTPUT=AFRDEF.H SYS$LIBRARY:SYS$STARLET_C.TLB
```
- Additional .H files included in SYS\$STARLET_C.TLB

In addition to the .H files derived from STARLET sources, SYS\$STARLET_C.TLB includes .H files that provide support for POSIX Threads Library, such as CMA.H.

21.2 NEW STARLET Definitions for C

As of OpenVMS Alpha Version 7.0, SYS\$LIBRARY:SYS\$STARLET_C.TLB (or STARLET) provides C function prototypes for system services, as well as new and enhanced data structure definitions. The new definitions are more consistent with the OpenVMS C language coding conventions and definitions (typedefs) used in SYS\$LIBRARY:SYS\$LIB_C.TLB.

To maintain source compatibility for existing users of STARLET.H, the “old style” function declarations and definitions are still provided by default. To take advantage of the new system service function prototypes and type definitions, you must explicitly enable them.

STARLET Structures and Definitions for C Programmers

21.2 NEW STARLET Definitions for C

You can define the `__NEW_STARLET` symbol with a Compaq C command line qualifier or include the definition directly in your source program. For example:

- Define the `__NEW_STARLET` symbol with the Compaq C command line qualifier as follows:

```
/DEFINE=(__NEW_STARLET=1)
```

or

- Define the `__NEW_STARLET` symbol in your C source program before including the `SYSS$STARLET_C.TLB` header files:

```
#define __NEW_STARLET 1
#include <starlet.h>
#include <vodef.h>
```

To see the currently available system service function prototypes in `STARLET.H`, you can use the Librarian utility as shown in the following example:

```
$ LIBRARY/OUTPUT=STARLET.H SYSS$LIBRARY:SYSS$STARLET_C.TLB/EXTRACT=STARLET
```

The following example shows a new system service function prototype as it is defined in `STARLET.H`:

```
#pragma __required_pointer_size __long
int sys$expreg_64(
    struct _generic_64 *region_id_64,
    unsigned __int64 length_64,
    unsigned int acmode,
    unsigned int flags,
    void *(*(return_va_64)),
    unsigned __int64 *return_length_64);
#pragma __required_pointer_size __short
```

For more information about Compaq C pointer size pragmas, see the *DEC C User's Guide for OpenVMS Systems*.

The following source code example shows the `sys$expreg_64` function prototype referenced in a program.

```
#define __NEW_STARLET 1                /* Enable "New Starlet" features */
#include <starlet.h>                    /* Declare prototypes for system services */
#include <gen64def.h>                  /* Define GENERIC_64 type */
#include <vodef.h>                     /* Define VA$ constants */
#include <ints.h>                      /* Define 64-bit integer types */
#include <far_pointers.h>              /* Define 64-bit pointer types */
{
    int status;                        /* Ubiquitous VMS status value */
    GENERIC_64 region = { VA$C_P2 };   /* Expand in "default" P2 region */
    VOID_PQ p2_va;                     /* Returned VA in P2 space */
    uint64 length;                     /* Allocated size in bytes */
    extern uint64 page_size;           /* Page size in bytes */
    status = sys$expreg_64( &region, request_size, 0, 0, &p2_va, &length );
    ...
}
```

STARLET Structures and Definitions for C Programmers

21.2 NEW STARLET Definitions for C

Table 21–1 lists the data structures that are used by the new function prototypes.

Table 21–1 Structures Used by `_NEW_STARLET` Prototypes

Structure Used by Prototype	Defined by Header File	Common Prefix for Structure Member Names	Description
<code>struct _cluevthndl</code>	<code>cluevthndl.h</code>	<code>cluevthndl\$</code>	Cluster event handle
<code>struct _fabdef</code>	<code>fabdef.h</code>	<code>fab\$</code>	File access block
<code>struct _generic_64</code>	<code>gen64def.h</code>	<code>gen64\$</code>	Generic quadword structure
<code>struct _ieee</code>	<code>ieeedef.h</code>	<code>ieee\$</code>	IEEE Floating point control structure
<code>struct _ile2</code> ¹	<code>iledef.h</code>	<code>ile2\$</code>	Item list entry 2
<code>struct _ile3</code> ¹	<code>iledef.h</code>	<code>ile3\$</code>	Item list entry 3
<code>struct _iosa</code>	<code>iosadef.h</code>	<code>iosa\$</code>	I/O status area
<code>struct _iosb</code>	<code>iosbdef.h</code>	<code>iosb\$</code>	I/O status block
<code>struct _lksb</code>	<code>lksbdef.h</code>	<code>lksb\$</code>	Lock status block
<code>struct _rabdef</code>	<code>rabdef.h</code>	<code>rab\$</code>	RMS record access block
<code>struct _secid</code>	<code>seciddef.h</code>	<code>secid\$</code>	Global section identifier
<code>struct _va_range</code>	<code>va_rangedef.h</code>	<code>va_range\$</code>	32-bit virtual address range

¹Use of this structure type is not required by the function prototypes in `starlet.h`. This structure type is provided as a convenience and can be used where it is appropriate.

Part II

I/O, System and Programming Routines

This part of this second volume describes the I/O operations, and the system and programming routines used by run-time libraries and system services.

Run-Time Library Input/Output Operations

This chapter describes the different I/O programming capabilities provided by the run-time library and illustrates these capabilities with examples of common I/O tasks. This chapter contains the following sections:

Section 22.1 describes the input and output operations within a program.

Section 22.2 describes using `SYSS$INPUT` and `SYSS$OUTPUT`.

Section 22.3 describes using `LIB$GET_INPUT` and `LIB$PUT_OUTPUT` for simple user I/O.

Section 22.4 describes using the `SMG$` run-time library routines for managing the appearance of terminal screens.

Section 22.5 describes using screen management input routines and the `SYSS$QIO` and `SYSS$QIOW` system services to perform special actions.

22.1 Choosing I/O Techniques

The operating system and its compilers provide the following methods for completing input and output operations within a program:

- DEC Text Processing Utility
- DECforms software
- Program language I/O statements
- OpenVMS Record Management Services (RMS) and Run-Time Library (RTL) routines
- `SYSS$QIO` and `SYSS$QIOW` system services
- Non-Compaq-supplied device drivers to control the I/O to the device itself

The DEC Text Processing Utility (DECTPU) is a text processor that can be used to create text editing interfaces. DECTPU has the following features:

- High-level procedure language with several data types, relational operators, error interception, looping, case language statements, and built-in procedures
- Compiler for the DECTPU procedure language
- Interpreter for the DECTPU procedure language
- Extensible Versatile Editor (EVE) editing interface which, in addition to the EVE keypad, provides EDT, VT100, WPS, and numeric keypad emulation

In addition, DECTPU offers the following special features:

- Multiple buffers
- Multiple windows
- Multiple subprocesses

Run-Time Library Input/Output Operations

22.1 Choosing I/O Techniques

- Text processing in batch mode
- Insert or overstrike text entry
- Free or bound cursor motion
- Learn sequences
- Pattern matching
- Key definition

The method you select for I/O operations depends on the task you want to accomplish, ease of use, speed, and level of control you want.

The Compaq DECforms for OpenVMS software is a forms management product for transaction processing. DECforms integrates text and graphics into forms and menus that application programs use as an interface to users. DECforms software offers application developers software development tools and a run-time environment for implementing interfaces.

DECforms software integrates with the Application Control and Management System (ACMS), a transaction process (TP) monitor that works with other Compaq commercial applications to provide complete customizable development and run-time environments for TP applications. An asynchronous call interface to ACMS allows a single DECforms run-time process to control multiple terminals simultaneously in a multithreaded way, resulting in an efficient use of memory. By using the ACMS Remote Access Option, DECforms software can be distributed to remote CPUs. This technique allows the host CPU to offload forms processing and distribute it as closely as possible to the end user.

In contrast to OpenVMS RMS, RTLs, SYSSQIOs, and device driver I/O, program language I/O statements have the slowest speed and lowest level of control, but they are the easiest to use and are highly portable.

OpenVMS RMS and RTL routines can perform most I/O operations for a high-level or assembly language program. For information about OpenVMS RMS, see the *OpenVMS Record Management Services Reference Manual*.

System services can complete any I/O operation and can access devices not supported within OpenVMS RMS. See Chapter 23 for a description of using I/O system services.

Writing a device driver provides the most control over I/O operations, but can be more complex to implement. For information about device drivers for VAX systems, see the *OpenVMS VAX Device Support Manual*. The *OpenVMS VAX Device Support Manual* has been archived but is available on the OpenVMS Documentation CD-ROM.

Several types of I/O operations can be performed within a program, including the following:

- RTL routines allow you either to read simple input from a user or send simple output to a user. One RTL routine allows you to specify a string to prompt for input from the current input device, defined by SYSSINPUT. Another RTL routine allows you to write a string to the current output device, defined by SYSSOUTPUT. See Section 22.2 and Section 22.3 for more information.

Run-Time Library Input/Output Operations

22.1 Choosing I/O Techniques

- RTL routines allow you either to read complex input from a user or to send complex output to a user. By providing an extensive number of screen management (SMG\$) routines, the RTL allows you either to read multiple lines of input from users or to send complex output to users. The SMG\$ routines also allow you to create and modify complicated displays that accept input and produce output. See Section 22.4 for more information.
- RTL routines allow you to use programming language I/O statements to send data to and receive data from files. Program language I/O statements call OpenVMS RMS routines to complete most file I/O. You can also use OpenVMS RMS directly in your programs for accomplishing file I/O. See Chapter 28 for more information.
- The SYSSQIO and SYSSQIOW system services allow you to send data to and from devices with the most flexibility and control. You can use system services to access devices not supported by your programming language or by OpenVMS RMS.

You can perform other special I/O actions, such as using interrupts, controlling echo, handling unsolicited input, using the type-ahead buffer, using case conversion, and sending system broadcast messages, by using SMG\$ routines or, for example, by using SYSSBRKTHRU system service to broadcast messages. See Section 22.5 for more information.

22.2 Using SYS\$INPUT and SYS\$OUTPUT

Typically, you set up your program so that the user is the invoker. The user starts the program either by entering a DCL command associated with the program or by using the RUN command.

22.2.1 Default Input and Output Devices

The user's input and output devices are defined by the logical names SYSS\$INPUT and SYSS\$OUTPUT, which are initially set to the values listed in Table 22-1.

Table 22-1 SYSS\$INPUT and SYSS\$OUTPUT Values

Logical Name	User Mode	Equivalence Device or File
SYSS\$INPUT	Interactive	Terminal at which the user is logged in
	Batch job	Data lines following the invocation of the program
	Command procedure	Data lines following the invocation of the program
SYSS\$OUTPUT	Interactive	Terminal at which the user is logged in
	Batch job	Batch log file
	Command procedure	Terminal at which the user is logged in

Generally, use of SYSS\$INPUT and SYSS\$OUTPUT as the primary input and output devices is recommended. A user of the program can redefine SYSS\$INPUT and SYSS\$OUTPUT to redirect input and output as desired. For example, the interactive user might redefine SYSS\$OUTPUT as a file name to save output in a file rather than display it on the terminal.

Run-Time Library Input/Output Operations

22.2 Using SYSS\$INPUT and SYSS\$OUTPUT

22.2.2 Reading and Writing to Alternate Devices and External Files

Alternatively, you can design your program to read input from and write output to a file or a device other than the user's terminal. Files may be useful for writing large amounts of data, for writing data that the user might want to save, and for writing data that can be reused as input. If you use files or devices other than SYSS\$INPUT and SYSS\$OUTPUT, you should provide the names of the files or devices (best form is to use logical names) and any conventions for their use. You can specify such information by having the program write it to the terminal, by creating a help file, or by providing user documentation.

22.3 Working with Simple User I/O

Usually, you can request information from or provide information to the user with little regard for formatting. For such simple I/O, use either LIB\$GET_INPUT and LIB\$PUT_OUTPUT or the I/O statements for your programming language.

To provide complex screen displays for input or output, use the screen management facility described in Section 22.4.

22.3.1 Default Devices for Simple I/O

The LIB\$GET_INPUT and LIB\$PUT_OUTPUT routines read from SYSS\$INPUT and write to SYSS\$OUTPUT, respectively. The logical names SYSS\$INPUT and SYSS\$OUTPUT are implicit to the routines, because you need only call the routine to access the I/O unit (device or file) associated with SYSS\$INPUT and SYSS\$OUTPUT. You cannot use these routines to access an I/O unit other than the one associated with SYSS\$INPUT or SYSS\$OUTPUT.

22.3.2 Getting a Line of Input

A read operation transfers one record from the input unit to a variable or variables of your choice. At a terminal, the user ends a record by pressing a terminator. The terminators are the ASCII characters NUL through US (0 through 31) except for LF, VT, FF, TAB, and BS. The usual terminator is CR (carriage return), which is generated by pressing the Return key.

If you are reading character data, LIB\$GET_INPUT is a simple way of prompting for and reading the data. If you are reading noncharacter data, programming language I/O statements are preferable since they allow you to translate the data to a format of your choice.

For example, Fortran offers the ACCEPT statement, which reads data from SYSS\$INPUT, and the READ statement, which reads data from an I/O unit of your choice.

Make sure the variables that you specify can hold the largest number of characters the user of your program might enter, unless you want to truncate the input deliberately. Overflowing the input variable using LIB\$GET_INPUT causes the fatal error LIB\$_INPSTRTRU (defined in \$LIBDEF); overflowing the input variable using language I/O statements may not cause an error but does truncate your data.

LIB\$GET_INPUT places the characters read in a variable of your choice. You must define the variable type as a character. Optionally, LIB\$GET_INPUT places the number of characters read in another variable of your choice. For input at a terminal, LIB\$GET_INPUT optionally writes a prompt before reading the input. The prompt is suppressed automatically for an operation not taking place at a terminal.

Run-Time Library Input/Output Operations

22.3 Working with Simple User I/O

Example 22–1 uses LIB\$GET_INPUT to read a line of input.

Example 22–1 Reading a Line of Data

```
INTEGER*4      STATUS,  
2             LIB$GET_INPUT  
INTEGER*2      INPUT_SIZE  
CHARACTER*512 INPUT  
STATUS = LIB$GET_INPUT (INPUT,           ! Input value  
2             'Input value: ', ! Prompt (optional)  
2             INPUT_SIZE)           ! Input size (optional)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.3.3 Getting Several Lines of Input

The usual technique for obtaining a variable number of input records—either values for which you are prompting or data records from a file—is to read and process records until the end-of-file. End-of-file means one of the following:

- **Terminal**—The user has pressed Ctrl/Z. To ensure that the convention is followed, you might first write a message telling the user to press Ctrl/Z to terminate the input sequence.
- **Command procedure**—The end of a sequence of data lines has been reached. That is, a sequence of data lines ends at the next DCL command (a line in the procedure beginning with a dollar sign [\$]) or at the end of the command procedure file.
- **File**—The end of an actual file has been reached.

Process the records in a loop (one record per iteration) and terminate the loop on end-of-file. LIB\$GET_INPUT returns the error RMS\$_EOF (defined in \$RMSDEF) when end-of-file occurs.

Example 22–2 uses a Fortran READ statement in a loop to read a sequence of integers from SYSSINPUT.

Example 22–2 Reading a Varying Number of Input Records

```
! Return status and error codes  
INTEGER STATUS,  
2       IOSTAT,  
3       STATUS_OK,  
4       IOSTAT_OK  
PARAMETER (STATUS_OK = 1,  
2         IO_OK = 0)  
INCLUDE '($FORDEF)'  
! Data record read on each iteration  
INTEGER INPUT_NUMBER  
! Accumulated data records  
INTEGER STORAGE_COUNT,  
2       STORAGE_MAX  
PARAMETER (STORAGE_MAX = 255)  
INTEGER STORAGE_NUMBER (STORAGE_MAX)
```

(continued on next page)

Run-Time Library Input/Output Operations

22.3 Working with Simple User I/O

Example 22–2 (Cont.) Reading a Varying Number of Input Records

```
! Write instructions to interactive user
TYPE *,
2 'Enter values below. Press CTRL/Z when done.'
! Get first input value
WRITE (UNIT=*,
2      FMT='(A,$)') ' Input value: '
READ (UNIT=*,
2     IOSTAT=IOSTAT,
2     FMT='(BN,I)') INPUT_NUMBER
IF (IOSTAT .EQ. IO_OK) THEN
    STATUS = STATUS_OK
ELSE
    CALL ERRSNS (,,,STATUS)
END IF
! Process each input value until end-of-file
DO WHILE ((STATUS .NE. FOR$_ENDDURREA) .AND.
          (STORAGE_COUNT .LT. STORAGE_MAX))
    ! Keep repeating on conversion error
    DO WHILE (STATUS .EQ. FOR$_INPCONERR)
        WRITE (UNIT=*,
2             FMT='(A,$)') ' Try again: '
        READ (UNIT=*,
2          IOSTAT=IOSTAT,
2          FMT='(BN,I)') INPUT_NUMBER
        IF (IOSTAT .EQ. IO_OK) THEN
            STATUS = STATUS_OK
        ELSE
            CALL ERRSNS (,,,STATUS)
        END IF
    END DO
    ! Continue if end-of-file not entered
    IF (STATUS .NE. FOR$_ENDDURREA) THEN
        ! Status check on last read
        IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
        ! Store input numbers in input array
        STORAGE_COUNT = STORAGE_COUNT + 1
        STORAGE_NUMBER (STORAGE_COUNT) = INPUT_NUMBER
        ! Get next input value
        WRITE (UNIT=*,
2            FMT='(A,$)') ' Input value: '
        READ (UNIT=*,
2          IOSTAT=IOSTAT,
2          FMT='(BN,I)') INPUT_NUMBER
        IF (IOSTAT .EQ. IO_OK) THEN
            STATUS = STATUS_OK
        ELSE
            CALL ERRSNS (,,,STATUS)
        END IF
    END IF
END DO
```

22.3.4 Writing Simple Output

You can use `LIB$PUT_OUTPUT` to write character data. If you are writing noncharacter data, programming language I/O statements are preferable because they allow you to translate the data to a format of your choice.

Run-Time Library Input/Output Operations

22.3 Working with Simple User I/O

LIB\$PUT_OUTPUT writes one record of output to SYSSOUTPUT. Typically, you should avoid writing records that exceed the device width. The width of a terminal is 80 or 132 characters, depending on the setting of the physical characteristics of the device. The width of a line printer is 132 characters. If your output record exceeds the width of the device, the excess characters are either truncated or wrapped to the next line, depending on the setting of the physical characteristics.

You must define a value (a variable, constant, or expression) to be written. The value must be expressed in characters. You should specify the exact number of characters being written and not include the trailing portion of a variable.

The following example writes a character expression to SYSSOUTPUT:

```
INTEGER*4    STATUS,
2           LIB$PUT_OUTPUT
CHARACTER*40 ANSWER
INTEGER*4    ANSWER_SIZE
.
.
.
STATUS = LIB$PUT_OUTPUT ('Answer: ' // ANSWER (1:ANSWER_SIZE))
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4 Working with Complex User I/O

The following sections present Compaq DECwindows Motif for OpenVMS (DECwindows Motif), and the SMG\$ run-time library routines that enable complex screen display I/O.

22.4.1 Compaq DECwindows Motif

The Compaq DECwindows Motif environment provides a consistent user interface for developing software applications. It also includes an extensive set of programming libraries and tools. The following Compaq DECwindows Motif software allows you to build a graphical user interface:

- Toolkit composed on graphical user interface objects, such as widgets and gadgets. Widgets provide advanced programming capabilities that permit you to create graphic applications easily; gadgets, similar to widgets, require less memory to create labels, buttons, and separators.
- Language to describe visual aspects of objects, such as menus, labels, and forms, and to specify changes resulting from user interaction.
- OSF/Motif Window Manager to allow you to customize the interface.

Compaq DECwindows Motif environment also makes available the LinkWorks services for creating, managing, and traversing informational links between different application-specific data. Along with the LinkWorks Manager application, LinkWorks services help organize information into a hyperinformation environment. LinkWorks Developer's Tools provide a development environment for creating, modifying, and maintaining hyperapplications.

Run-Time Library Input/Output Operations

22.4 Working with Complex User I/O

22.4.1.1 DECwindows Server Height or Width Exceeding 32767 (VAX Only)

On OpenVMS VAX systems, when an X application sends the display server a width or height greater than 32767, the application may terminate with a BadValue error similar to the following:

```
X error event received from server: BadValue (integer parameter out of
range for operation)
Major opcode of failed request: 61 (X_ClearArea)
Value in failed request: 0xffff****
Serial number of failed request: ###
Current serial number in output stream: ###
```

The following calls can cause this problem:

```
CopyArea()
CreateWindow ()
PutImage()
GetImage()
CopyPlane()
ClearArea()
```

This is due to the width and height being defined as a signed word by the display server when it should be defined as an unsigned word (CARD16) that allows for values up to 65536.

To modify the default operation, perform the following steps:

1. Set the logical name DECW\$CARD16_VALIDATE to TRUE as follows:

```
$DEFINE/TABLE=DECW$SERVER0_TABLE DECW$CARD16_VALIDATE TRUE
```

2. Exit the session and log back in.

Exiting the session causes the display server to reset using the new value of the logical name DECW\$CARD16_VALIDATE. The server will now accept values that are greater than 32767 without generating an error.

To make this a permanent change, add the command from step 1 to the file SYSS\$MANAGER:DECW\$PRIVATE_SERVER_SETUP.COM.

22.4.1.2 SET DISPLAY Used to Create WSA Pseudo Workstation Devices

When creating WSA pseudo workstation devices using the SET DISPLAY command, be careful not to create WSA devices that are never destroyed. For example, this DCL command procedure is wrong:

```
$LOOP:
$ SET DISPLAY/CREATE/NODE=remote
$ RUN SYS$SYSTEM:DECW$CLOCK
$ IF $STATUS THEN GOTO DONE
$ WAIT 0:0:5
$ GOTO LOOP
$DONE:
```

If the clock cannot be started for some reason, one WSA device will be created for each failed attempt. These WSA devices will use up non-paged dynamic memory, and eventually the process will exceed its BYTLM quota and enter a resource wait state (if resource waiting is enabled, as it is by default).

Run-Time Library Input/Output Operations

22.4 Working with Complex User I/O

A better version of this command procedure is the following:

```
$ SET DISPLAY/CREATE/NODE=remote
$LOOP:
$ RUN SYS$SYSTEM:DECW$CLOCK
$ IF $STATUS THEN GOTO DONE
$ WAIT 0:0:5
$ GOTO LOOP
$DONE:
$ SET DISPLAY/DELETE 'F$TRNLNM("DECW$DISPLAY")'
```

The SET DISPLAY/DELETE command deletes the WSA device that was created at the beginning of the command procedure; the logical name DECW\$DISPLAY contains the name of the WSA device that was created.

For information about using OpenVMS Compaq DECwindows Motif, see the *Overview of DECwindows Motif for OpenVMS Documentation* and the *DECwindows Motif Guide to Application Programming*.

22.4.2 SMG\$ Run-Time Routines

The SMG\$ run-time library routines provide a simple, device-independent interface for managing the appearance of the terminal screen. The SMG\$ routines are primarily for use with video terminals; however, they can be used with files or hardcopy terminals.

To use the screen management facility for output, do the following:

1. Create a pasteboard—A pasteboard is a logical, two-dimensional area on which you place virtual displays. Use the SMG\$CREATE_PASTEBOARD routine to create a pasteboard, and associate it with a physical device. When you refer to the pasteboard, SMG performs the necessary I/O operation to the device.
2. Create a virtual display—A virtual display is a logical, two-dimensional area in which you place the information to be displayed. Use the SMG\$CREATE_VIRTUAL_DISPLAY routine to create a virtual display.
3. Paste virtual displays to the pasteboard—To make a virtual display visible, map (or paste) it to the pasteboard using the SMG\$PASTE_VIRTUAL_DISPLAY routine. You can reference a virtual display regardless of whether that display is currently pasted to a pasteboard.
4. Create a viewport for a virtual display—A viewport is a rectangular viewing area that can be moved around on a buffer to view different pieces of the buffer. The viewport is associated with a virtual display.

Run-Time Library Input/Output Operations

22.4 Working with Complex User I/O

Example 22–3 associates a pasteboard with the terminal, creates a virtual display the size of the terminal screen, and pastes the display to the pasteboard. When text is written to the virtual display, the text appears on the terminal screen.

Example 22–3 Associating a Pasteboard with a Terminal

```
.
.
.
! Screen management control structures
INTEGER*4 PBID, ! Pasteboard ID
2 VDID, ! Virtual display ID
2 ROWS, ! Rows on screen
2 COLS ! Columns on screen
! Status variable and routines called as functions
INTEGER*4 STATUS,
2 SMG$CREATE_PASTEBOARD,
2 SMG$CREATE_VIRTUAL_DISPLAY,
2 SMG$PASTE_VIRTUAL_DISPLAY
! Set up SYS$OUTPUT for screen management
! and get the number of rows and columns on the screen
STATUS = SMG$CREATE_PASTEBOARD (PBID, ! Return value
2 'SYS$OUTPUT',
2 ROWS, ! Return value
2 COLUMNS) ! Return value
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Create virtual display that pastes to the full screen size
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (ROWS,
2 COLUMNS,
2 VDID) ! Return value
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Paste virtual display to pasteboard
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (VDID,
2 PBID,
2 1, ! Starting at row 1 and
2 1) ! column 1 of the screen
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
.
```

To use the SMG\$ routines for input, you associate a virtual keyboard with a physical device or file using the SMG\$CREATE_VIRTUAL_KEYBOARD routine. The SMG\$ input routines can be used alone or with the output routines. This section assumes that you are using the input routines with the output routines. Section 22.5 describes how to use the input routines without the output routines.

The screen management facility keeps an internal representation of the screen contents; therefore, it is important that you do not mix SMG\$ routines with other forms of terminal I/O. The following subsections contain guidelines for using most of the SMG\$ routines; for more details, see the *OpenVMS RTL Screen Management (SMG\$) Manual*.

22.4.3 Pasteboards

Use the SMG\$CREATE_PASTEBOARD routine to create a pasteboard and associate it with a physical device. SMG\$CREATE_PASTEBOARD returns a unique pasteboard identification number; use that number to refer to the pasteboard in subsequent calls to SMG\$ routines. After associating a pasteboard with a device, your program references only the pasteboard. The screen

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22.4 Working with Complex User I/O

management facility performs all necessary operations between the pasteboard and the physical device. Example 22–4 creates a pasteboard.

Example 22–4 Creating a Pasteboard

```
STATUS = SMG$CREATE_PASTEBOARD (PBID, ROWS, COLUMNS)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4.3.1 Erasing a Pasteboard

When you create a pasteboard, the screen management facility clears the screen by default. To clear the screen yourself, invoke the `SMG$ERASE_PASTEBOARD` routine. Any virtual displays associated with the pasteboard are removed from the screen, but their contents in memory are not affected. The following example erases the screen:

```
STATUS = SMG$ERASE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4.3.2 Deleting a Pasteboard

Invoking the `SMG$DELETE_PASTEBOARD` routine deletes a pasteboard, making the screen unavailable for further pasting. The optional second argument of the `SMG$DELETE_PASTEBOARD` routine allows you to indicate whether the routine clears the screen (the default) or leaves it as is. The following example deletes a pasteboard and clears the screen:

```
STATUS = SMG$DELETE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

By default, the screen is erased when you create a pasteboard. Generally, you should erase the screen at the end of a session.

22.4.3.3 Setting Screen Dimensions and Background Color

The `SMG$CHANGE_PBD_CHARACTERISTICS` routine sets the dimensions of the screen and its background color. You can also use this routine to retrieve dimensions and background color. To get more detailed information about the physical device, use the `SMG$GET_PASTEBOARD_ATTRIBUTES` routine. Example 22–5 changes the screen width to 132 and the background to white, then restores the original width and background before exiting.

Example 22–5 Modifying Screen Dimensions and Background Color

```
.
.
.
INTEGER*4 WIDTH,
2          COLOR
INCLUDE   '($SMGDEF)'
```

(continued on next page)

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22.4 Working with Complex User I/O

Example 22–5 (Cont.) Modifying Screen Dimensions and Background Color

```
! Get current width and background color
STATUS = SMG$CHANGE_PBD_CHARACTERISTICS (PBID,,
2                                     WIDTH,,,,
2                                     COLOR)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Change width and background color
STATUS = SMG$CHANGE_PBD_CHARACTERISTICS (PBID,
2                                     132,,,,
2                                     SMG$C_COLOR_WHITE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
! Restore width and background color
STATUS = SMG$CHANGE_PBD_CHARACTERISTICS (PBID,
2                                     WIDTH,,,,
2                                     COLOR)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4.4 Virtual Displays

You write to virtual displays, which are logically configured as rectangles, by using the SMG\$ routines. The dimensions of a virtual display are designated vertically as rows and horizontally as columns. A position in a virtual display is designated by naming a row and a column. Row and column numbers begin at 1.

22.4.4.1 Creating a Virtual Display

Use the SMG\$CREATE_VIRTUAL_DISPLAY routine to create a virtual display. SMG\$CREATE_VIRTUAL_DISPLAY returns a unique virtual display identification number; use that number to refer to the virtual display.

Optionally, you can use the fifth argument of SMG\$CREATE_VIRTUAL_DISPLAY to specify one or more of the following video attributes: blinking, bolding, reversing background, and underlining. All characters written to that display will have the specified attribute unless you indicate otherwise when writing text to the display. The following example makes everything written to the display HEADER_VDID appear bold by default:

```
INCLUDE '($SMGDEF)'
.
.
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (1, ! Rows
2                                     80, ! Columns
2                                     HEADER_VDID,,
2                                     SMG$M_BOLD)
```

You can border a virtual display by specifying the fourth argument when you invoke SMG\$CREATE_VIRTUAL_DISPLAY. You can label the border with the routine SMG\$LABEL_BORDER. If you use a border, you must leave room for it: a border requires two rows and two columns more than the size of the display. The following example places a labeled border around the STATS_VDID display. As pasted, the border occupies rows 2 and 13 and columns 1 and 57.

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22.4 Working with Complex User I/O

```
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (10, ! Rows
2                                     55, ! Columns
2                                     STATS_VDID,
2                                     SMG$M_BORDER)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$LABEL_BORDER (STATS_VDID,
2                          'statistics')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (STATS_VDID,
2                                  PBID,
2                                  3, ! Row
2                                  2) ! Column
```

22.4.4.2 Pasting Virtual Displays

To make a virtual display visible, paste it to a pasteboard using the `SMG$PASTE_VIRTUAL_DISPLAY` routine. You position the virtual display by specifying which row and column of the pasteboard should contain the upper left corner of the display. Example 22–6 defines two virtual displays and pastes them to one pasteboard.

Example 22–6 Defining and Pasting a Virtual Display

```
.
.
.
INCLUDE '($SMGDEF)'
INTEGER*4 PBID,
2      HEADER_VDID,
2      STATS_VDID
INTEGER*4 STATUS,
2      SMG$CREATE_PASTEBOARD,
2      SMG$CREATE_VIRTUAL_DISPLAY,
2      SMG$PASTE_VIRTUAL_DISPLAY
! Create pasteboard for SYS$OUTPUT
STATUS = SMG$CREATE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Header pastes to first rows of screen
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (3, ! Rows
2                                     78, ! Columns
2                                     HEADER_VDID, ! Name
2                                     SMG$M_BORDER) ! Border
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (HEADER_VDID,
2                                  PBID,
2                                  2, ! Row
2                                  2) ! Column
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

(continued on next page)

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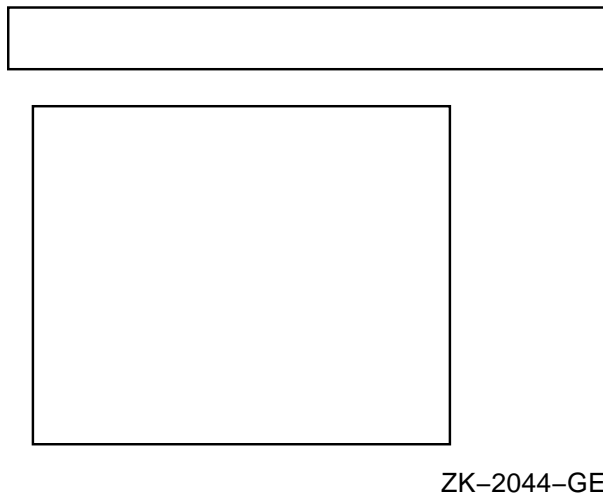
22.4 Working with Complex User I/O

Example 22–6 (Cont.) Defining and Pasting a Virtual Display

```
! Statistics area pastes to rows 5 through 15,  
! columns 2 through 56  
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (10,           ! Rows  
2                                     55,         ! Columns  
2                                     STATS_VDID, ! Name  
2                                     SMG$M_BORDER) ! Border  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (STATS_VDID,  
2                                     PBID,  
2                                     5,           ! Row  
2                                     2)           ! Column  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
.  
.  
.
```

Figure 22–1 shows the screen that results from Example 22–6.

Figure 22–1 Defining and Pasting Virtual Displays



You can paste a single display to any number of pasteboards. Any time you change the display, all pasteboards containing the display are automatically updated.

A pasteboard can hold any number of virtual displays. You can paste virtual displays over one another to any depth, occluding the displays underneath. The displays underneath are only occluded to the extent that they are covered; that is, the parts not occluded remain visible on the screen. (In Figure 22–2, displays 1 and 2 are partially occluded.) When you unpaste a virtual display that occludes another virtual display, the occluded part of the display underneath becomes visible again.

You can find out whether a display is occluded by using the `SMG$CHECK_FOR_OCCLUSION` routine. The following example pastes a two-row summary display over the last two rows of the statistics display, if the statistics display is not already occluded. If the statistics display is occluded, the example assumes that it is occluded by the summary display and unpastes the summary display, making the last two rows of the statistics display visible again.

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```

STATUS = SMG$CHECK_FOR_OCCLUSION (STATS_VDID,
2                               PBID,
2                               OCCLUDE_STATE)
! OCCLUDE_STATE must be defined as INTEGER*4
IF (OCCLUDE_STATE) THEN
  STATUS = SMG$UNPASTE_VIRTUAL_DISPLAY (SUM_VDID,
2                                     PBID)
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
ELSE
  STATUS = SMG$PASTE_VIRTUAL_DISPLAY (SUM_VDID,
2                                    PBID,
2                                    11,
2                                    2)
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
END IF

```

22.4.4.3 Rearranging Virtual Displays

Pasted displays can be rearranged by moving or repasting.

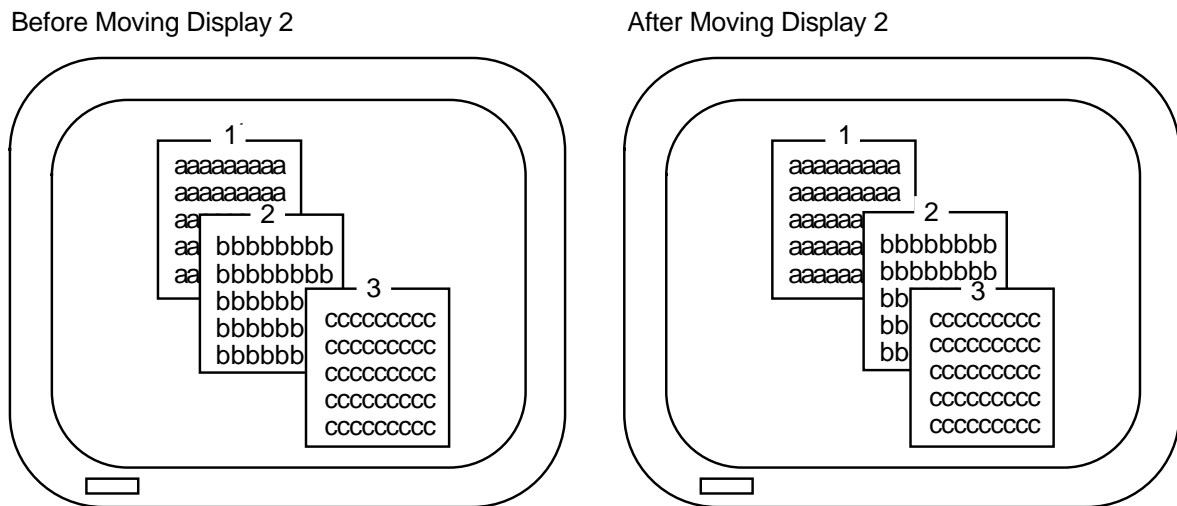
- **Moving**—To move a display, use the `SMG$MOVE_VIRTUAL_DISPLAY` routine. The following example moves display 2. Figure 22–2 shows the screen before and after the statement executes.

```

STATUS = SMG$MOVE_VIRTUAL_DISPLAY (VDID,
2                               PBID,
2                               5,
2                               10)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

```

Figure 22–2 Moving a Virtual Display



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- **Repasting**—To repaste a display, use the `SMG$REPASTE_VIRTUAL_DISPLAY` routine. The following example repastes display 2. Figure 22–3 shows the screen before and after the statement executes.

```

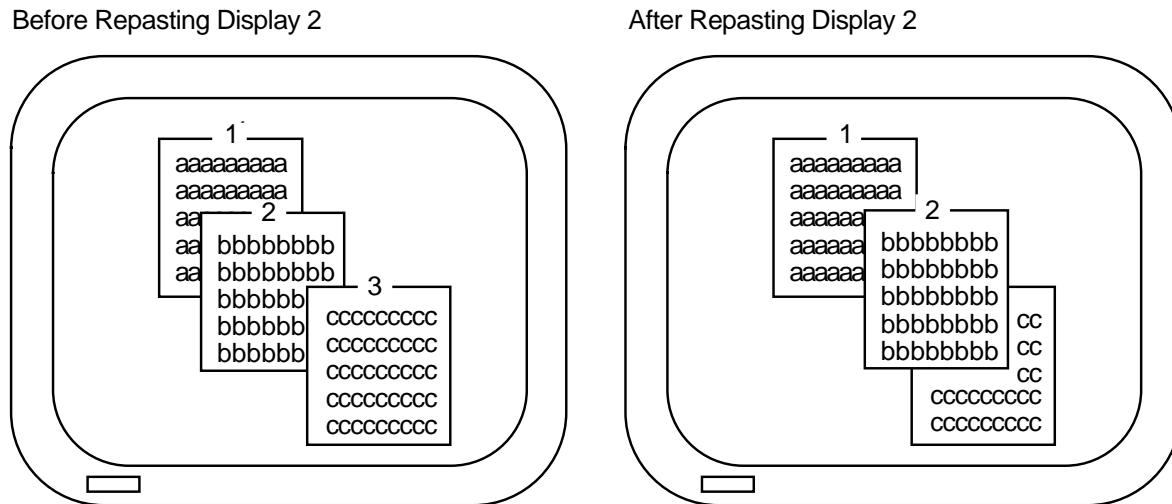
STATUS = SMG$REPASTE_VIRTUAL_DISPLAY (VDID,
2                               PBID,
2                               4,
2                               4)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

```

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22.4 Working with Complex User I/O

Figure 22–3 Repasting a Virtual Display



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You can obtain the pasting order of the virtual displays using `SMG$LIST_PASTING_ORDER`. This routine returns the identifiers of all the virtual displays pasted to a specified pasteboard.

22.4.4.4 Removing Virtual Displays

You can remove a virtual display from a pasteboard in a number of different ways:

- Erase a virtual display—Invoking `SMG$UNPASTE_VIRTUAL_DISPLAY` erases a virtual display from the screen but retains its contents in memory. The following example erases the statistics display:

```
STATUS = SMG$UNPASTE_VIRTUAL_DISPLAY (STATS_VDID,
2                                     PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

- Delete a virtual display—Invoking `SMG$DELETE_VIRTUAL_DISPLAY` removes a virtual display from the screen and removes its contents from memory. The following example deletes the statistics display:

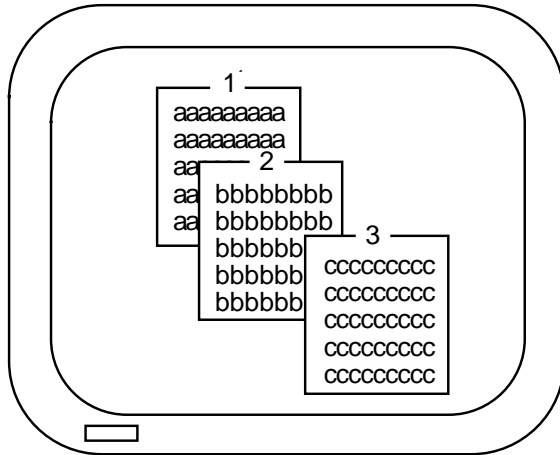
```
STATUS = SMG$DELETE_VIRTUAL_DISPLAY (STATS_VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

- Delete several virtual displays—Invoking `SMG$POP_VIRTUAL_DISPLAY` removes a specified virtual display and any virtual displays pasted after that display from the screen and removes the contents of those displays from memory. The following example “pops” display 2. Figure 22–4 shows the screen before and after popping. (Note that display 3 is deleted because it was pasted after display 2, and not because it is occluding display 2.)

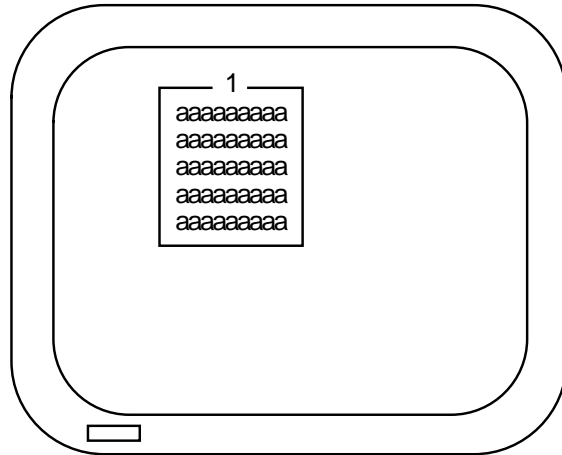
```
STATUS = SMG$POP_VIRTUAL_DISPLAY (STATS_VDID,
2                                 PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

Figure 22–4 Popping a Virtual Display

Before Popping Display 2



After Popping Display 2



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22.4.4.5 Modifying a Virtual Display

The screen management facility provides several routines for modifying the characteristics of an existing virtual display:

- SMG\$CHANGE_VIRTUAL_DISPLAY—Changes the size, video attributes, or border of a display
- SMG\$CHANGE_RENDITION—Changes the video attributes of a portion of a display
- SMG\$MOVE_TEXT—Moves text from one virtual display to another

The following example uses SMG\$CHANGE_VIRTUAL_DISPLAY to change the size of the WHOOPS display to five rows and seven columns and to turn off all of the display's default video attributes. If you decrease the size of a display that is on the screen, any characters in the excess area are removed from the screen.

```
STATUS = SMG$CHANGE_VIRTUAL_DISPLAY (WHOOPS_VDID,
2                                     5, ! Rows
2                                     7,, ! Columns
2                                     0) ! Video attributes off
```

The following example uses SMG\$CHANGE_RENDITION to direct attention to the first 20 columns of the statistics display by setting the reverse video attribute to the complement of the display's default setting for that attribute:

```
STATUS = SMG$CHANGE_RENDITION (STATS_VDID,
2                               1,           ! Row
2                               1,           ! Column
2                               10,         ! Number of rows
2                               20,         ! Number of columns
2                               ,           ! Video-set argument
2                               SMG$M_REVERSE) ! Video-comp argument
2
```

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SMG\$CHANGE_RENDITION uses three sets of video attributes to determine the attributes to apply to the specified portion of the display: (1) the display's default video attributes, (2) the attributes specified by the **rendition-set** argument of SMG\$CHANGE_RENDITION, and (3) the attributes specified by the **rendition-complement** argument of SMG\$CHANGE_RENDITION. Table 22–2 shows the result of each possible combination.

Table 22–2 Setting Video Attributes

rendition-set	rendition-complement	Result
off	off	Uses display default
on	off	Sets attribute
off	on	Uses the complement of display default
on	on	Clears attribute

In the preceding example, the reverse video attribute is set in the **rendition-complement** argument but not in the **rendition-set** argument, thus specifying that SMG\$CHANGE_RENDITION use the complement of the display's default setting to ensure that the selected portion of the display is easily seen.

Note that the resulting attributes are based on the display's default attributes, not its current attributes. If you use SMG\$ routines that explicitly set video attributes, the current attributes of the display may not match its default attributes.

22.4.4.6 Using Spawned Subprocesses

You can create a spawned subprocess directly with an SMG\$ routine to allow execution of a DCL command from an application. Only one spawned subprocess is allowed per virtual display. Use the following routines to work with subprocesses:

- SMG\$CREATE_SUBPROCESS—Creates a DCL spawned subprocess and associates it with a virtual display.
- SMG\$EXECUTE_COMMAND—Allows execution of a specified command in the created spawned subprocess by using mailboxes. Some restrictions apply to specifying the following commands:
 - SPAWN, GOTO, or LOGOUT cannot be used and will result in unpredictable results.
 - Single-character commands such as Ctrl/C have no effect. You can signal an end-of-file (that is, press Ctrl/Z) command by setting the **flags** argument.
 - A dollar sign (\$) must be specified as the first character of any DCL command.
- SMG\$DELETE_SUBPROCESS—Deletes the subprocess created by SMG\$CREATE_SUBPROCESS.

22.4.5 Viewports

Viewports allow you to view different pieces of a virtual display by moving a rectangular area around on the virtual display. Only one viewport is allowed for each virtual display. Once you have associated a viewport with a virtual display, the only part of the virtual display that is viewable is contained in the viewport.

The SMG\$ routines for working with viewports include the following:

- **SMG\$CREATE_VIEWPORT**—Creates a viewport and associates it with a virtual display. You must create the virtual display first. To view the viewport, you must paste the virtual display first with **SMG\$PASTE_VIRTUAL_DISPLAY**.
- **SMG\$SCROLL_VIEWPORT**—Scrolls the viewport within the virtual display. If you try to move the viewport outside of the virtual display, the viewport is truncated to stay within the virtual display. This routine allows you to specify the direction and extent of the scroll.
- **SMG\$CHANGE_VIEWPORT**—Moves the viewport to a new starting location and changes the size of the viewport.
- **SMG\$DELETE_VIEWPORT**—Deletes the viewport and dissociates it from the virtual display. The viewport is automatically unpasted. The virtual display associated with the viewport remains intact. You can unpaste a viewport without deleting it by using **SMG\$UNPASTE_VIRTUAL_DISPLAY**.

22.4.6 Writing Text to Virtual Display

The SMG\$ output routines allow you to write text to displays and to delete or modify the existing text of a display. Remember that changes to a virtual display are visible only if the virtual display is pasted to a pasteboard.

22.4.6.1 Positioning the Cursor

Each virtual display has its own logical cursor position. You can control the position of the cursor in a virtual display with the following routines:

- **SMG\$HOME_CURSOR**—Moves the cursor to a corner of the virtual display. The default corner is the upper left corner, that is, row 1, column 1 of the display.
- **SMG\$SET_CURSOR_ABS**—Moves the cursor to a specified row and column.
- **SMG\$SET_CURSOR_REL**—Moves the cursor to offsets from the current cursor position. A negative value means up (rows) or left (columns). A value of 0 means no movement.

In addition, many routines permit you to specify a starting location other than the current cursor position for the operation.

The **SMG\$RETURN_CURSOR_POS** routine returns the row and column of the current cursor position within a virtual display. You do not have to write special code to track the cursor position.

Typically, the physical cursor is at the logical cursor position of the most recently written-to display. If necessary, you can use the **SMG\$SET_PHYSICAL_CURSOR** routine to set the physical cursor location.

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22.4 Working with Complex User I/O

22.4.6.2 Writing Data Character by Character

If you are writing character by character (see Section 22.4.6.3 for line-oriented output), you can use three routines:

- `SMG$DRAW_CHAR`—Puts one line-drawing character on the screen at a specified position. It does not change the cursor position.
- `SMG$PUT_CHARS`—Puts one or more characters on the screen at a specified position, with the option of one video attribute.
- `SMG$PUT_CHARS_MULTI`—Puts several characters on the screen at a specified position, with multiple video attributes.

These routines are simple and precise. They place exactly the specified characters on the screen, starting at a specified position in a virtual display. Anything currently in the positions written-to is overwritten; no other positions on the screen are affected. Convert numeric data to character data with language I/O statements before invoking `SMG$PUT_CHARS`.

The following example converts an integer to a character string and places it at a designated position in a virtual display:

```
CHARACTER*4 HOUSE_NO_STRING
INTEGER*4   HOUSE_NO,
2          LINE_NO,
2          STATS_VDID
.
.
.
WRITE (UNIT=HOUSE_NO_STRING,
2      FMT='(I4)') HOUSE_NO
STATUS = SMG$PUT_CHARS (STATS_VDID,
2                      HOUSE_NO_STRING,
2                      LINE_NO, ! Row
2                      1)      ! Column
```

Note that the converted integer is right-justified from column 4 because the format specification is `I4` and the full character string is written. To left-justify a converted number, you must locate the first nonblank character and write a substring starting with that character and ending with the last character.

Inserting and Overwriting Text

To insert characters rather than overwrite the current contents of the screen, use the routine `SMG$INSERT_CHARS`. Existing characters at the location written to are shifted to the right. Characters pushed out of the display are truncated; no wrapping occurs and the cursor remains at the end of the last character inserted.

Specifying Double-Size Characters

In addition to the preceding routines, you can use `SMG$PUT_CHARS_WIDE` to write characters to the screen in double width or `SMG$PUT_CHARS_HIGHWIDE` to write characters to the screen in double height and double width. When you use these routines, you must allot two spaces for each double-width character on the line and two lines for each line of double-height characters. You cannot mix single-and double-size characters on a line.

All the character routines provide **rendition-set** and **rendition-complement** arguments, which allow you to specify special video attributes for the characters being written. `SMG$PUT_CHARS_MULTI` allows you to specify more than one video attribute at a time. The explanation of the `SMG$CHANGE_RENDITION` routine in Section 22.4.4.5 discusses how to use **rendition-set** and **rendition-complement** arguments.

22.4.6.3 Writing Data Line by Line

The `SMG$PUT_LINE` and `SMG$PUT_LINE_MULTI` routines write lines to virtual displays one line after another. If the display area is full, it is scrolled. You do not have to keep track of which line you are on. All routines permit you to scroll forward (up); `SMG$PUT_LINE` and `SMG$PUT_LINE_MULTI` permit you to scroll backward (down) as well. `SMG$PUT_LINE` permits spacing other than single spacing.

Example 22–7 writes lines from a buffer to a display area. The output is scrolled forward if the buffer contains more lines than the display area.

Example 22–7 Scrolling Forward Through a Display

```
INTEGER*4      BUFF_COUNT,  
2             BUFF_SIZE (4096)  
CHARACTER*512 BUFF (4096)  
.  
.  
.  
DO I = 1, BUFF_COUNT  
  STATUS = SMG$PUT_LINE (VDID,  
2             BUFF (I) (1:BUFF_SIZE (I)))  
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
END DO
```

Example 22–8 scrolls the output backward.

Example 22–8 Scrolling Backward Through a Display

```
DO I = BUFF_COUNT, 1, -1  
  STATUS = SMG$PUT_LINE (VDID,  
2             BUFF (I) (1:BUFF_SIZE (I)),  
2             SMG$M_DOWN)  
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
END DO
```

Cursor Movement and Scrolling

To maintain precise control over cursor movement and scrolling, you can write with `SMG$PUT_CHARS` and scroll explicitly with `SMG$SCROLL_DISPLAY_AREA`. `SMG$PUT_CHARS` leaves the cursor after the last character written and does not force scrolling; `SMG$SCROLL_DISPLAY_AREA` scrolls the current contents of the display forward, backward, or sideways without writing to the display. To restrict the scrolling region to a portion of the display area, use the `SMG$SET_DISPLAY_SCROLL_REGION` routine.

Inserting and Overwriting Text

To insert text rather than overwrite the current contents of the screen, use the `SMG$INSERT_LINE` routine. Existing lines are shifted up or down to open space for the new text. If the text is longer than a single line, you can specify whether or not you want the excess characters to be truncated or wrapped.

Using Double-Width Characters

In addition, you can use `SMG$PUT_LINE_WIDE` to write a line of text to the screen using double-width characters. You must allot two spaces for each double-width character on the line. You cannot mix single- and double-width characters on a line.

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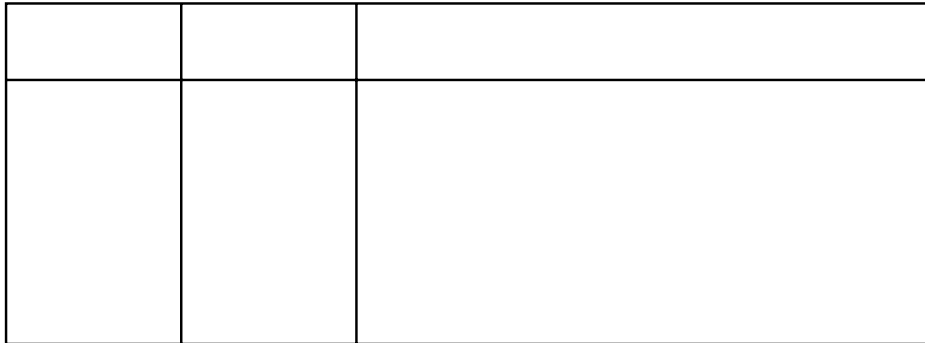
Specifying Special Video Attributes

All line routines provide **rendition-set** and **rendition-complement** arguments, which allow you to specify special video attributes for the text being written. SMG\$PUT_LINE_MULTI allows you to specify more than one video attribute for the text. The explanation of the SMG\$CHANGE_RENDITION routine in Section 22.4.4.5 discusses how to use the **rendition-set** and **rendition-complement** arguments.

22.4.6.4 Drawing Lines

The routine SMG\$DRAW_LINE draws solid lines on the screen. Appropriate corner and crossing marks are drawn when lines join or intersect. The routine SMG\$DRAW_CHARACTER draws a single character. You can also use the routine SMG\$DRAW_RECTANGLE to draw a solid rectangle. Suppose that you want to draw an object such as that shown in Figure 22–5 in the statistics display area (an area of 10 rows by 55 columns).

Figure 22–5 Statistics Display



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Example 22–9 shows how you can create a statistics display using SMG\$DRAW_LINE and SMG\$DRAW_RECTANGLE.

Example 22–9 Creating a Statistics Display

```
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (10,  
2                                     55,  
2                                     STATS_VDID)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
! Draw rectangle with upper left corner at row 1 column 1  
! and lower right corner at row 10 column 55  
STATUS =SMG$DRAW_RECTANGLE (STATS_VDID,  
2                             1, 1,  
2                             10, 55)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
! Draw vertical lines at columns 11, 21, and 31  
DO I = 11, 31, 10  
    STATUS = SMG$DRAW_LINE (STATS_VDID,  
2                             1, I,  
2                             10, I)  
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
END DO
```

(continued on next page)

Example 22–9 (Cont.) Creating a Statistics Display

```
! Draw horizontal line at row 3
STATUS = SMG$DRAW_LINE (STATS_VDID,
2                      3, 1,
2                      3, 55)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (STATS_VDID,
2                                  PBID,
2                                  3,
2                                  2)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4.6.5 Deleting Text

The following routines erase specified characters, leaving the rest of the screen intact:

- **SMG\$ERASE_CHARS**—Erases specified characters on one line.
- **SMG\$ERASE_LINE**—Erases the characters on one line starting from a specified position.
- **SMG\$ERASE_DISPLAY**—Erases specified characters on one or more lines.
- **SMG\$ERASE_COLUMN**—Erases a column from the specified row to the end of the column from the virtual display.

The following routines perform delete operations. In a delete operation, characters following the deleted characters are shifted into the empty space.

- **SMG\$DELETE_CHARS**—Deletes specified characters on one line. Any characters to the right of the deleted characters are shifted left.
- **SMG\$DELETE_LINE**—Deletes one or more full lines. Any remaining lines in the display are scrolled up to fill the empty space.

The following example erases the remaining characters on the line whose line number is specified by **LINE_NO**, starting at the column specified by **COLUMN_NO**:

```
STATUS = SMG$ERASE_LINE (STATS_VDID,
2                      LINE_NO,
2                      COLUMN_NO)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.4.7 Using Menus

You can use **SMG\$** routines to set up menus to read user input. The type of menu you can create include the following:

- **Block menu**—Selections are in matrix format. This is the type of menu often used.
- **Vertical menu**—Each selection is on its own line.
- **Horizontal menu**—All selections are on one line.

Menus are associated with a virtual display, and only one menu can be used for each virtual display.

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The menu routines include the following:

- `SMG$CREATE_MENU`—Creates a menu associated with a virtual display. This routine allows you to specify the type of menu, the position in which the menu is displayed, the format of the menu (single or double spaced), and video attributes.
- `SMG$SELECT_FROM_MENU`—Sets up menu selection capability. You can specify a default menu selection (which is shown in reverse video), whether online help is available, a maximum time limit for making a menu selection, a key indicating read termination, whether to send the text of the menu item selected to a string, and a video attribute.
- `SMG$DELETE_MENU`—Discontinues access to the menu and erases it.

When you are using menus, no other output should be sent to the menu area; otherwise, unpredictable results may occur.

The default `SMG$SELECT_FROM_MENU` allows specific operations, such as use of the arrow keys to move up and down the menu selections, keys to make a menu selection, ability to select more than one item at a time, ability to reselect an item already selected, and the key sequence to invoke online help. By using the **flags** argument to modify this operation, you have the option of disallowing reselection of a menu item and of allowing any key pressed to select an item.

22.4.8 Reading Data

You can read text from a virtual display (`SMG$READ_FROM_DISPLAY`) or from a virtual keyboard (`SMG$READ_STRING`, `SMG$READ_COMPOSED_LINE`, or `SMG$READ_KEYSTROKE`). The three routines for virtual keyboard input are known as the `SMG$` input routines. `SMG$READ_FROM_DISPLAY` is not a true input routine because it reads text from the virtual display rather than from a user.

The `SMG$` input routines can be used alone or with the `SMG$` output routines. This section assumes that you are using the input routines with the output routines. Section 22.5 describes how to use the input routines without the output routines.

When you use the `SMG$` input routines with the `SMG$` output routines, always specify the optional **vdid** argument of the input routine, which specifies the virtual display in which the input is to occur. The specified virtual display must be pasted to the device associated with the virtual keyboard that is specified as the first argument of the input routine. The display must be pasted in column 1, cannot be occluded, and cannot have any other display to its right; input begins at the current cursor position, but the cursor must be in column 1.

22.4.8.1 Reading from a Display

You can read the contents of the display using the routine `SMG$READ_FROM_DISPLAY`. By default, the read operation reads all of the characters from the current cursor position to the end of that line. The **row** argument of `SMG$READ_FROM_DISPLAY` allows you to choose the starting point of the read operation, that is, the contents of the specified row to the rightmost column in that row.

If the **terminator-string** argument is specified, `SMG$READ_FROM_DISPLAY` searches backward from the current cursor position and reads the line beginning at the first **terminator** encountered (or at the beginning of the line). A

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22.4 Working with Complex User I/O

terminator is a character string. You must calculate the length of the character string read operation yourself.

The following example reads the current contents of the first line in the STATS_VDID display:

```
CHARACTER*4 STRING
INTEGER*4   SIZE
.
.
.
STATUS = SMG$HOME_CURSOR (STATS_VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = SMG$READ_FROM_DISPLAY (STATS_VDID,
2                               STRING)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
SIZE = 55
DO WHILE ((STRING (SIZE:SIZE) .EQ. ' ') .AND.
2         (SIZE .GT. 1))
    SIZE = SIZE - 1
END DO
```

22.4.8.2 Reading from a Virtual Keyboard

The SMG\$CREATE_VIRTUAL_KEYBOARD routine establishes a device for input operations; the default device is the user's terminal. The routine SMG\$READ_STRING reads characters typed on the screen either until the user types a terminator or until the maximum size (which defaults to 512 characters) is exceeded. (The terminator is usually a carriage return; see the routine description in the *OpenVMS RTL Screen Management (SMG\$) Manual* for a complete list of terminators.) The current cursor location for the display determines where the read operation begins.

The operating system's terminal driver processes carriage returns differently than the SMG\$ routines. Therefore, in order to scroll input accurately, you must keep track of your vertical position in the display area. Explicitly set the cursor position and scroll the display. If a read operation takes place on a row other than the last row of the display, advance the cursor to the beginning of the next row before the next operation. If a read operation takes place on the last row of the display, scroll the display with SMG\$SCROLL_DISPLAY_AREA and then set the cursor to the beginning of the row. Modify the read operation with TRM\$M_TM_NOTRMECHO to ensure that no extraneous scrolling occurs.

Example 22–10 reads input until Ctrl/Z is pressed.

Example 22–10 Reading Data from a Virtual Keyboard

```
.
.
.
! Read first record
STATUS = SMG$HOME_CURSOR (VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (KBID,
2                         TEXT,
2                         'Prompt: ',
2                         4,
2                         TRM$M_TM_TRMNOECHO,,,
2                         TEXT_SIZE,,
2                         VDID)
```

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22.4 Working with Complex User I/O

Example 22–10 (Cont.) Reading Data from a Virtual Keyboard

```
! Read remaining records until CTRL/Z
DO WHILE (STATUS .NE. SMG$_EOF)
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
  ! Process record
  .
  .
  ! Set up screen for next read
  ! Display area contains four rows
  STATUS = SMG$RETURN_CURSOR_POS (VDID, ROW, COL)
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
  IF (ROW .EQ. 4) THEN
    STATUS = SMG$SCROLL_DISPLAY_AREA (VDID)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
    STATUS = SMG$SET_CURSOR_ABS (VDID, 4, 1)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
  ELSE
    STATUS = SMG$SET_CURSOR_ABS (VDID,, 1)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
    STATUS = SMG$SET_CURSOR_REL (VDID, 1)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
  END IF
  ! Read next record
  STATUS = SMG$READ_STRING (KBID,
2      TEXT,
2      'Prompt: ',
2      4,
2      TRM$_TM_TRMNOECHO,,,
2      TEXT_SIZE,,
2      VDID)
END DO
```

Note

Because you are controlling the scrolling, `SMG$PUT_LINE` and `SMG$PUT_LINE_MULTI` might not scroll as expected. When scrolling a mix of input and output, you can prevent problems by using `SMG$PUT_CHARS`.

22.4.8.3 Reading from the Keypad

To read from the keypad in keypad mode (that is, pressing a keypad character to perform some special action rather than entering data), modify the read operation with `TRM$_TM_ESCAPE` and `TRM$_TM_NOECHO`. Examine the terminator to determine which key was pressed.

Example 22–11 moves the cursor on the screen in response to the user's pressing the keys surrounding the keypad 5 key. The keypad 8 key moves the cursor north (up); the keypad 9 key moves the cursor northeast; the keypad 6 key moves the cursor east (right); and so on. The `SMG$SET_CURSOR_REL` routine is called, instead of being invoked as a function, because you do not want to abort the program on an error. (The error attempts to move the cursor out of the display area and, if this error occurs, you do not want the cursor to move.) The read operation is also modified with `TRM$_TM_PURGE` to prevent the user from getting ahead of the cursor.

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22.4 Working with Complex User I/O

See Section 22.4.8.1 for the guidelines for reading from the display.

Example 22–11 Reading Data from the Keypad

```
.
.
.
INTEGER STATUS,
2     PBID,
2     ROWS,
2     COLUMNS,
2     VDIM,      ! Virtual display ID
2     KID,       ! Keyboard ID
2     SMG$CREATE_PASTEBOARD,
2     SMG$CREATE_VIRTUAL_DISPLAY,
2     SMG$CREATE_VIRTUAL_KEYBOARD,
2     SMG$PASTE_VIRTUAL_DISPLAY,
2     SMG$HOME_CURSOR,
2     SMG$SET_CURSOR_REL,
2     SMG$READ_STRING,
2     SMG$ERASE_PASTEBOARD,
2     SMG$PUT_CHARS,
2     SMG$READ_FROM_DISPLAY
CHARACTER*31 INPUT_STRING,
2         MENU_STRING
INTEGER*2   TERMINATOR
INTEGER*4   MODIFIERS
INCLUDE '$SMGDEF'
INCLUDE '$TRMDEF'
! Set up screen and keyboard
STATUS = SMG$CREATE_PASTEBOARD (PBID,
2                               'SYS$OUTPUT',
2                               ROWS,
2                               COLUMNS)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (ROWS,
2                                     COLUMNS,
2                                     VDIM)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PUT_CHARS (VDIM,
2                       '___ MENU CHOICE ONE',
2                       10,30)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PUT_CHARS (VDIM,
2                       '___ MENU CHOICE TWO',
2                       15,30)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (KID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (VDIM,
2                                   PBID,
2                                   1,
2                                   1)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Put cursor in NW corner
STATUS = SMG$HOME_CURSOR (VDIM)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

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22.4 Working with Complex User I/O

Example 22–11 (Cont.) Reading Data from the Keypad

```
! Read character from keyboard
MODIFIERS = TRM$M_TM_ESCAPE .OR.
2          TRM$M_TM_NOECHO .OR.
2          TRM$M_TM_PURGE
STATUS = SMG$READ_STRING (KID,
2          INPUT_STRING,
2          ,
2          6,
2          MODIFIERS,
2          ,
2          ,
2          TERMINATOR)
DO WHILE ((STATUS) .AND.
2          (TERMINATOR .NE. SMG$K_TRM_CR))
! Check status of last read
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! North
IF (TERMINATOR .EQ. SMG$K_TRM_KP8) THEN
CALL SMG$SET_CURSOR_REL (VDID, -1, 0)
! Northeast
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP9) THEN
CALL SMG$SET_CURSOR_REL (VDID, -1, 1)
! Northwest
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP7) THEN
CALL SMG$SET_CURSOR_REL (VDID, -1, -1)
! South
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP2) THEN
CALL SMG$SET_CURSOR_REL (VDID, 1, 0)
! Southeast
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP3) THEN
CALL SMG$SET_CURSOR_REL (VDID, 1, 1)
! Southwest
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP1) THEN
CALL SMG$SET_CURSOR_REL (VDID, 1, -1)
! East
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP6) THEN
CALL SMG$SET_CURSOR_REL (VDID, 0, 1)
! West
ELSE IF (TERMINATOR .EQ. SMG$K_TRM_KP4) THEN
CALL SMG$SET_CURSOR_REL (VDID, 0, -1)
END IF
! Read another character
STATUS = SMG$READ_STRING (KID,
2          INPUT_STRING,
2          ,
2          6,
2          MODIFIERS,
2          ,
2          ,
2          TERMINATOR)
END DO
```

(continued on next page)

Example 22–11 (Cont.) Reading Data from the Keypad

```
! Read menu entry and process
!
STATUS = SMG$READ_FROM_DISPLAY (VDID,
2                               MENU_STRING)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
.
! Clear screen
STATUS = SMG$ERASE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
END
```

22.4.8.4 Reading Composed Input

The SMG\$CREATE_KEY_TABLE routine creates a table that equates keys to character strings. When you read input using the routine SMG\$READ_COMPOSED_LINE and the user presses a defined key, the corresponding character string in the table is substituted for the key. You can use the SMG\$ADD_KEY_DEF routine to load the table. Composed input also permits the following:

- **If states**—You can define the same key to mean different things in different states. You can define a key to cause a change in state. The change in state can be temporary (until after the next defined key is pressed) or permanent (until a key that changes states is pressed).
- **Input termination**—You can define the key to cause termination of the input transmission (as if the Return key were pressed after the character string). If the key is not defined to cause termination of the input, the user must press a terminator or another key that does cause termination.

Example 22–12 defines keypad keys 1 through 9 and permits the user to change state temporarily by pressing the PF1 key. Pressing the keypad 1 key is equivalent to typing 1000 and pressing the Return key. Pressing PF1 key and then the keypad 1 key is equivalent to typing 10000 and pressing the Return key.

Example 22–12 Redefining Keys

```
INTEGER*4 TABLEID
.
.
.
! Create table for key definitions
STATUS = SMG$CREATE_KEY_TABLE (TABLEID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Load table
! If user presses PF1, the state changes to BYTEN
! The BYTEN state is in effect only for the very next key
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2                          'PF1',
2                          'BYTEN')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

(continued on next page)

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22.4 Working with Complex User I/O

Example 22–12 (Cont.) Redefining Keys

```
! Pressing KP1 through Kp9 in the null state is like typing
! 1000 through 9000 and pressing return
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP1',
2      ,
2      SMG$M_KEY_TERMINATE,
2      '1000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP2',
2      ,
2      SMG$M_KEY_TERMINATE,
2      '2000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP9',
2      ,
2      SMG$M_KEY_TERMINATE,
2      '9000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Pressing KP1 through KP9 in the BYTEN state is like
! typing 10000 through 90000 and pressing return
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP1',
2      'BYTEN',
2      SMG$M_KEY_TERMINATE,
2      '10000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP2',
2      'BYTEN',
2      SMG$M_KEY_TERMINATE,
2      '20000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
STATUS = SMG$ADD_KEY_DEF (TABLEID,
2      'KP9',
2      'BYTEN',
2      SMG$M_KEY_TERMINATE,
2      '90000')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

(continued on next page)

Example 22–12 (Cont.) Redefining Keys

```
! End loading key definition table
.
.
! Read input which substitutes key definitions where appropriate
STATUS = SMG$READ_COMPOSED_LINE (KBID,
2          TABLEID,
2          STRING,
2          SIZE,
2          VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
```

Use the `SMG$DELETE_KEY_DEF` routine to delete a key definition; use the `SMG$GET_KEY_DEF` routine to examine a key definition. You can also load key definition tables with the `SMG$DEFINE_KEY` and `SMG$LOAD_KEY_DEFS` routines; use the DCL command `DEFINE/KEY` to specify input to these routines.

To use keypad keys 0 through 9, the keypad must be in application mode. For details, see `SMG$SET_KEYPAD_MODE` in the *OpenVMS RTL Screen Management (SMG\$) Manual*.

22.4.9 Controlling Screen Updates

If your program needs to make a number of changes to a virtual display, you can use `SMG$` routines to make all of the changes before updating the display. The `SMG$BEGIN_DISPLAY_UPDATE` routine causes output operations to a pasted display to be reflected only in the display's buffers. The `SMG$END_DISPLAY_UPDATE` routine writes the display's buffer to the pasteboard.

The `SMG$BEGIN_DISPLAY_UPDATE` and `SMG$END_DISPLAY_UPDATE` routines increment and decrement a counter. When this counter's value is 0, output to the virtual display is sent to the pasteboard immediately. The counter mechanism allows a subroutine to request and turn off batching without disturbing the batching state of the calling program.

A second set of routines, `SMG$BEGIN_PASTEBOARD_UPDATE` and `SMG$END_PASTEBOARD_UPDATE`, allow you to buffer output to a pasteboard in a similar manner.

22.4.10 Maintaining Modularity

When using the `SMG$` routines, you must take care not to corrupt the mapping between the screen appearance and the internal representation of the screen. Therefore, observe the following guidelines:

- **Mixing SMG I/O and other forms of I/O**
In general, do not use any other form of terminal I/O while the terminal is active as a pasteboard. If you do use I/O other than SMG I/O (for example, if you invoke a subprogram that may perform non-SMG terminal I/O), first invoke the `SMG$SAVE_PHYSICAL_SCREEN` routine and when the non-SMG I/O completes, invoke the `SMG$RESTORE_PHYSICAL_SCREEN` routine, as demonstrated in the following example:

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```
STATUS = SMG$SAVE_PHYSICAL_SCREEN (PBID,
2                                SAVE_VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
CALL GET_EXTRA_INFO (INFO_ARRAY)
STATUS = SMG$RESTORE_PHYSICAL_SCREEN (PBID,
2                                SAVE_VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

- **Sharing the pasteboard**

A routine using the terminal screen without consideration for its current contents must use the existing pasteboard ID associated with the terminal and delete any virtual displays it creates before returning control to the high-level code. This guideline also applies to the program unit that invokes a subprogram that also performs screen I/O. The safest way to clean up your virtual displays is to call the SMG\$POP_VIRTUAL_DISPLAY routine and name the first virtual display you created. The following example invokes a subprogram that uses the terminal screen:

Invoking Program Unit

```
CALL GET_EXTRA_INFO (PBID,
2                    INFO_ARRAY)
.
.
.
CALL STATUS = SMG$CREATE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

Subprogram

```
SUBROUTINE GET_EXTRA_INFO (PBID,
2                          INFO_ARRAY)
.
.
.
! Start executable code
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (4,
2                                40,
2                                INSTR_VDID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (INSTR_VDID,
2                                PBID, 1, 1)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
.
STATUS = SMG$POP_VIRTUAL_DISPLAY (INSTR_VDID,
2                                PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
END
```

- **Sharing virtual displays**

To share a virtual display created by high-level code, the low-level code must use the virtual display ID created by the high-level code; an invoking program unit must pass the virtual display ID to the subprogram. To share a virtual display created by low-level code, the high-level code must use the virtual display ID created by the low-level code; a subprogram must return the virtual display ID to the invoking program.

The following example permits a subprogram to use a virtual display created by the invoking program unit:

Invoking Program Unit

```
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (4,  
2                                40,  
2                                INSTR_VDID)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (INSTR_VDID,  
2                                PBID, 1, 1)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))  
CALL GET_EXTRA_INFO (PBID,  
2                                INSTR_VDID)  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

Subprogram

```
SUBROUTINE GET_EXTRA_INFO (PBID,  
2                                INSTR_VDID)
```

22.5 Performing Special Input/Output Actions

Screen management input routines and the SYSSQIO and SYSSQIOW system services allow you to perform I/O operations otherwise unavailable to high-level languages. For example, you can allow a user to interrupt normal program execution by typing a character and by providing a mechanism for reading that character. You can also control such things as echoing, time allowed for input, and whether data is read from the type-ahead buffer.

Some of the operations described in the following sections require the use of the SYSSQIO or SYSSQIOW system services. For more information about the QIO system services, see the *OpenVMS System Services Reference Manual* and Chapter 23.

Other operations, described in the following sections, can be performed by calling the SMG\$ input routines. The SMG\$ input routines can be used alone or with the SMG\$ output routines. Section 22.4 describes how to use the input routines with the output routines. This section assumes that you are using the input routines alone. To use the SMG\$ input routines, do the following:

1. Call SMG\$CREATE_VIRTUAL_KEYBOARD to associate a logical keyboard with a device or file specification (SYSS\$INPUT by default). SMG\$CREATE_VIRTUAL_KEYBOARD returns a keyboard identification number; use that number to identify the device or file to the SMG\$ input routines.
2. Call an SMG\$ input routine (SMG\$READ_STRING or SMG\$READ_COMPOSED_LINE) to read data typed at the device associated with the virtual keyboard.

When using the SMG\$ input routines without the SMG\$ output routines, do not specify the optional VDID argument of the input routine.

22.5.1 Using Ctrl/C and Ctrl/Y Interrupts

The QIO system services enable you to detect a Ctrl/C or Ctrl/Y interrupt at a user terminal, even if you have not issued a read to the terminal. To do so, you must take the following steps:

1. Queue an asynchronous system trap (AST)—Issue the SYSSQIO or SYSSQIOW system service with a function code of IOS_SETMODE modified by either IOSM_CTRLCAST (for Ctrl/C interrupts) or IOSM_CTRLYAST (for Ctrl/Y interrupts). For the **P1** argument, provide the

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name of a subroutine to be executed when the interrupt occurs. For the **P2** argument, you can optionally identify one longword argument to pass to the AST subroutine.

2. Write an AST subroutine—Write the subroutine identified in the **P1** argument of the QIO system service and link the subroutine into your program. Your subroutine can take one longword dummy argument to be associated with the **P2** argument in the QIO system service. You must define common areas to access any other data in your program from the AST routine.

If you press Ctrl/C or Ctrl/Y after your program queues the appropriate AST, the system interrupts your program and transfers control to your AST subroutine (this action is called delivering the AST). After your AST subroutine executes, the system returns control to your program at the point of interruption (unless your AST subroutine causes the program to exit, or unless another AST has been queued). Note the following guidelines for using Ctrl/C and Ctrl/Y ASTs:

- ASTs are asynchronous—Since your AST subroutine does not know exactly where you are in your program when the interrupt occurs, you should avoid manipulating data or performing other mainline activities. In general, the AST subroutine should either notify the mainline code (for example, by setting a flag) that the interrupt occurred, or clean up and exit from the program (if that is what you want to do).
- ASTs need new channels to the terminal—If you try to access the terminal with language I/O statements using SYSS\$INPUT or SYSS\$OUTPUT, you may receive a redundant I/O error. You must establish another channel to the terminal by explicitly opening the terminal.
- Ctrl/C and Ctrl/Y ASTs are one-time ASTs—After a Ctrl/C or Ctrl/Y AST is delivered, it is dequeued. You must reissue the QIO system service if you wish to trap another interrupt.
- Many ASTs can be queued—You can queue multiple ASTs (for the same or different AST subroutines, on the same or different channels) by issuing the appropriate number of QIO system services. The system delivers the ASTs on a last-in, first-out (LIFO) basis.
- Unhandled Ctrl/Cs turn into Ctrl/Ys—If the user enters Ctrl/C and you do not have an AST queued to handle the interrupt, the system turns the Ctrl/C interrupt into a Ctrl/Y interrupt.
- DCL handles Ctrl/Y interrupts—DCL handles Ctrl/Y interrupts by returning the user to DCL command level, where the user has the option of continuing or exiting from your program. DCL takes precedence over your AST subroutine for Ctrl/Y interrupts. Your Ctrl/Y AST subroutine is executed only under the following circumstances:
 - If Ctrl/Y interrupts are disabled at DCL level (SET NOCONTROL_Y) before your program is executed
 - If your program disables DCL Ctrl/Y interrupts with LIB\$DISABLE_CTRL
 - If the user elects to continue your program after DCL interrupts it
- You can dequeue Ctrl/C and Ctrl/Y ASTs—You can dequeue all Ctrl/C or Ctrl/Y ASTs on a channel by issuing the appropriate QIO system service with a value of 0 for the **P1** argument (passed by immediate value). You can dequeue all Ctrl/C ASTs on a channel by issuing the SYSS\$CANCEL system

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service for the appropriate channel. You can dequeue all Ctrl/Y ASTs on a channel by issuing the SYSSDASSGN system service for the appropriate channel.

- You can use SMGS routines—You can connect to the terminal using the SMGS routines from either AST level or mainline code. Do not attempt to connect to the terminal from AST level if you do so in your mainline code.

Example 22–13 permits the terminal user to interrupt a display to see how many lines have been typed up to that point.

Example 22–13 Using Interrupts to Perform I/O

```
!Main Program
.
.
.
INTEGER STATUS
! Accumulated data records
CHARACTER*132 STORAGE (255)
INTEGER*4 STORAGE_SIZE (255),
2 STORAGE_COUNT
! QIOW and QIO structures
INTEGER*2 INPUT_CHAN
INTEGER*4 CODE
STRUCTURE /IOSTAT_BLOCK/
  INTEGER*2 IOSTAT
  BYTE TRANSMIT,
2 RECEIVE,
2 CRFILL,
2 LFFILL,
2 PARITY,
2 ZERO
END STRUCTURE
RECORD /IOSTAT_BLOCK/ IOSB
! Flag to notify program of CTRL/C interrupt
LOGICAL*4 CTRLC_CALLED
! AST subroutine to handle CTRL/C interrupt
EXTERNAL CTRLC_AST
! Subroutines
INTEGER SYS$ASSIGN,
2 SYS$QIOW
! Symbols used for I/O operations
INCLUDE '($IODEF)'
! Put values into array
CALL LOAD_STORAGE (STORAGE,
2 STORAGE_SIZE,
2 STORAGE_COUNT)
! Assign channel and set up QIOW structures
STATUS = SYS$ASSIGN ('SYS$INPUT',
2 INPUT_CHAN,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
CODE = IO$_SETMODE .OR. IO$_M_CTRLCAST
```

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Example 22–13 (Cont.) Using Interrupts to Perform I/O

```
! Queue an AST to handle CTRL/C interrupt
STATUS = SYS$QIOW (,
2           %VAL (INPUT_CHAN),
2           %VAL (CODE),
2           IOSB,
2           '',
2           CTRLC_AST, ! Name of AST routine
2           CTRLC_CALLED, ! Argument for AST routine
2           ',,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
IF (.NOT. IOSB.IOSTAT)
2 CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
! Display STORAGE array, one element per line
DO I = 1, STORAGE_COUNT
  TYPE *, STORAGE (I) (1:STORAGE_SIZE (I))

  ! Additional actions if user types CTRL/C
  IF (CTRLC_CALLED) THEN
    CTRLC_CALLED = .FALSE.
    ! Show user number of lines displayed so far
    TYPE *, 'Number of lines: ', I
    ! Requeue AST
    STATUS = SYS$QIOW (,
2           %VAL (INPUT_CHAN),
2           %VAL (CODE),
2           IOSB,
2           '',
2           CTRLC_AST,
2           CTRLC_CALLED,
2           ',,)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
    IF (.NOT. IOSB.IOSTAT)
2 CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
  END IF
END DO
END
```

AST Routine

```
! AST routine
! Notifies program that user typed CTRL/C
SUBROUTINE CTRLC_AST (CTRLC_CALLED)
LOGICAL*4 CTRLC_CALLED
CTRLC_CALLED = .TRUE.
END
```

22.5.2 Detecting Unsolicited Input

You can detect input from the terminal even if you have not called `SMG$READ_COMPOSED_LINE` or `SMG$READ_STRING` by using `SMG$ENABLE_UNSOLICITED_INPUT`. This routine uses the AST mechanism to transfer control to a subprogram of your choice each time the user types at the terminal; the AST subprogram is responsible for reading any input. When the subprogram completes, control returns to the point in your mainline code where it was interrupted.

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The `SMG$ENABLE_UNSOLICITED_INPUT` routine is not an `SMG$` input routine. Before invoking `SMG$ENABLE_UNSOLICITED_INPUT`, you must invoke `SMG$CREATE_PASTEBOARD` to associate a pasteboard with the terminal and `SMG$CREATE_VIRTUAL_KEYBOARD` to associate a virtual keyboard with the same terminal.

`SMG$ENABLE_UNSOLICITED_INPUT` accepts the following arguments:

- The pasteboard identification number (use the value returned by `SMG$CREATE_PASTEBOARD`)
- The name of an AST subprogram
- An argument to be passed to the AST subprogram

When `SMG$ENABLE_UNSOLICITED_INPUT` invokes the AST subprogram, it passes two arguments to the subprogram: the pasteboard identification number and the argument that you specified. Typically, you write the AST subprogram to read the unsolicited input with `SMG$READ_STRING`. Since `SMG$READ_STRING` requires that you specify the virtual keyboard at which the input was typed, specify the virtual keyboard identification number as the second argument to pass to the AST subprogram.

Example 22–14 permits the terminal user to interrupt the display of a series of arrays, and either to go on to the next array (by typing input beginning with an uppercase N) or to exit from the program (by typing input beginning with anything else).

Example 22–14 Receiving Unsolicited Input from a Virtual Keyboard

```
! Main Program
! The main program calls DISPLAY_ARRAY once for each array.
! DISPLAY_ARRAY displays the array in a DO loop.
! If the user enters input from the terminal, the loop is
! interrupted and the AST routine takes over.
! If the user types anything beginning with an N, the AST
! sets DO_NEXT and resumes execution -- DISPLAY_ARRAY drops
! out of the loop processing the array (because DO_NEXT is
! set -- and the main program calls DISPLAY_ARRAY for the
! next array.
! If the user types anything not beginning with an N,
! the program exits.
.
.
.
INTEGER*4 STATUS,
2          VKID, ! Virtual keyboard ID
2          PBID  ! Pasteboard ID
! Storage arrays
INTEGER*4 ARRAY1 (256),
2          ARRAY2 (256),
2          ARRAY3 (256)
! System routines
INTEGER*4 SMG$CREATE_PASTEBOARD,
2          SMG$CREATE_VIRTUAL_KEYBOARD,
2          SMG$ENABLE_UNSOLICITED_INPUT
! AST routine
EXTERNAL  AST_ROUTINE
```

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Example 22–14 (Cont.) Receiving Unsolicited Input from a Virtual Keyboard

```
! Create a pasteboard
STATUS = SMG$CREATE_PASTEBOARD (PBID,          ! Pasteboard ID
2                                'SYS$INPUT')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Create a keyboard for the same device
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID,    ! Keyboard ID
2                                           'SYS$INPUT')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Enable unsolicited input
STATUS = SMG$ENABLE_UN SOLICITED_INPUT (PBID, ! Pasteboard ID
2                                       AST_ROUTINE,
2                                       VKID) ! Pass keyboard
                                           ! ID to AST
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
! Call display subroutine once for each array
CALL DISPLAY_ARRAY (ARRAY1)
CALL DISPLAY_ARRAY (ARRAY2)
CALL DISPLAY_ARRAY (ARRAY3)
END
```

Array Display Routine

```
! Subroutine to display one array
SUBROUTINE DISPLAY_ARRAY (ARRAY)
! Dummy argument
INTEGER*4 ARRAY (256)
! Status
INTEGER*4 STATUS
! Flag for doing next array
LOGICAL*4 DO_NEXT
COMMON /DO_NEXT/ DO_NEXT
! If AST has been delivered, reset
IF (DO_NEXT) DO_NEXT = .FALSE.
! Initialize control variable
I = 1
! Display entire array unless interrupted by user
! If interrupted by user (DO_NEXT is set), drop out of loop
DO WHILE ((I .LE. 256) .AND. (.NOT. DO_NEXT))
    TYPE *, ARRAY (I)
    I = I + 1
END DO
END
```

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Example 22–14 (Cont.) Receiving Unsolicited Input from a Virtual Keyboard

AST Routine

```
! Subroutine to read unsolicited input
SUBROUTINE AST_ROUTINE (PBID,
2                      VKID)
! dummy arguments
INTEGER*4 PBID,          ! Pasteboard ID
2          VKID          ! Keyboard ID
! Status
INTEGER*4 STATUS
! Flag for doing next array
LOGICAL*4 DO_NEXT
COMMON /DO_NEXT/ DO_NEXT
! Input string
CHARACTER*4 INPUT
! Routines
INTEGER*4 SMG$READ_STRING
! Read input
STATUS = SMG$READ_STRING (VKID, ! Keyboard ID
2                          INPUT)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! If user types anything beginning with N, set DO_NEXT
! otherwise, exit from program
IF (INPUT (1:1) .EQ. 'N') THEN
    DO_NEXT = .TRUE.
ELSE
    CALL EXIT
END IF
END
```

22.5.3 Using the Type-Ahead Buffer

Normally, if the user types at the terminal before your application is able to read from that device, the input is saved in a special data structure maintained by the system called the type-ahead buffer. When your application is ready to read from the terminal, the input is transferred from the type-ahead buffer to your input buffer. The type-ahead buffer is preset at a size of 78 bytes. If the HOSTSYNC characteristic is on (the usual condition), input to the type-ahead buffer is stopped (the keyboard locks) when the buffer is within 8 bytes of being full. If the HOSTSYNC characteristic is off, the bell rings when the type-ahead buffer is within 8 bytes of being full; if you overflow the buffer, the excess data is lost. The TTY_ALTALARM system parameter determines the point at which either input is stopped or the bell rings.

You can clear the type-ahead buffer by reading from the terminal with `SMG$READ_STRING` and by specifying `TRM$M_TM_PURGE` in the **modifiers** argument. Clearing the type-ahead buffer has the effect of reading only what the user types on the terminal after the read operation is invoked. Any characters in the type-ahead buffer are lost. The following example illustrates how to purge the type-ahead buffer:

```
INTEGER*4      SMG$CREATE_VIRTUAL_KEYBOARD,
2             SMG$READ_STRING,
2             STATUS,
2             VKID,      ! Virtual keyboard ID
2             INPUT_SIZE
```

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```
CHARACTER*512 INPUT
INCLUDE      '($TRMDEF)'
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID,
2                                     'SYS$INPUT') ! I/O device
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (VKID,      ! Keyboard ID
2                               INPUT, ! Data read
2                               'Prompt> ',
2                               512,
2                               TRM$M_TM_PURGE,
2                               ''
2                               INPUT_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

You can also clear the type-ahead buffer with a QIO read operation modified by `IOSM_PURGE` (defined in `SIODEF`). You can turn off the type-ahead buffer for further read operations with a QIO set mode operation that specifies `TTSM_NOTYPEAHD` as a basic terminal characteristic.

You can examine the type-ahead buffer by issuing a QIO sense mode operation modified by `IOSM_TYPEAHDcnt`. The number of characters in the type-ahead buffer and the value of the first character are returned to the **P1** argument.

The size of the type-ahead buffer is determined by the `TTY_TYPAHDSZ` system parameter. You can specify an alternative type-ahead buffer by turning on the `ALTYPEAHD` terminal characteristic; the size of the alternative type-ahead buffer is determined by the `TTY_ALTYPAHD` system parameter.

22.5.4 Using Echo

Normally, the system writes back to the terminal any printable characters that the user types at that terminal. The system also writes highlighted words in response to certain control characters; for example, the system writes EXIT if the user enters Ctrl/Z. If the user types ahead of your read, the characters are not echoed until you read them from the type-ahead buffer.

You can turn off echoing when you invoke a read operation by reading from the terminal with `SMG$READ_STRING` and by specifying `TRM$M_TM_NOECHO` in the **modifiers** argument. You can turn off echoing for control characters only by modifying the read operation with `TRM$M_TM_TRMNOECHO`. The following example turns off all echoing for the read operation:

```
INTEGER*4      SMG$CREATE_VIRTUAL_KEYBOARD,
2              SMG$READ_STRING,
2              STATUS,
2              VKID,      ! Virtual keyboard ID
2              INPUT_SIZE
CHARACTER*512 INPUT
INCLUDE      '($TRMDEF)'
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID,      ! Keyboard ID
2                                     'SYS$INPUT') ! I/O device
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (VKID,      ! Keyboard ID
2                               INPUT, ! Data read
2                               'Prompt> ',
2                               512,
2                               TRM$M_TM_NOECHO,
2                               ''
2                               INPUT_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

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You can also turn off echoing with a QIO read operation modified by IOSM_NOECHO (defined in \$IODEF). You can turn off echoing for further read operations with a QIO set mode operation that specifies TTSM_NOECHO as a basic terminal characteristic.

22.5.5 Using Timeout

Using SMG\$READ_STRING, you can restrict the user to a certain amount of time in which to respond to a read command. If your application reads data from the terminal using SMG\$READ_STRING, you can modify the timeout characteristic by specifying, in the **timeout** argument, the number of seconds the user has to respond. If the user fails to type a character in the allotted time, the error condition SSS_TIMEOUT (defined in \$\$SDEF) is returned. The following example restricts the user to 8 seconds in which to respond to a read command:

```
INTEGER*4      SMG$CREATE_VIRTUAL_KEYBOARD,
2             SMG$READ_STRING,
2             STATUS,
2             VKID,      ! Virtual keyboard ID
2             INPUT_SIZE
CHARACTER*512 INPUT
INCLUDE      '$(SSSDEF)'
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID,
2                                     'SYS$INPUT')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (VKID,      ! Keyboard ID
2                          INPUT,    ! Data read
2                          'Prompt> ',
2                          512,
2                          ,
2                          8,
2                          ,
2                          INPUT_SIZE)
IF (.NOT. STATUS) THEN
  IF (STATUS .EQ. SSS_TIMEOUT) CALL NO_RESPONSE ()
ELSE
  CALL LIB$SIGNAL (%VAL (STATUS))
END IF
```

You can cause a QIO read operation to time out after a certain number of seconds by modifying the operation with IOSM_TIMED and by specifying the number of seconds in the **P3** argument. A message broadcast to a terminal resets a timer that is set for a timed read operation (regardless of whether the operation was initiated with QIO or SMG).

Note that the timed read operations work on a character-by-character basis. To set a time limit on an input record rather than an input character, you must use the SYS\$SETIMR system service. The SYS\$SETIMR executes an AST routine at a specified time. The specified time is the input time limit. When the specified time is reached, the AST routine cancels any outstanding I/O on the channel that is assigned to the user's terminal.

Run-Time Library Input/Output Operations

22.5 Performing Special Input/Output Actions

22.5.6 Converting Lowercase to Uppercase

You can automatically convert lowercase user input to uppercase by reading from the terminal with the `SMG$READ_STRING` routine and by specifying `TRM$M_TM_CVTLOW` in the **modifiers** argument, as shown in the following example:

```
INTEGER*4      SMG$CREATE_VIRTUAL_KEYBOARD,
2             SMG$READ_STRING,
2             STATUS,
2             VKID,      ! Virtual keyboard ID
2             INPUT_SIZE
CHARACTER*512  INPUT
INCLUDE       '($TRMDEF)'
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID, ! Keyboard ID
2                                     'SYS$INPUT')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (VKID, ! Keyboard ID
2                         INPUT, ! Data read
2                         'Prompt> ',
2                         512,
2                         TRM$M_TM_CVTLOW,
2                         ''
2                         INPUT_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

You can also convert lowercase characters to uppercase with a QIO read operation modified by `IOSM_CVTLOW` (defined in `$IODEF`).

22.5.7 Performing Line Editing and Control Actions

Normally, the user can edit input as explained in the *OpenVMS I/O User's Reference Manual*. You can inhibit line editing on the read operation by reading from the terminal with `SMG$READ_STRING` and by specifying `TRM$M_TM_NOFILTR` in the **modifiers** argument. The following example shows how you can inhibit line editing:

```
INTEGER*4      SMG$CREATE_VIRTUAL_KEYBOARD,
2             SMG$READ_STRING,
2             STATUS,
2             VKID,      ! Virtual keyboard ID
2             INPUT_SIZE
CHARACTER*512  INPUT
INCLUDE       '($TRMDEF)'
STATUS = SMG$CREATE_VIRTUAL_KEYBOARD (VKID, ! Keyboard ID
2                                     'SYS$INPUT')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$READ_STRING (VKID, ! Keyboard ID
2                         INPUT, ! Data read
2                         'Prompt> ',
2                         512,
2                         TRM$M_TM_NOFILTR,
2                         ''
2                         INPUT_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

You can also inhibit line editing with a QIO read operation modified by `IOSM_NOFILTR` (defined in `$IODEF`).

22.5.8 Using Broadcasts

You can write, or broadcast, to any interactive terminal by using the SYS\$BRKTHRU system service. The following example broadcasts a message to all terminals at which users are currently logged in. Use of SYS\$BRKTHRU to write to a terminal allocated to a process other than your own requires the OPER privilege.

```
INTEGER*4 STATUS,  
2      SYS$BRKTHRUW  
INTEGER*2 B_STATUS (4)  
INCLUDE '($BRKDEF)'  
STATUS = SYS$BRKTHRUW (,  
2      'Accounting system started',,  
2      %VAL (BRK$C_ALLUSERS),  
2      B_STATUS,,,,,  
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

22.5.8.1 Default Handling of Broadcasts

If the terminal user has taken no action to handle broadcasts, a broadcast is written to the terminal screen at the current position (after a carriage return and line feed). If a write operation is in progress, the broadcast occurs after the write ends. If a read operation is in progress, the broadcast occurs immediately; after the broadcast, any echoed user input to the aborted read operation is written to the screen (same effect as pressing Ctrl/R).

22.5.8.2 How to Create Alternate Broadcast Handlers

You can handle broadcasts to the terminal on which your program is running with SMG\$SET_BROADCAST_TRAPPING. This routine uses the AST mechanism to transfer control to a subprogram of your choice each time a broadcast message is sent to the terminal; when the subprogram completes, control returns to the point in your mainline code where it was interrupted.

The SMG\$SET_BROADCAST_TRAPPING routine is not an SMG\$ input routine. Before invoking SMG\$SET_BROADCAST_TRAPPING, you must invoke SMG\$CREATE_PASTEBOARD to associate a pasteboard with the terminal. SMG\$CREATE_PASTEBOARD returns a pasteboard identification number; pass that number to SMG\$SET_BROADCAST_TRAPPING to identify the terminal in question. Read the contents of the broadcast with SMG\$GET_BROADCAST_MESSAGE.

Example 22–15 demonstrates how you might trap a broadcast and write it at the bottom of the screen. For more information about the use of SMG\$ pasteboards and virtual displays, see Section 22.4.

Run-Time Library Input/Output Operations

22.5 Performing Special Input/Output Actions

Example 22–15 Trapping Broadcast Messages

```

:
:
:
INTEGER*4 STATUS,
2      PBID,                ! Pasteboard ID
2      VDID,                ! Virtual display ID
2      SMG$CREATE_PASTEBOARD,
2      SMG$SET_BROADCAST_TRAPPING
2      SMG$PASTE_VIRTUAL_DISPLAY
COMMON /ID/ PBID,
2      VDID
INTEGER*2 B_STATUS (4)
INCLUDE '$SMGDEF'
INCLUDE '$BRKDEF'
EXTERNAL BRKTHRU_ROUTINE
STATUS = SMG$CREATE_PASTEBOARD (PBID)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$CREATE_VIRTUAL_DISPLAY (3,      ! Height
2      80,                ! Width
2      VDID,,            ! Display ID
2      SMG$M_REVERSE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SMG$SET_BROADCAST_TRAPPING (PBID,  ! Pasteboard ID
2      BRKTHRU_ROUTINE) ! AST
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
:
:
:
SUBROUTINE BRKTHRU_ROUTINE ()
INTEGER*4 STATUS,
2      PBID,                ! Pasteboard ID
2      VDID,                ! Virtual display ID
2      SMG$GET_BROADCAST_MESSAGE,
2      SMG$PUT_CHARS,
2      SMG$PASTE_VIRTUAL_DISPLAY
COMMON /ID/ PBID,
2      VDID
CHARACTER*240 MESSAGE
INTEGER*2 MESSAGE_SIZE
! Read the message
STATUS = SMG$GET_BROADCAST_MESSAGE (PBID,
2      MESSAGE,
2      MESSAGE_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Write the message to the virtual display
STATUS = SMG$PUT_CHARS (VDID,
2      MESSAGE (1:MESSAGE_SIZE),
2      1,                ! Line
2      1)                ! Column
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Make the display visble by pasting it to the pasteboard
STATUS = SMG$PASTE_VIRTUAL_DISPLAY (VDID,
2      PBID,
2      22,                ! Row
2      1)                ! Column
END

```

System Service Input/Output Operations

This chapter describes how to use system services to perform input and output operations. It contains the following sections:

Section 23.1 describes the QIO operation.

Section 23.2 describes the use of quotas, privileges, and protection.

Section 23.3 describes device addressing modes.

Section 23.4 describes I/O function encoding.

Section 23.5 describes how to assign channels.

Section 23.6 describes how to queue I/O requests.

Section 23.7 describes how to synchronize I/O completions.

Section 23.8 describes the routine to use to wait for completion of an asynchronous event.

Section 23.9 describes executing I/O services synchronously or asynchronously.

Section 23.10 describes the completion status of an I/O operation.

Section 23.11 describes how to deassign I/O channels.

Section 23.12 presents a program example of a complete input and output operation.

Section 23.13 describes how to cancel I/O requests.

Section 23.14 describes how to use logical names and physical device names for I/O operations.

Section 23.15 describes how to use device name defaults.

Section 23.16 describes how to obtain information about physical devices.

Section 23.17 describes device allocation.

Section 23.18 describes how to mount, dismount, and initialize disk and tape volumes.

Section 23.19 describes format output strings.

Section 23.20 describes how to use mailboxes for I/O operations.

Section 23.21 provides a program example of using I/O system services.

Section 23.22 describes the Fast I/O and Fast Path features that improve I/O performance.

Examples are provided to show you how to use the I/O services for simple functions, such as terminal input and output operations. If you plan to write device-dependent I/O routines, see the *OpenVMS I/O User's Reference Manual*.

System Service Input/Output Operations

On VAX systems, if you want to write your own device driver or connect to a device interrupt vector, see the *OpenVMS VAX Device Support Reference Manual*. The *OpenVMS VAX Device Support Reference Manual* has been archived but is available on the OpenVMS Documentation CD-ROM.

Besides using I/O system services, you can use OpenVMS Record Management Services (RMS). OpenVMS RMS provides a set of routines for general-purpose, device-independent functions such as data storage, retrieval, and modification.

Unlike RMS services, 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 OpenVMS RMS. Using I/O services requires more programming knowledge than using OpenVMS RMS, but can result in more efficient input/output operations.

23.1 Overview of OpenVMS QIO Operations

The OpenVMS operating system provides QIO operations that perform three basic I/O functions: read, write, and set mode. The read function transfers data from a device to a user-specified buffer. The write function transfers data in the opposite direction—from a user-specified buffer to the device. For example, in a read QIO function to a terminal device, a user-specified buffer is filled with characters received from the terminal. In a write QIO function to the terminal, the data in a user-specified buffer is transferred to the terminal where it is displayed.

The set mode QIO function is used to control or describe the characteristics and operation of a device. For example, a set mode QIO function to a line printer can specify either uppercase or lowercase character format. Not all QIO functions are applicable to all types of devices. The line printer, for example, cannot perform a read QIO function.

23.2 Quotas, Privileges, and Protection

To preserve the integrity of the operating system, the I/O operations are performed under the constraints of quotas, privileges, and protection.

Quotas limit the number and type of I/O operations that a process can perform concurrently and the total size of outstanding transfers. They ensure that all users have an equitable share of system resources and usage.

Privileges are granted to a user to allow the performance of certain I/O-related operations, for example, creating a mailbox and performing logical I/O to a file-structured device. Restrictions on user privileges protect the integrity and performance of both the operating system and the services provided to other users.

Protection controls access to files and devices. Device protection is provided in much the same way as file protection: shareable and nonshareable devices are protected by protection masks.

The Set Resource Wait Mode (SYSS\$SETRWM) system service allows a process to select either of two modes when an attempt to exceed a quota occurs. In the enabled (default) mode, the process waits until the required resource is available before continuing. In the disabled mode, the process is notified immediately by a system service status return that an attempt to exceed a quota has occurred. Waiting for resources is transparent to the process when resource wait mode is enabled; the process takes no explicit action when a wait is necessary.

The different types of I/O-related quotas, privilege, and protection are described in the following sections.

23.2.1 Buffered I/O Quota

The buffered I/O limit quota (BIOLM) specifies the maximum number of concurrent buffered I/O operations that can be active in a process. In a buffered I/O operation, the user's data is buffered in system dynamic memory. The driver deals with the system buffer and not the user buffer. Buffered I/O is used for terminal, line printer, card reader, network, mailbox, and console medium transfers and file system operations. For a buffered I/O operation, the system does not have to lock the user's buffer in memory.

The system manager, or the person who creates the process, establishes the buffered I/O quota value in the user authorization file. If you use the Set Resource Wait Mode (SYSSSETRWM) system service to enable resource wait mode for the process, the process enters resource wait mode if it attempts to exceed its direct I/O quota.

23.2.2 Buffered I/O Byte Count Quota

The buffered I/O byte count quota (BYTLM) specifies the maximum amount of buffer space that can be consumed from system dynamic memory for buffering I/O requests. All buffered I/O requests require system dynamic memory in which the actual I/O operation takes place.

The system manager, or the person who creates the process, establishes the buffered I/O byte count quota in the user authorization file. If you use the SYSSSETRWM system service to enable resource wait mode for the process, the process enters resource wait mode if it attempts to exceed its direct I/O quota.

23.2.3 Direct I/O Quota

The direct I/O limit quota (DIOLM) specifies the maximum number of concurrent direct (unbuffered) I/O operations that a process can have active. In a direct I/O operation, data is moved directly to or from the user buffer. Direct I/O is used for disk, magnetic tape, most direct memory access (DMA) real-time devices, and nonnetwork transfers, such as DMC11/DMR11 write transfers. For direct I/O, the user's buffer must be locked in memory during the transfer.

The system manager, or the person who creates the process, establishes the direct I/O quota value in the user authorization file. If you use the SYSSSETRWM system service to enable resource wait mode for the process, the process enters resource wait mode if it attempts to exceed its direct I/O quota.

23.2.4 AST Quota

The AST quota specifies the maximum number of outstanding asynchronous system traps that a process can have. The system manager, or the person who creates the process, establishes the quota value in the user authorization file. There is never an implied wait for that resource.

23.2.5 Physical I/O Privilege

Physical I/O privilege (PHY_IO) allows a process to perform physical I/O operations on a device. Physical I/O privilege also allows a process to perform logical I/O operations on a device.

System Service Input/Output Operations

23.2 Quotas, Privileges, and Protection

23.2.6 Logical I/O Privilege

Logical I/O privilege (LOG_IO) allows a process to perform logical I/O operations on a device. A process can also perform physical operations on a device if the process has logical I/O privilege, the volume is mounted foreign, and the volume protection mask allows access to the device. (A foreign volume is one volume that contains no standard file structure understood by any of the operating system software.) See Section 23.3.2 for further information about logical I/O privilege.

23.2.7 Mount Privilege

Mount privilege (MOUNT) allows a process to use the IOS_MOUNT function to perform mount operations on disk and magnetic tape devices. The IOS_MOUNT function is used in ancillary control process (ACP) interface operations.

23.2.8 Share Privilege

Share privilege (SHARE) allows a process to use the SYSSASSIGN system service to override another process's exclusive access request on the specified device.

Performing any I/O operations to a device driver coded to expect exclusive access—performing I/O to any device driver not explicitly coded to expect shared multiple-process access—can result in unusual and unexpected device and application behaviour, and can result in problems of device ownership, and failures during the device driver last channel deassign operation.

Using SHARE to override access is useful for a few specific situations, such as user-written device driver debugging and user-written device driver diagnostic tools. General use of SHARE is not recommended.

23.2.9 Volume Protection

Volume protection protects the integrity of mailboxes and both foreign and Files-11 On-Disk Structure Level 2 structured volumes. Volume protection for a foreign volume is established when the volume is mounted. Volume protection for a Files-11 structured volume is established when the volume is initialized. (If the process mounting the volume has the override volume protection privilege, VOLPRO, protection can be overridden when the volume is mounted.)

The SYSSCREMBX system service protection mask argument establishes mailbox protection.

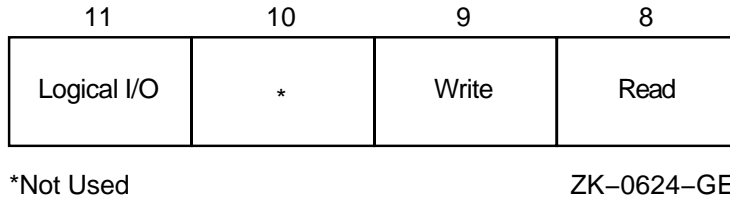
Set Protection QIO requests allow you to set volume protection on a mailbox. You must either be the owner of the mailbox or have the BYPASS privilege.

Protection for structured volumes and mailboxes is provided by a volume protection mask that contains four 4-bit fields. These fields correspond to the four classes of user permitted to access the volume. (User classes are based on the volume owner's UIC.)

The 4-bit fields are interpreted differently for volumes that are mounted as structured (that is, volumes serviced by an ACP), volumes that are mounted as foreign, and mailboxes (both temporary and permanent).

Figure 23-1 shows the 4-bit protection fields for mailboxes. Usually, volume protection is meaningful only for read and write operations.

Figure 23–1 Mailbox Protection Fields



23.2.10 Device Protection

Device protection protects the allocation of nonshareable devices, such as terminals and card readers.

Protection is provided by a device protection mask similar to that of volume protection. The difference is that only the bit corresponding to read access is checked, and that bit determines whether the process can allocate or assign a channel to the device.

You establish device protection with the DCL command SET PROTECTION /DEVICE. This command sets both the protection mask and the device owner UIC.

23.2.11 System Privilege

System UIC privilege (SYSPRV) allows a process to be eligible for the volume or device protection specified for the system protection class, even if the process does not have a UIC in one of the system groups.

23.2.12 Bypass Privilege

Bypass privilege (BYPASS) allows a process to bypass volume and device protection completely.

23.3 Physical, Logical, and Virtual I/O

I/O data transfers can occur in any one of three device addressing modes: physical, logical, or virtual. Any process with device access allowed by the volume protection mask can perform logical I/O on a device that is mounted foreign; physical I/O requires privileges. Virtual I/O does not require privileges; however, intervention by an ACP to control user access might be necessary if the device is under ACP control. (ACP functions are described in the *OpenVMS I/O User's Reference Manual*.)

23.3.1 Physical I/O Operations

In physical I/O operations, data is read from and written to the actual, physically addressable units accepted by the hardware (for example, sectors on a disk or binary characters on a terminal in the PASSALL mode). This mode allows direct access to all device-level I/O operations.

Physical I/O requires that one of the following conditions be met:

- The issuing process has physical I/O privilege (PHY_IO).
- The issuing process has all of the following characteristics:
 - The issuing process has logical I/O privilege (LOG_IO).
 - The device is mounted foreign.

System Service Input/Output Operations

23.3 Physical, Logical, and Virtual I/O

- The volume protection mask allows physical access to the device.

If neither of these conditions is met, the physical I/O operation is rejected by the SYSSQIO system service, which returns a condition value of SSS_NOPRIV (no privilege). Figure 23–2 illustrates the physical I/O access checks in greater detail.

The inhibit error-logging function modifier (IO\$M_INHERLOG) can be specified for all physical I/O functions. The IO\$M_INHERLOG function modifier inhibits the logging of any error that occurs during the I/O operation.

23.3.2 Logical I/O Operations

In logical I/O operations, data is read from and written to logically addressable units of the device. Logical operations can be performed on both block-addressable and record-oriented devices. For block-addressable devices (such as disks), the addressable units are 512-byte blocks. They are numbered from 0 to $n-1$, where n is the number of blocks on the device. For record-oriented or non-block-structured devices (such as terminals), logical addressable units are not pertinent and are ignored. Logical I/O requires that one of the following conditions be met:

- The issuing process has physical I/O privilege (PHY_IO).
- The issuing process has logical I/O privilege (LOG_IO).
- The volume is mounted foreign and the volume protection mask allows access to the device.

If none of these conditions is met, the logical I/O operation is rejected by the SYSSQIO system service, which returns a condition value of SSS_NOPRIV (no privilege). Figure 23–3 illustrates the logical I/O access checks in greater detail.

23.3.3 Virtual I/O Operations

You can perform virtual I/O operations on both record-oriented (non-file-structured) and block-addressable (file-structured) devices. For record-oriented devices (such as terminals), the virtual function is the same as a logical function; the virtual addressable units of the devices are ignored.

For block-addressable devices (such as disks), data is read from and written to open files. The addressable units in the file are 512-byte blocks. They are numbered starting at 1 and are relative to a file rather than to a device. Block-addressable devices must be mounted and structured and must contain a file that was previously accessed on the I/O channel.

Virtual I/O operations also require that the volume protection mask allow access to the device (a process having either physical or logical I/O privilege can override the volume protection mask). If these conditions are not met, the virtual I/O operation is rejected by the QIO system service, which returns one of the following condition values:

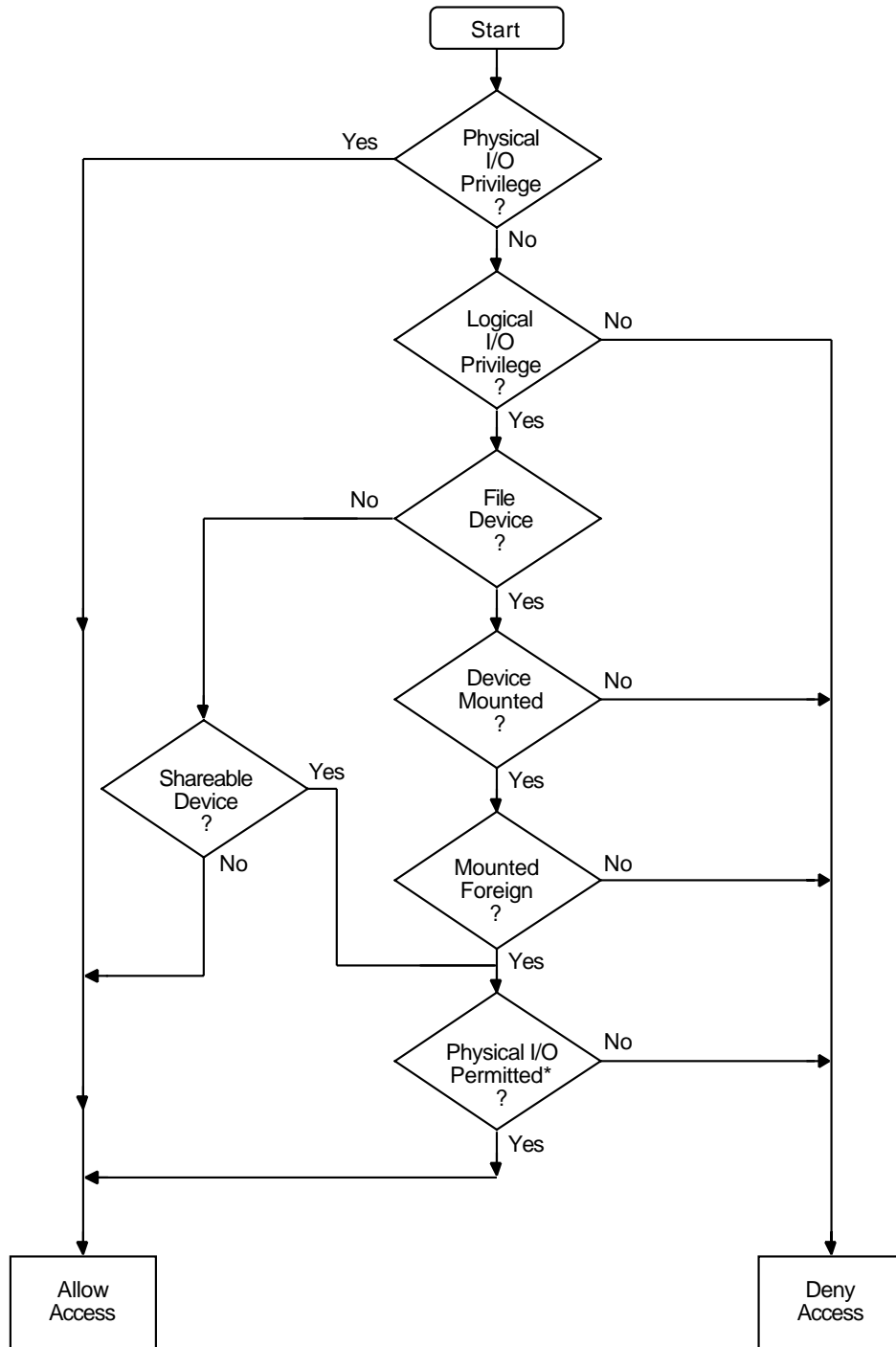
Condition Value	Meaning
SSS_NOPRIV	No privilege
SSS_DEVNOTMOUNT	Device not mounted
SSS_DEVFOREIGN	Volume mounted foreign

Figure 23–4 shows the relationship of physical, logical, and virtual I/O to the driver.

System Service Input/Output Operations

23.3 Physical, Logical, and Virtual I/O

Figure 23–2 Physical I/O Access Checks



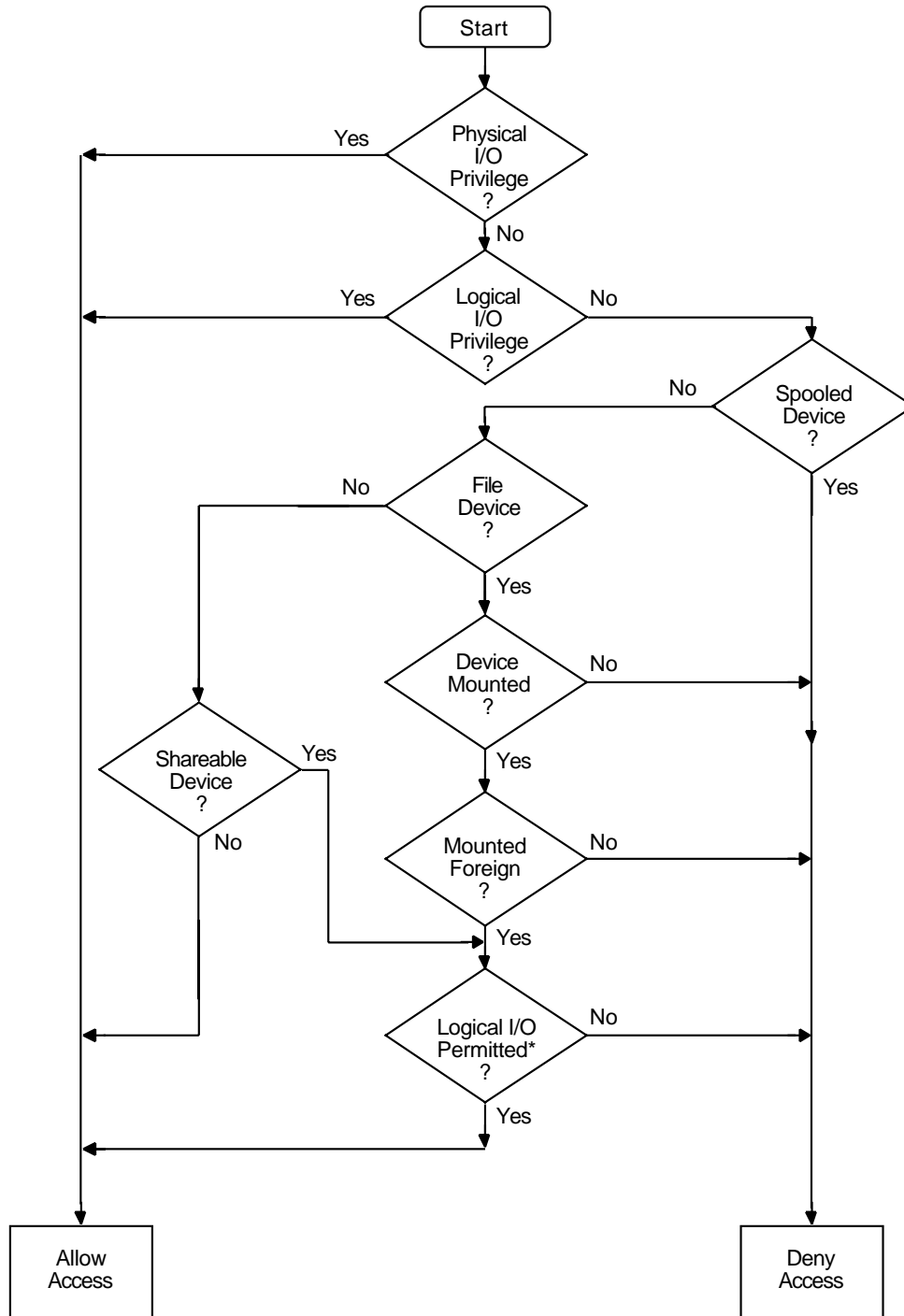
*Volume protection mask allows access.

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System Service Input/Output Operations

23.3 Physical, Logical, and Virtual I/O

Figure 23-3 Logical I/O Access Checks



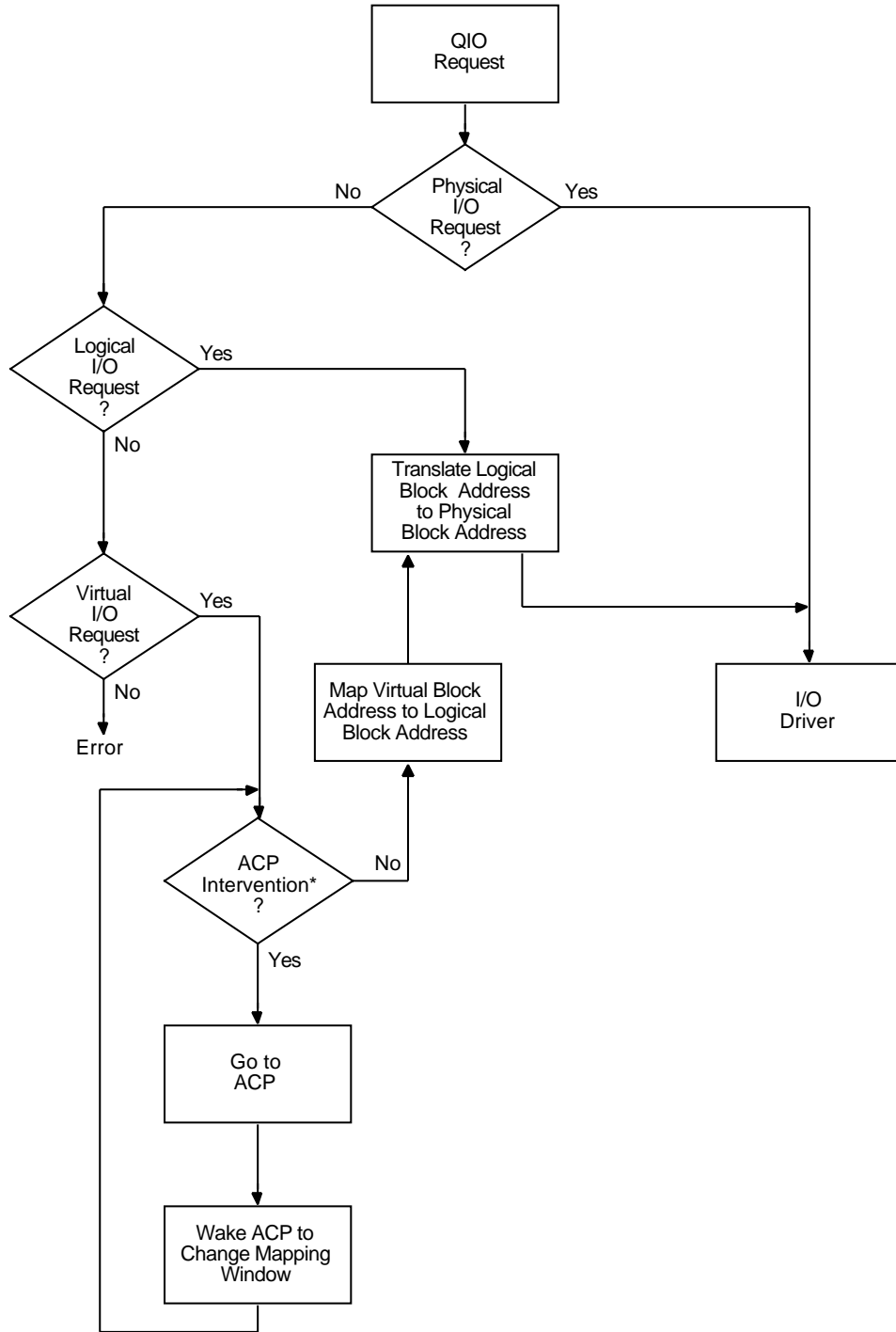
* Volume protection mask allows access.

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System Service Input/Output Operations

23.3 Physical, Logical, and Virtual I/O

Figure 23-4 Physical, Logical, and Virtual I/O



*Needed to map virtual address to logical address.

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System Service Input/Output Operations

23.4 I/O Function Encoding

23.4 I/O Function Encoding

I/O functions fall into three groups that correspond to the three I/O device addressing modes (physical, logical, and virtual) described in Section 23.3. Depending on the device to which it is directed, an I/O function can be expressed in one, two, or all three modes.

I/O functions are described by 16-bit, symbolically expressed values that specify the particular I/O operation to be performed and any optional function modifiers. Figure 23–5 shows the format of the 16-bit function value.

Symbolic names for I/O function codes are defined by the \$IODEF macro.

Figure 23–5 I/O Function Format



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23.4.1 Function Codes

The low-order 6 bits of the function value are a code that specifies the particular operation to be performed. For example, the code for read logical block is expressed as `IOS_READLBLK`. Table 23–1 lists the symbolic values for read and write I/O functions in the three transfer modes.

Table 23–1 Read and Write I/O Functions

Physical I/O	Logical I/O	Virtual I/O
<code>IOS_READPBLK</code>	<code>IOS_READLBLK</code>	<code>IOS_READVBLK</code>
<code>IOS_WRITEPBLK</code>	<code>IOS_WRITELBLK</code>	<code>IOS_WRITEVBLK</code>

The set mode I/O function has a symbolic value of `IOS_SETMODE`.

Function codes are defined for all supported devices. Although some of the function codes (for example, `IOS_READVBLK` and `IOS_WRITEVBLK`) are used with several types of devices, most are device dependent; that is, they perform functions specific to particular types of devices. For example, `IOS_CREATE` is a device-dependent function code; it is used only with file-structured devices such as disks and magnetic tapes. The I/O user's reference documentation provides complete descriptions of the functions and function codes.

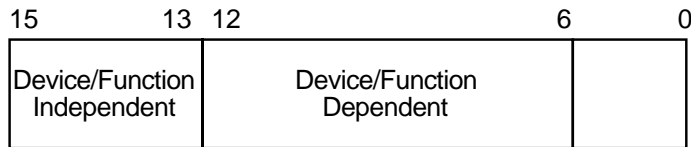
Note

You should determine the device class before performing any QIO function, because the requested function might be incompatible with some devices. For example, the `SYSSINPUT` device could be a terminal, a disk, or some other device. Unless this device is a terminal, an `IOS_SETMODE` request that enables a Ctrl/C AST is not performed.

23.4.2 Function Modifiers

The high-order 10 bits of the function value are function modifiers. These are individual bits that alter the basic operation to be performed. For example, you can specify the function modifier `IO$M_NOECHO` with the function `IO$_READLBLK` to a terminal. When used together, the two values are written in VAX MACRO as `IO$_READLBLK!IO$M_NOECHO`. This causes data typed at the terminal keyboard to be entered into the user buffer but not echoed to the terminal. Figure 23-6 shows the format of function modifiers.

Figure 23-6 Function Modifier Format



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As shown in Figure 23-6, bits <15:13> are device- or function-independent bits, and bits <12:6> are device- or function-dependent bits. Device- or function-dependent bits have the same meaning, whenever possible, for different device classes. For example, the function modifier `IO$M_ACCESS` is used with both disk and magnetic tape devices to cause a file to be accessed during a create operation. Device- or function-dependent bits always have the same function within the same device class.

There are two device- or function-independent modifier bits: `IO$M_INHRETRY` and `IO$M_DATACHECK` (a third bit is reserved). `IO$M_INHRETRY` is used to inhibit all error recovery. If any error occurs and this modifier bit is specified, the operation is terminated immediately and a failure status is returned in the I/O status block (see Section 23.10). Use `IO$M_DATACHECK` to compare the data in memory with that on a disk or magnetic tape.

23.5 Assigning Channels

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

When you write a call to the `SYSS$ASSIGN` service, you must supply the name of the device, which can 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 write an input or 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`.

System Service Input/Output Operations

23.5 Assigning Channels

```
#include <descrip.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>
#include <stsdef.h>

main() {
    unsigned int status;
    unsigned short ttchan;
    $DESCRIPTOR(ttname,"TTA2:");

    /* Assign a channel to a device */
    status = SYS$ASSIGN( &ttname, /* devnam - device name */
                       &ttchan, /* chan - channel number */
                       0,        /* acmode - access mode */
                       0,        /* mbxnam - logical name for mailbox */
                       0 );     /* flags */
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL(status);

    return SS$_NORMAL;
}
```

To assign a channel to the current default input or output device, use the logical name `SYSS$INPUT` or `SYSS$OUTPUT`.

For more details on how `SYSS$ASSIGN` and other I/O services handle logical names, see Section 23.2.5.

23.5.1 Using the Share Privilege with the `SYSS$ASSIGN` and `SYSS$DASSGN` Services

Use of `SHARE` privilege should be made only with caution, as applications, application protocols, and device drivers coded to expect only exclusive access can encounter unexpected and potentially errant behavior when access to the device is unexpectedly shared via use of `SHARE` privilege.

If you use the `SHARE` privilege to override the exclusivity requested by another process's call to the system service `SYSS$ASSIGN`, and the original process then attempts to deassign its channels via explicit calls to `SYSS$DASSGN` or via the implicit calls to `SYSS$DASSGN` made during image or process rundown, the OpenVMS last-channel-deassign code may not operate as expected due to the assignment of the additional I/O channels to the device. The presence of these extra channels will prevent the last-channel-deassign code from releasing the ownership of the device, potentially resulting in a device owned by the process identification (PID) of a nonexistent process.

Unless its use is explicitly supported by the application, the application protocol, and the device driver, the use of `SHARE` privilege is generally discouraged.

23.6 Queuing I/O Requests

All input and output operations in the operating system are initiated with the Queue I/O Request (`SYSS$QIO`) system service. The `SYSS$QIO` system service permits direct interaction with the system's terminal driver. `SYSS$QIO`s permit some operations that cannot be performed with language I/O statements and RTL routines; calls to `SYSS$QIO` reduce overhead and permit asynchronous I/O operations. However, calls to `SYSS$QIO` are device dependent. The `SYSS$QIO` service queues the request and returns immediately to the caller. While the

System Service Input/Output Operations

23.6 Queuing I/O Requests

operating system processes the request, the program that issued the request can continue execution.

The format for SYSSQIO is as follows:

```
SYSSQIO([efn],chan,func[,iosb][,astadr][,astprm][,p1][,p2][,p3][,p4][,p5][,p6]
```

Required arguments to the SYSSQIO service include the channel number assigned to the device on which the I/O is to be performed, and a function code (expressed symbolically) that indicates the specific operation to be performed. Depending on the function code, one to 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 SYSSQIO to write a line to a terminal may look like the following:

```
#include <starlet.h>

    unsigned int status, func=IO$_WRITEVBLK;
    .
    .
    .
    status = SYSSQIO(0,          /* efn - event flag */
                    ttchan,     /* chan - channel number */
                    func,       /* func - function modifier */
                    0,          /* iosb - I/O status block */
                    0,          /* astadr - AST routine */
                    0,          /* astprm - AST parameter */
                    buffadr,    /* p1 - output buffer */
                    buflen);    /* p2 - length of message */
```

Function codes are defined for all supported device types, and most of the codes are device dependent; that is, they perform functions specific to a particular device. The \$IODEF macro defines symbolic names for these function codes. For information about how to obtain a listing of these symbolic names, see Appendix A. For details about all function codes and an explanation of the parameters required by each, see the *OpenVMS I/O User's Reference Manual*.

To read from or write to a terminal with the SYSSQIO or SYSSQIOW system service, you must first associate the terminal name with an I/O channel by calling the SYSSASSIGN system service, then use the assigned channel in the SYSSQIO or SYSSQIOW system service. To read from SYSSINPUT or write to SYSSOUTPUT, specify the appropriate logical name as the terminal name in the SYSSASSIGN system service. In general, use SYSSQIO for asynchronous operations, and use SYSSQIOW for all other operations.

23.7 Synchronizing Service Completion

The SYSSQIO system service returns control to the calling program as soon as a request is queued; the status code returned in R0 indicates whether the request was queued successfully. To ensure proper synchronization of the queuing operation with respect to the program, the program must do the following:

- Test whether the operation was queued successfully.
- Test whether the operation itself completed successfully.

System Service Input/Output Operations

23.7 Synchronizing Service Completion

Optional arguments to the SYSSQIO 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 operation completes.
- Specify the address of an AST routine to be executed when the operation completes.
- Specify the address of an I/O status block in which the system can place the return status when the operation completes.

I/O status blocks are explained in Section 23.10.

The use of these three techniques is shown in the examples that follow. Example 23-1 shows specifying event flags.

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23.7 Synchronizing Service Completion

Example 23–1 Event Flags

```
#include <lib$routines.h>
#include <starlet.h>
unsigned int status, efn=0, efn1=1, efn=2;
.
.
.
status = SYS$QIO(efn1, . . . ); /* Issue 1st I/O request */
if (!$VMS_STATUS_SUCCESS(status))
LIB$SIGNAL( status );          /* Queued successfully? */ ❶
.
.
.
status = SYS$QIO(efn2, . . . ); /* Issue second I/O request */ ❷
if (!$VMS_STATUS_SUCCESS(status)) /* Queued successfully? */
    LIB$SIGNAL( status );
.
.
.
status = SYS$WFLAND( efn,          /* Wait until both are done */ ❸
                    &mask, . . . ❹
                    .
                    .
                    .
```

- ❶ When you specify an event flag number as an argument, `SYS$QIO` clears the event flag when it queues the I/O request. When the I/O completes, the flag is set.
- ❷ In this example, the program issues two Queue I/O requests. A different event flag is specified for each request.
- ❸ The Wait for Logical AND of Event Flags (`SYS$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 for which the process is to wait.
- ❹ Note that the `SYS$WFLAND` system service (and the other wait system services) wait for the event flag to be set; they do not wait for the I/O operation to complete. If some other event were to set the required event flags, the wait for event flag would complete too soon. You must coordinate the use of event flags carefully. (See Section 23.8 for a discussion of the recommended method for testing I/O completion.)

System Service Input/Output Operations

23.7 Synchronizing Service Completion

Example 23–2 shows specifying an AST routine.

Example 23–2 AST Routine

```
#include <lib$routines.h>
#include <starlet.h>
#include <stsdef.h>
    unsigned int status, astprm=1;
    .
    .
    .
        status = SYSSQIO( ... &ttast, /* I/O request with AST */ ❶
                        astprm ... );
        if (!$VMS_STATUS_SUCCESS( status )) /* Queued successfully? */
            LIB$SIGNAL( status );
    .
    .
    .
}
void ttast ( int astprm ) { /* AST service routine */ ❷
/* Handle I/O completion */
    .
    .
    .
    return;
} /* End of AST routine */
```

- ❶ When you specify the **astadr** argument to the SYSSQIO system service, the system interrupts the process when the I/O completes and passes control to the specified AST service routine.

The SYSSQIO 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 SQIO returns control, the process continues execution.

- ❷ When the I/O completes, the AST routine TTAST is called, and it responds to the I/O completion. By examining the AST parameter, TTAST can determine the origin of the I/O request.

When this routine is finished executing, control returns to the process at the point at which it was interrupted. If you specify the **astadr** argument in your call to SYSSQIO, you should also specify the **iosb** argument so that the AST routine can evaluate whether the I/O completed successfully.

Example 23–3 shows specifying an I/O status block.

Example 23–3 I/O Status Block

```
#include <lib$routines.h>
#include <stdio.h>
#include <ssdef.h>
#include <starlet.h>
#include <stsdef.h>

.
.
.
/* I/O status block */
struct {
    unsigned short iostat, iolen;
    unsigned int dev_info;
}ttiosb;
    unsigned int status;
.
.
.
    status = SYSSQIO(, . . . , &ttiosb, . . . );
    if( !$VMS_STATUS_SUCCESS( status )) /* Queued successfully? */
        LIB$SIGNAL( status );
.
.
.
    while(ttiosb.iostat == 0) {
        /* Loop -- with delay -- until done */
    }
    if( !$VMS_STATUS_SUCCESS( ttiosb.iostat )) {
        /* Perform error handling */
    }
.
.
.
}
```

- ❶ An I/O status block is a quadword structure that the system uses to post the status of an I/O operation. You must define the quadword area in your program. TTIO SB defines the I/O status block for this I/O operation. The **iosb** argument in the SYSSQIO system service refers to this quadword.
- ❷ Instead of polling the low-order word of the I/O status block for the completion status, the program uses the preferred method of using an event flag and calling SYSSYNCH to determine I/O completion.
- ❸ The process polls the I/O status block. If the low-order word still contains zero, the I/O operation has not yet completed. In this example, the program loops until the request is complete.

System Service Input/Output Operations

23.8 Recommended Method for Testing Asynchronous Completion

23.8 Recommended Method for Testing Asynchronous Completion

Compaq recommends that you use the Synchronize (SYSSYNCH) system service to wait for completion of an asynchronous event. The SYSSYNCH service correctly waits for the actual completion of an asynchronous event, even if some other event sets the event flag.

To use the SYSSYNCH service to wait for the completion of an asynchronous event, you must specify both an event flag number and the address of an I/O status block (IOSB) in your call to the asynchronous system service. The asynchronous service queues the request and returns control to your program. When the asynchronous service completes, it sets the event flag and places the final status of the request in the IOSB.

In your call to SYSSYNCH, you must specify the same **efn** and I/O status block that you specified in your call to the asynchronous service. The SYSSYNCH service waits for the event flag to be set by means of the SYSSWAITFR system service. When the specified event flag is set, SYSSYNCH checks the specified I/O status block. If the I/O status block is nonzero, the system service has completed and SYSSYNCH returns control to your program. If the I/O status block is zero, SYSSYNCH clears the event flag by means of the SYSSCLREF service and calls the \$WAITFR service to wait for the event flag to be set.

The SYSSYNCH service sets the event flag before returning control to your program. This ensures that the call to SYSSYNCH does not interfere with testing for completion of another asynchronous event that completes at approximately the same time and uses the same event flag to signal completion.

The following call to the Queue I/O Request (SYSSQIO) system service demonstrates how the SYSSYNCH service is used:

```
.
.
.
#include <lib$routines.h>
#include <starlet.h>
    unsigned int status, event_flag = 1;
    struct {
        short int iostat, iolen;
        unsigned int dev_info;
    }ttiosb;
.
.
.
/* Request I/O */
    status = SYSSQIO (event_flag, ... , &ttiosb ... );
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL( status );
.
.
.
/* Wait until I/O completes */
    status = SYSSYNCH (event_flag, &ttiosb );
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL( status );
.
.
.
```

System Service Input/Output Operations

23.8 Recommended Method for Testing Asynchronous Completion

Note

The SYSSQIOW service provides a combination of SYSSQIO and SYSSYNCH.

23.9 Synchronous and Asynchronous Forms of Input/Output Services

You can execute some input/output services either synchronously or asynchronously. A “W” at the end of a system service name indicates the synchronous version of the system service.

The synchronous version of a system service combines the functions of the asynchronous version of the service and the Synchronize (SYSSYNCH) system service. The synchronous version acts exactly as if you had used the asynchronous version of the system service followed immediately by a call to SYSSYNCH; it queues the I/O request, and then places the program in a wait state until the I/O request completes. The synchronous version takes the same arguments as the asynchronous version.

Table 23–2 lists the asynchronous and synchronous names of input/output services that have synchronous versions.

Table 23–2 Asynchronous Input/Output Services and Their Synchronous Versions

Asynchronous Name	Synchronous Name	Description
\$BRKTHRU	\$BRKTHRUW	Breakthrough
\$GETDVI	\$GETDVIW	Get Device/Volume Information
\$GETJPI	\$GETJPIW	Get Job/Process Information
\$GETLKI	\$GETLKIW	Get Lock Information
\$GETQUI	\$GETQUIW	Get Queue Information
\$GETSYI	\$GETSYIW	Get Systemwide Information
\$QIO	\$QIOW	Queue I/O Request
\$SNDJBC	\$SNDJBCW	Send to Job Controller
\$UPDSEC	\$UPDSECW	Update Section File on Disk

23.9.1 Reading Operations with SYSSQIOW

The SYSSQIO and SYSSQIOW system services move one record of data from a terminal to a variable. For synchronous I/O, use SYSSQIOW. Complete information about the SYSSQIO and SYSSQIOW system services is presented in the *OpenVMS System Services Reference Manual*.

Note

Do not use the SYSSQIO and SYSSQIOW system services for input from a file or nonterminal device.

System Service Input/Output Operations

23.9 Synchronous and Asynchronous Forms of Input/Output Services

The SYSSQIO and SYSSQIOW system services place the data read in the variable specified in the 1 argument. The second word of the status block contains the offset from the beginning of the buffer to the terminator—hence, it equals the size of the data read. Always reference the data as a substring, using the offset to the terminator as the position of the last character (that is, the size of the substring). If you reference the entire buffer, your data will include the terminator for the operation (for example, the CR character) and any excess characters from a previous operation using the buffer. (The only exception to the substring guideline is if you deliberately overflow the buffer to terminate the I/O operation.)

Example 23–4 shows use of the SYSSQIOW system service and reads a line of data from the terminal and waits for the I/O to complete.

Example 23–4 Reading Data from the Terminal Synchronously

```
.
.
.
INTEGER STATUS
! QIOW structures
INTEGER*2 INPUT_CHAN           ! I/O channel
INTEGER CODE,                  ! Type of I/O operation
2     INPUT_BUFF_SIZE,         ! Size of input buffer
2     PROMPT_SIZE,             ! Size of prompt
2     INPUT_SIZE               ! Size of input line as read
PARAMETER (PROMPT_SIZE = 13,
2     INPUT_BUFF_SIZE = 132)
CHARACTER*132 INPUT
CHARACTER*(*) PROMPT
PARAMETER (PROMPT = 'Input value: ')
! Define symbols used in I/O operations
INCLUDE '($IODEF)'
! Status block for QIOW
STRUCTURE /IOSTAT_BLOCK/
  INTEGER*2 IOSTAT,            ! Return status
  2     TERM_OFFSET,          ! Location of line terminator
  2     TERMINATOR,          ! Value of terminator
  2     TERM_SIZE            ! Size of terminator
END STRUCTURE
RECORD /IOSTAT_BLOCK/ IOSB
! Subprograms
INTEGER*4 SYS$ASSIGN,
2     SYS$QIOW
.
.
.
! Assign an I/O channel to SYS$INPUT
STATUS = SYS$ASSIGN ('SYS$INPUT',
2     INPUT_CHAN,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

(continued on next page)

System Service Input/Output Operations

23.9 Synchronous and Asynchronous Forms of Input/Output Services

Example 23–4 (Cont.) Reading Data from the Terminal Synchronously

```
! Read with prompt
CODE = IO$_READPROMPT
STATUS = SYS$QIOW (,
2           %VAL (INPUT_CHAN),
2           %VAL (CODE),
2           IOSB,
2           '',
2           %REF (INPUT),
2           %VAL (INPUT_BUFF_SIZE),
2           '',
2           %REF (PROMPT),
2           %VAL (PROMPT_SIZE))
! Check QIOW status
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Check status of I/O operation
IF (.NOT. IOSB.IOSTAT) CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
! Set size of input string
INPUT_SIZE = IOSB.TERM_OFFSET
.
.
.
```

23.9.2 Reading Operations with SYS\$QIO

To perform an asynchronous read operation, use the SYSSQIO system service and specify an event flag (the first argument, which must be passed by value). Your program continues while the I/O is taking place. When you need the input from the I/O operation, invoke the SYSSYNCH system service to wait for the event flag and status block specified in the SYSSQIO system service. If the I/O is not complete, your program pauses until it is. In this manner, you can overlap processing within your program. Naturally, you must take care not to assume data has been returned by the I/O operation before you call SYSSYNCH and it returns successfully. Example 23–5 demonstrates an asynchronous read operation.

Example 23–5 Reading Data from the Terminal Asynchronously

```
.
.
.
INTEGER STATUS
! QIO structures
INTEGER*2 INPUT_CHAN      ! I/O channel
INTEGER CODE,             ! Type of I/O operation
2     INPUT_BUFF_SIZE,    ! Size of input buffer
2     PROMPT_SIZE,        ! Size of prompt
2     INPUT_SIZE          ! Size of input line as read
PARAMETER (INPUT_BUFF_SIZE = 132,
2     PROMPT = 13)
CHARACTER*132 INPUT
CHARACTER*(*) PROMPT
PARAMETER (PROMPT = 'Input value: ')
INCLUDE '($IODEF)'        ! Symbols used in I/O operations
```

(continued on next page)

System Service Input/Output Operations

23.9 Synchronous and Asynchronous Forms of Input/Output Services

Example 23–5 (Cont.) Reading Data from the Terminal Asynchronously

```
! Status block for QIO
STRUCTURE /IOSTAT_BLOCK/
  INTEGER*2 IOSTAT,      ! Return status
  2          TERM_OFFSET, ! Location of line terminator
  2          TERMINATOR,  ! Value of terminator
  2          TERM_SIZE    ! Size of terminator
END STRUCTURE
RECORD /IOSTAT_BLOCK/ IOSB
! Event flag for I/O
INTEGER INPUT_EF
! Subprograms
INTEGER*4 SYS$ASSIGN,
2          SYS$QIO,
2          SYS$SYNCH,
2          LIB$GET_EF
.
.
! Assign an I/O channel to SYS$INPUT
STATUS = SYS$ASSIGN ('SYS$INPUT',
2                  INPUT_CHAN,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Get an event flag
STATUS = LIB$GET_EF (INPUT_EF)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Read with prompt
CODE = IO$_READPROMPT
STATUS = SYS$QIO (%VAL (INPUT_EF),
2              %VAL (INPUT_CHAN),
2              %VAL (CODE),
2              IOSB,
2              ',
2              %REF (INPUT),
2              %VAL (INPUT_BUFF_SIZE),
2              ',
2              %REF (PROMPT),
2              %VAL (PROMPT_SIZE))
! Check status of QIO
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
STATUS = SYS$SYNCH (%VAL (INPUT_EF),
2                 IOSB)
! Check status of SYNCH
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Check status of I/O operation
IF (.NOT. IOSB.IOSTAT) CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
! Set size of input string
INPUT_SIZE = IOSB.TERM_OFFSET
.
.
.
```

Be sure to check the status of the I/O operation as returned in the I/O status block. In an asynchronous operation, you can check this status only after the I/O operation is complete (that is, after the call to SYSSYNCH).

System Service Input/Output Operations

23.9 Synchronous and Asynchronous Forms of Input/Output Services

23.9.3 Write Operations with SYS\$QIOW

The SYS\$QIO and SYS\$QIOW system services move one record of data from a character value to the terminal. Do not use these system services, as described here, for output to a file or nonterminal device.

For synchronous I/O, use SYS\$QIOW and omit the first argument (the event flag number). For complete information about SYS\$QIO and SYS\$QIOW, refer to the *OpenVMS System Services Reference Manual*.

Example 23–6 writes a line of character data to the terminal.

Example 23–6 Writing Character Data to a Terminal

```
INTEGER STATUS,
2     ANSWER_SIZE
CHARACTER*31 ANSWER
INTEGER*2 OUT_CHAN
! Status block for QIO
STRUCTURE /IOSTAT_BLOCK/
  INTEGER*2 IOSTAT,
2         BYTE_COUNT,
2         LINES_OUTPUT
  BYTE     COLUMN,
2         LINE
END STRUCTURE
RECORD /IOSTAT_BLOCK/ IOSB
! Routines
INTEGER SYS$ASSIGN,
2     SYS$QIOW
! IO$ symbol definitions
INCLUDE '($IODEF)'
.
.
.
STATUS = SYS$ASSIGN ('SYS$OUTPUT',
2     OUT_CHAN,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SYS$QIOW (,
2     %VAL (OUT_CHAN),
2     %VAL (IO$_WRITEVBLK),
2     IOSB,
2     ,
2     ,
2     %REF ('Answer: '//ANSWER(1:ANSWER_SIZE)),
2     %VAL (8+ANSWER_SIZE),
2     ,
2     %VAL (32),,) ! Single spacing
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
IF (.NOT. IOSB.IOSTAT) CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
END
```

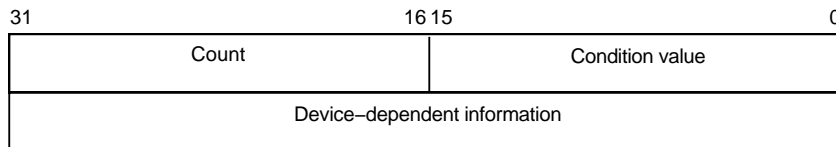
23.10 I/O Completion Status

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 completed successfully, the number of bytes that were transferred, and additional device-dependent return information.

System Service Input/Output Operations

23.10 I/O Completion Status

Figure 23–7 I/O Status Block



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Figure 23–7 illustrates the format for the SYSSQIO system service of the information written in the IOSB.

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, SSS_NORMAL indicates successful completion.

The second word contains the number of bytes actually transferred in the I/O operation. Note that for some devices this word contains only the low-order word of the count. For information about specific devices, see the *OpenVMS I/O User's Reference Manual*.

The second longword contains device-dependent return information.

System services other than SYSSQIO use the quadword I/O status block, but the format is different. See the description of each system service in the *OpenVMS System Services Reference Manual* for the format of the information written in the IOSB for that service.

To ensure successful I/O completion and the integrity of data transfers, you should check the IOSB following I/O requests, particularly for device-dependent I/O functions. For complete details about how to use the I/O status block, see the *OpenVMS I/O User's Reference Manual*.

23.11 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 calling the Deassign I/O Channel (SYSSDASSGN) system service:

```
$DASSGN_S CHAN=TTCHAN
```

This service call releases the terminal channel assignment acquired in the SYSSASSIGN example shown in Section 23.5. The system automatically deassigns channels for a process when the image that assigned the channel exits.

23.12 Using Complete Terminal I/O

The following example shows a complete sequence of input and output operations using the \$QIOW macro to read and write lines to the current default SYSSINPUT device. Because the input/output of this program must be to the current terminal, it functions correctly only if you execute it interactively.

System Service Input/Output Operations 23.12 Using Complete Terminal I/O

```

#include <descrip.h>
#include <iodef.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>
#include <string.h>
#define BUFSIZ 80
/* I/O status block */
struct {
    unsigned short iostat, ttiolen;
    unsigned int dev_info;
} ttiosb;
main() {
    unsigned int status ,outlen, inlen = BUFSIZ;
    unsigned short ttchan;
    char buffer[BUFSIZ];
    $DESCRIPTOR(ttname,"SYS$INPUT");

/* Assign a channel */
    status = SYS$ASSIGN(&ttname, /* devnam - device number */
                      &ttchan, /* chan - channel number */
                      0, 0, 0);
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL( status );

/* Request I/O */
    status = SYS$QIOW(0, /* efn - event flag */
                    ttchan, /* chan - channel number */
                    IO$_READVBLK, /* func - function modifier */
                    &ttiosb, /* iosb - I/O status block */
                    0, /* astadr - AST routine */
                    0, /* astprm - AST parameter */
                    buffer, /* p1 - buffer */
                    inlen, /* p2 - length of buffer */
                    0, 0, 0, 0);
    if (!$VMS_STATUS_SUCCESS( status ))
        LIB$SIGNAL( status );

/* Get length from IOSB */
    outlen = ttiosb.ttiolen;

status = SYS$QIOW(0, ttchan, IO$_WRITEVBLK, &ttiosb, 0, 0, buffer, outlen,
                0, 0, 0, 0);
    if (!$VMS_STATUS_SUCCESS( status ))
        LIB$SIGNAL( status );

/* Deassign the channel */
    status = SYS$DASSGN( ttchan ); /* chan - channel */
    if (!$VMS_STATUS_SUCCESS( status ))
        LIB$SIGNAL( status );
}

```

- ❶ 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).
- ❷ The string will be read into the buffer BUFFER; the longword OUTLEN will contain the length of the string for the output operation.
- ❸ The TTNAME label is a character string descriptor for the logical device SYS\$INPUT, and TTCHAN is a word to receive the channel number assigned to it.
- ❹ The \$ASSIGN service assigns a channel and writes the channel number at TTCHAN.

System Service Input/Output Operations

23.12 Using Complete Terminal I/O

- ⑤ If the \$ASSIGN service completes successfully, the \$QIOW macro reads a line from the terminal, and requests that the completion status be posted in the I/O status block defined at TTIOSB.
- ⑥ 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 unsuccessful, the program takes an error path.
- ⑦ The length of the string read is moved into the longword at OUTLEN, because the \$QIOW macro requires a longword argument. However, the length field of the I/O status block is only 1 word long. The \$QIOW macro writes the line just read to the terminal.
- ⑧ 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.
- ⑨ When all I/O operations on the channel are finished, the channel is deassigned.

23.13 Canceling I/O Requests

If a process must cancel I/O requests that have been queued but not yet completed, it can issue the Cancel I/O On Channel (SYSSCANCEL) system service. All pending I/O requests issued by the process on that channel are canceled; you cannot specify a particular I/O request.

The SYSSCANCEL system service performs an asynchronous cancel operation. This means that the application *must* wait for each I/O operation issued to the driver to complete before checking the status for that operation.

For example, you can call the SYSSCANCEL system service as follows:

```
    unsigned int status, efn1=3, efn2=4;
    .
    .
    .
    status = SYSSQIO(efn1, ttchan, &iosb1, ... );
    status = SYSSQIO(efn2, ttchan, &iosb2, ... );
    .
    .
    .
    status = SYSSCANCEL(ttchan);
    status = SYSSYNCH(efn1, &iosb1);
    status = SYSSYNCH(efn2, &iosb2);
```

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

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

23.14 Logical Names and Physical Device Names

When you specify a device name as input to an I/O system service, it can be a physical device name or a logical name. If the device name contains a colon (:), the colon and the characters after it are ignored. When an underscore character (_) precedes a device name string, it indicates that the string is a physical device name string, for example, `_TTB3:`.

Any string that does not begin with an underscore is considered a logical name, even though it may be a physical device name. Table 23–3 lists system services that translate a logical name iteratively until a physical device name is returned, or until the system default number of translations have been performed.

Table 23–3 System Services for Translating Logical Names

System Service	Definition
SYSSALLOC	Allocate Device
SYSSASSIGN	Assign I/O Channel
SYSSBRDCST	Broadcast
SYSSDALLOC	Deallocate Device
SYSSDISMOU	Dismount Volume
SYSSGETDEV	Get I/O Device Information
SYSSGETDVI	Get Device/Volume Information
SYSSMOUNT	Mount Volume

In each translation, the logical name tables defined by the logical name `LNMS$FILE_DEV` are searched in order. These tables, listed in search order, are normally `LNMS$PROCESS`, `LNMS$JOB`, `LNMS$GROUP`, and `LNMS$SYSTEM`. If a physical device name is located, the I/O request is performed for that device.

If the services do not locate an entry for the logical name, the I/O service treats the name specified as a physical device name. When you specify the name of an actual physical device in a call to one of these services, include the underscore character to bypass the logical name translation.

When the `SYSSALLOC` system service returns the device name of the physical device that has been allocated, the device name string returned is prefixed with an underscore character. When this name is used for the subsequent `SYSSASSIGN` system service, the `SYSSASSIGN` 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 either by issuing a `DEFINE` 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 (`SYSS$CRELNM`) system service.

For details about how to create and use logical names, see Chapter 32.

System Service Input/Output Operations

23.15 Device Name Defaults

23.15 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 SYSS\$ASSIGN and SYSS\$DALLOC system services apply default values, as shown in Table 23–4.
- The SYSS\$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 specified, as shown in Table 23–4.

Table 23–4 Default Device Names for I/O Services

Device	Device Name ¹	Generic Device
<i>dd:</i>	<i>ddA0:</i> (unit 0 on controller A)	<i>ddxy:</i> (any available device of the specified type)
<i>ddc:</i>	<i>ddc0:</i> (unit 0 on controller specified)	<i>ddcy:</i> (any available unit on the specified controller)
<i>ddu:</i>	<i>ddAu:</i> (unit specified on controller A)	<i>ddxu:</i> (device of specified type and unit on any available controller)
<i>ddcu:</i>	<i>ddcu:</i> (unit and controller specified)	<i>ddcu:</i> (unit and controller specified)

¹See the *OpenVMS User's Manual* for a summary of the device names.

Key

dd—Specified device type (capital letters indicate a specific controller; numbers indicate a specific unit)
c—Specified controller
x—Any controller
u—Specified unit number
y—Any unit number

23.16 Obtaining Information About Physical Devices

The Get Device/Volume Information (SYSS\$GETDVI) system service returns information about devices. The information returned is specified by an item list created before the call to SYSS\$GETDVI.

When you call the SYSS\$GETDVI system service, you must provide the address of an item list that specifies the information to be returned. The format of the item list is described in the description of SYSS\$GETDVI in the *OpenVMS System Services Reference Manual*. The *OpenVMS I/O User's Reference Manual* contains details on the device-specific information these services return.

In cases where a generic (that is, nonspecific) device name is used in an I/O service, a program may need to find out what device has been used. To do this, the program should provide SYSS\$GETDVI with the number of the channel to the device and request the name of the device with the DVI\$_DEVNAM item identifier.

System Service Input/Output Operations

23.16 Obtaining Information About Physical Devices

The operating system also supports a device called the null device for program development. The mnemonic for the null device is NL. Its characteristics are as follows:

- A read from NL returns an end-of-file error (SS\$_ENDOFFILE).
- A write to NL immediately returns a success message (SS\$_NORMAL).

The null device functions as a virtual device to which you can direct output but from which the data does not return.

23.16.1 Checking the Terminal Device

You are restricted to a terminal device if you use any of the special functions described in this section. If the user of your program redirects SY\$\$INPUT or SY\$\$OUTPUT to a file or nonterminal device, an error occurs. You can use the SY\$\$GETDVIW system service to make sure the logical name is associated with a terminal, as shown in Example 23–7. SY\$\$GETDVIW returns a status of SS\$_IVDEVNAM if the logical name is defined as a file or otherwise does not equate to a device name. The type of device is the response associated with the DVI\$_DEVCLASS request code and should be DC\$_TERM for a terminal.

Example 23–7 Using SY\$\$GETDVIW to Verify the Device Name

```
RECORD /ITMLST/ DVI_LIST
LOGICAL*4 STATUS
! GETDVI buffers
INTEGER CLASS,           ! Response buffer
2      CLASS_LEN        ! Response length
! GETDVI symbols
INCLUDE '($DCDEF)'
INCLUDE '($SDEF)'
INCLUDE '($DVIDEF)'
! Define subprograms
INTEGER SY$$GETDVIW
! Find out the device class of SY$$INPUT
DVI_LIST.BUFLen = 4
DVI_LIST.CODE = DVI$_DEVCLASS
DVI_LIST.BUFADR = %LOC (CLASS)
DVI_LIST.RETLNADR = %LOC (CLASS_LEN)
STATUS = SY$$GETDVIW (,, 'SY$$INPUT',
2      DVI_LIST,,,,)
IF ((.NOT. STATUS) .AND. (STATUS .NE. SS$_IVDEVNAM)) THEN
    CALL LIB$SIGNAL (%VAL (STATUS))
END IF
! Make sure device is a terminal
IF ((STATUS .NE. SS$_IVDEVNAM) .AND. (CLASS .EQ. DC$_TERM)) THEN
    .
    .
    .
ELSE
    TYPE *, 'Input device not a terminal'
END IF
```

23.16.2 Terminal Characteristics

The *OpenVMS I/O User's Reference Manual* describes device-specific characteristics associated with terminals. To examine a characteristic, issue a call to SY\$\$QIO or SY\$\$QIOW system service with the IO\$_SENSEMODE function and examine the appropriate bit in the structure returned to the **P1** argument. To change a characteristic:

System Service Input/Output Operations

23.16 Obtaining Information About Physical Devices

1. Issue a call to SYSSQIO or SYSSQIOW system service with the IOS_ SENSEMODE function.
2. Set or clear the appropriate bit in the structure returned to the **P1** argument.
3. Issue a call to SYSSQIO or SYSSQIOW system service with the IOS_ SETMODE function passing, as the **P1** argument, to modify the structure you obtained from the sense mode operation.

Example 23–8 turns off the HOSTSYNC terminal characteristic. To check whether NOHOSTSYNC has been set, enter the SHOW TERMINAL command.

Example 23–8 Disabling the HOSTSYNC Terminal Characteristic

```
.
.
.
INTEGER*4 STATUS
! I/O channel
INTEGER*2 INPUT_CHAN
! I/O status block
STRUCTURE /IOSTAT_BLOCK/
  INTEGER*2 IOSTAT
  BYTE      TRANSMIT,
2          RECEIVE,
2          CRFILL,
2          LFFILL,
2          PARITY,
2          ZERO
END STRUCTURE
RECORD /IOSTAT_BLOCK/ IOSB
! Characteristics buffer
! Note: basic characteristics are first three
!       bytes of second longword -- length is
!       last byte
STRUCTURE /CHARACTERISTICS/
  BYTE      CLASS,
2          TYPE
  INTEGER*2 WIDTH
  UNION
  MAP
  INTEGER*4 BASIC
  END MAP
  MAP
  BYTE LENGTH(4)
  END MAP
  END UNION
  INTEGER*4 EXTENDED
END STRUCTURE
RECORD /CHARACTERISTICS/ CHARBUF
! Define symbols used for I/O and terminal operations
INCLUDE '($IODEF)'
INCLUDE '($TTDEF)'
! Subroutines
INTEGER*4 SYSS$ASSIGN,
2          SYSS$QIOW
```

(continued on next page)

System Service Input/Output Operations

23.16 Obtaining Information About Physical Devices

Example 23–8 (Cont.) Disabling the HOSTSYNC Terminal Characteristic

```
! Assign channel to terminal
STATUS = SYS$ASSIGN ('SYS$INPUT',
2           INPUT_CHAN,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Get current characteristics
STATUS = SYS$QIOW (,
2           %VAL (INPUT_CHAN),
2           %VAL (IO$_SENSEMODE),
2           IOSB,,,
2           CHARBUF,           ! Buffer
2           %VAL (12),,,,) ! Buffer size
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
IF (.NOT. IOSB.IOSTAT) CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))
! Turn off hostsync
CHARBUF.BASIC = IBCLR (CHARBUF.BASIC, TT$V_HOSTSYNC)
! Set new characteristics
STATUS = SYS$QIOW (,
2           %VAL (INPUT_CHAN),
2           %VAL (IO$_SETMODE),
2           IOSB,,,
2           CHARBUF,
2           %VAL (12),,,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
IF (.NOT. IOSB.IOSTAT) CALL LIB$SIGNAL (%VAL (IOSB.IOSTAT))

END
```

If you modify terminal characteristics with set mode QIO operations, you should save the characteristics buffer that you obtain on the first sense mode operation, and restore those characteristics with a set mode operation before exiting. (Resetting is not necessary if you just use modifiers on each read operation.) To ensure that the restoration is performed if the program aborts (for example, if the user presses Ctrl/Y), you should restore the user's environment in an exit handler. See Chapter 9 for a description of exit handlers.

23.16.3 Record Terminators

A QIO read operation ends when the user enters a terminator or when the input buffer fills, whichever occurs first. The standard set of terminators applies unless you specify the **4** argument in the read QIO operation. You can examine the terminator that ended the read operation by examining the input buffer starting at the terminator offset (second word of the I/O status block). The length, in bytes, of the terminator is specified by the high-order word of the I/O status block. The third word of the I/O status block contains the value of the first character of the terminator.

Examining the terminator enables you to read escape sequences from the terminal, provided that you modify the QIO read operation with the IO\$M_ESCAPE modifier (or the ESCAPE terminal characteristic is set). The first character of the terminator will be the ESC character (an ASCII value of 27). The remaining characters will contain the value of the escape sequence.

23.16.4 File Terminators

You must examine the terminator to detect end-of-file (Ctrl/Z) on the terminal. No error condition is generated at the QIO level. If the user presses Ctrl/Z, the terminator will be the SUB character (an ASCII value of 26).

System Service Input/Output Operations

23.17 Device Allocation

23.17 Device Allocation

Many I/O devices are shareable; that is, more than one process at a time can access the device. By calling the Assign I/O Channel (SYSSASSIGN) system service, a process 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 with the DCL command ALLOCATE. A process can also allocate a device by calling the Allocate Device (SYSSALLOC) 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 call the SYSSALLOC system service, you must provide a device name. The device name specified can be any of the following:

- 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, SYSSALLOC attempts to allocate the specified device.

If you specify a logical name, SYSSALLOC 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 or unit number, or both), SYSSALLOC attempts to allocate any device available of the specified type. For more information about the allocation of devices by generic names, see Section 23.15.

When you specify generic device names, you must provide fields for the SYSSALLOC system service to return the name and the length of the physical device that is actually allocated so that you can provide this name as input to the SYSSASSIGN system service.

The following example illustrates the allocation of a tape device specified by the logical name TAPE:

```
#include <descrip.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>

main() {
    unsigned int status;
    char devstr[64];
    unsigned short phylen, tapechan;

    $DESCRIPTOR(logdev, "TAPE");    /* Descriptor for logical name */
    $DESCRIPTOR(devdesc, devstr);  /* Descriptor for physical name */
```


System Service Input/Output Operations

23.17 Device Allocation

```
/* Allocate a device */
status = SYSS$ALLOC( &logdev, /* devnam - device name */ ❶
                    &phylen, /* phylen - length device name string */
                    &devdesc, /* phybuf - buffer for devnam string */
                    0, 0);
if (!$VMS_STATUS_SUCCESS( status ))
    LIB$SIGNAL( status );

/* Assign a channel to the device */
status = SYSS$ASSIGN( &devdesc, /* devnam - device name */ ❷
                    &tapechan, /* chan - channel number */
                    0, 0, 0);
if (!$VMS_STATUS_SUCCESS( status ))
    LIB$SIGNAL( status );

/* Deassign the channel */
status = SYSS$DASSGN( tapechan ); /* chan - channel number */ ❸
if (!$VMS_STATUS_SUCCESS( status ))
    LIB$SIGNAL( status );

/* Deallocate the device */
status = SYSS$DALLOC( &devdesc, /* devnam - device name */
                    0 ); /* acmode - access mode */
if (!$VMS_STATUS_SUCCESS( status ))
    LIB$SIGNAL( status );
}
```

- ❶ The SYSS\$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 that is allocated and the length of the name string. The SYSS\$ALLOC service 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.
- ❷ The SYSS\$ASSIGN command uses the character string returned by the SYSS\$ALLOC system service as the input device name argument, and requests that the channel number be written into TAPECHAN.
- ❸ When I/O operations are completed, the SYSS\$DASSGN system service deassigns the channel, and the SYSS\$DALLOC system service deallocates the device. The channel must be deassigned before the device can be deallocated.

23.17.1 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. Because they are nonshareable, they are implicitly allocated by the SYSS\$ASSIGN system service when SYSS\$ASSIGN is called to assign a channel to the device.

23.17.2 Deallocation

When the program has finished using an allocated device, it should release the device with the Deallocate Device (SYSS\$DALLOC) system service to make it available for other processes.

At image exit, the system automatically deallocates devices allocated by the image.

System Service Input/Output Operations

23.18 Mounting, Dismounting, and Initializing Volumes

23.18 Mounting, Dismounting, and Initializing Volumes

This section introduces you to using system services to mount, dismount, and initialize disk and tape volumes.

23.18.1 Mounting a Volume

Mounting a volume establishes a link between a volume, a device, and a process. A volume, or volume set, must be mounted before I/O operations can be performed on the volume. You interactively mount or dismount a volume from the DCL command stream with the MOUNT or DISMOUNT command. A process can also mount or dismount a volume or volume set programmatically using the Mount Volume (SYSSMOUNT) or the Dismount Volume (SYSSDISMOU) system service, respectively.

Mounting a volume involves two operations:

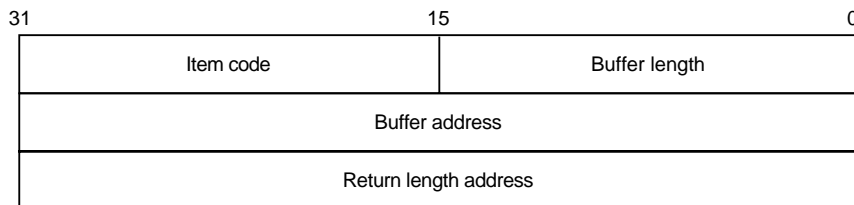
1. Place the volume on the device and start the device (by pressing the START or LOAD button).
2. Mount the volume with the SYSSMOUNT system service.

23.18.1.1 Calling the SYSSMOUNT System Service

The Mount Volume (SYSSMOUNT) system service allows a process to mount a single volume or a volume set. When you call the SYSSMOUNT system service, you must specify a device name.

The SYSSMOUNT system service has a single argument, which is the address of a list of item descriptors. The list is terminated by a longword of binary zeros. Figure 23-8 shows the format of an item descriptor.

Figure 23-8 SYSSMOUNT Item Descriptor



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Most item descriptors do not have to be in any order. To mount volume sets, you must specify one item descriptor per device and one item descriptor per volume; you must specify the descriptors for the volumes in the same order as the descriptors for the devices on which the volumes are loaded.

For item descriptors other than device and volume names, if you specify the same item descriptor more than once, the last occurrence of the descriptor is used.

The following example illustrates a call to SYSSMOUNT. The call is equivalent to the DCL command that precedes the example.

System Service Input/Output Operations

23.18 Mounting, Dismounting, and Initializing Volumes

```
$ MOUNT/SYSTEM/NOQUOTA DRA4:,DRA5: USER01,USER02 USERD$
```

```
#include <descrip.h>
#include <lib$routines.h>
#include <mntdef.h>
#include <starlet.h>
#include <stdio.h>
.
.
.

struct {
    unsigned short buflen, item_code;
    void *bufaddr;
    int *retlenaddr;
}itm;

    struct itm itm[7];

main() {
    .
    .
    .
    unsigned int status, flags;

    $DESCRIPTOR(dev1,"DRA4:");
    $DESCRIPTOR(vol1,"USER01");
    $DESCRIPTOR(dev2,"DRA5:");
    $DESCRIPTOR(vol2,"USER02");
    $DESCRIPTOR(log,"USERD$");

    flags = MNT$M_SYSTEM | MNT$M_NODISKQ;

    i = 0;
    itm[i].buflen = sizeof( flags );
    itm[i].item_code = MNT$_FLAGS;
    itm[i].bufaddr = flags;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = dev1.dsc$w_length;
    itm[i].item_code = MNT$_DEVNAM;
    itm[i].bufaddr = dev1.dsc$a_pointer;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = vol1.dsc$w_length;
    itm[i].item_code = MNT$_VOLNAM;
    itm[i].bufaddr = vol1.dsc$a_pointer;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = dev2.dsc$w_length;
    itm[i].item_code = MNT$_DEVNAM;
    itm[i].bufaddr = dev2.dsc$a_pointer;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = vol2.dsc$w_length;
    itm[i].item_code = MNT$_VOLNAM;
    itm[i].bufaddr = vol2.dsc$a_pointer;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = log.dsc$w_length;
    itm[i].item_code = MNT$_LOGNAM;
    itm[i].bufaddr = log.dsc$a_pointer;
    itm[i++].retlenaddr = NULL;

    itm[i].buflen = 0;
    itm[i].item_code = 0;
    itm[i].bufaddr = NULL;
    itm[i++].retlenaddr = NULL;
}
```

System Service Input/Output Operations

23.18 Mounting, Dismounting, and Initializing Volumes

```
.  
. .  
    status = SYS$MOUNT ( itm );  
    if (!$VMS_STATUS_SUCCESS(status))  
        LIB$SIGNAL( status );  
. .  
}
```

23.18.1.2 Calling the SYS\$DISMOU System Service

The SYS\$DISMOU system service allows a process to dismount a volume or volume set. When you call SYS\$DISMOU, you must specify a device name. If the volume mounted on the device is part of a fully mounted volume set, and you do not specify flags, the whole volume set is dismounted.

The following example illustrates a call to SYS\$DISMOU. The call dismounts the volume set mounted in the previous example.

```
    $DESCRIPTOR(dev1_desc, "DRA4:");  
. .  
    status = SYS$DISMOU(&dev1_desc); /* devnam - device */  
. .  
}
```

23.18.2 Initializing Volumes

Initializing a volume writes a label on the volume, sets protection and ownership for the volume, formats the volume (depending on the device type), and overwrites data already on the volume.

You interactively initialize a volume from the DCL command stream using the INITIALIZE command. A process can programmatically initialize a volume using the Initialize Volume (SYS\$INIT_VOL) system service.

23.18.2.1 Calling the Initialize Volume System Service

You must specify a device name and a new volume name when you call the SYS\$INIT_VOL system service. You can also use the **itmlst** argument of \$INIT_VOL to specify options for the initialization. For example, you can specify that data compaction should be performed by specifying the INIT\$_COMPACTION item code. See the *OpenVMS System Services Reference Manual* for more information on initialization options.

Before initializing the volume with SYS\$INIT_VOL, be sure you have placed the volume on the device and started the device (by pressing the START or LOAD button).

The default format for files on disk volumes is called Files-11 On-Disk Structure Level 2. Files-11 On-Disk Structure Level 1 format, available on VAX systems, is used by other Compaq operating systems, including RSX-11M, RSX-11M-PLUS, RSX-11D, and IAS, but is not supported on Alpha systems. For more information, see the *OpenVMS System Manager's Manual*.

Here are two examples of calling SYS\$INIT_VOL programmatically: one from a C program and one from a BASIC program.

System Service Input/Output Operations

23.18 Mounting, Dismounting, and Initializing Volumes

The following example illustrates a call to SYSSINIT_VOL from Compaq C:

```
#include <descrip.h>
#include <initdef.h>
#include <lib$routines.h>
#include <starlet.h>
#include <stsdef.h>

struct item_descrip_3
{
    unsigned short buffer_size;
    unsigned short item_code;
    void *buffer_address;
    unsigned short *return_length;
};

main ()
{
    unsigned long
        density_code,
        status;
    $DESCRIPTOR(drive_dsc, "MUA0:");
    $DESCRIPTOR(label_dsc, "USER01");
    struct
    {
        struct item_descrip_3 density_item;
        long terminator;
    } init_itmlst;

    /*
    ** Initialize the input item list.
    */

    density_code = INIT$K_DENSITY_6250_BPI;
    init_itmlst.density_item.buffer_size = 4;
    init_itmlst.density_item.item_code = INIT$_DENSITY;
    init_itmlst.density_item.buffer_address = &density_code;

    init_itmlst.terminator = 0;

    /*
    ** Initialize the volume.
    */

    status = SYS$INIT_VOL (&drive_dsc, &label_dsc, &init_itmlst);

    /*
    ** Report an error if one occurred.
    */

    if (!$VMS_STATUS_SUCCESS (status ))
        LIB$STOP (status);
}
```

The following example illustrates a call to SYSSINIT_VOL from VAX BASIC:

```
OPTION TYPE = EXPLICIT
%INCLUDE '$INITDEF' %FROM %LIBRARY
EXTERNAL LONG FUNCTION SYS$INIT_VOL
```

System Service Input/Output Operations

23.18 Mounting, Dismounting, and Initializing Volumes

```
RECORD ITEM_DESC
  VARIANT
  CASE
    WORD BUFLEN
    WORD ITMCO
    LONG BUFADR
    LONG LENADR
  CASE
    LONG TERMINATOR
  END VARIANT
END RECORD

DECLARE LONG RET_STATUS, &
  ITEM_DESC INIT_ITMLST(2)

! Initialize the input item list.

INIT_ITMLST(0)::ITMCO = INIT$_READCHECK
INIT_ITMLST(1)::TERMINATOR = 0

! Initialize the volume.

RET_STATUS = SYSS$INIT_VOL ("DJA21:" BY DESC, "USERVOLUME" BY DESC,
  INIT_ITMLST() BY REF)
```

23.19 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 (SYSS\$FAO) system service performs these functions.

Input to the SYSS\$FAO system service consists of the following:

- 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.

The following example shows a call to the SYSS\$FAO system service to format an output string for a SYSS\$QIOW macro. Complete details on how to use SYSS\$FAO, with additional examples, are provided in the description of the SYSS\$FAO system service in the *OpenVMS System Services Reference Manual*.

```
#include <descrip.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>
#include <stsdef.h>

main() {
```

System Service Input/Output Operations

23.19 Formatting Output Strings

```
unsigned int status, faolen;
char faobuf[80];
$DESCRIPTOR(faostr,"FILE !AS DOES NOT EXIST"); ❶
$DESCRIPTOR(outbuf, faobuf); ❷
$DESCRIPTOR(filespec,"DISK$USER:MYFILE.DAT"); ❸

status = SYS$FAO( &faostr, &outlen, &outbuf, &filespec ); ❹
if (!$VMS_STATUS_SUCCESS(status))
    LIB$SIGNAL(status);
.
.
.
status = SYS$QIOW( ... faobuf, outlen, ... ); ❺
if (!$VMS_STATUS_SUCCESS(status))
    LIB$SIGNAL(status);
.
.
.
}
```

- 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 SYS\$FAO is called to format this control string, !AS will be substituted with the string whose descriptor address is specified.
- ❷ FAODESC is a character string descriptor for the output buffer; SYS\$FAO writes the string into the buffer, and writes 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 SYS\$QIOW macro.)
- ❸ FILESPEC is a character string descriptor defining an input string for the FAO directive !AS.
- ❹ The call to SYS\$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 SYS\$FAO completes successfully, SYS\$QIOW writes the following output string:

```
FILE DISK$USER:MYFILE.DAT DOES NOT EXIST
```

23.20 Mailboxes

Mailboxes are virtual devices that can be used for communication among processes. You accomplish actual data transfer by using OpenVMS RMS or I/O services. When the Create Mailbox and Assign Channel (SYS\$CREMBX) system 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 SYS\$CREMBX or SYS\$ASSIGN system service.

The SYS\$CREMBX system service creates the mailbox. The SYS\$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 *MBA n* , where *n* is a unit number. The equivalence name has the terminal attribute.

System Service Input/Output Operations

23.20 Mailboxes

When another process assigns a channel to the mailbox with the SYSSCREMBX or SYSSASSIGN system service, it can identify the mailbox by its logical name. The service automatically translates the logical name. The process can obtain the MBAN name either by translating the logical name (with the SYSTRNLNM system service), or by calling the Get Device/Volume Information (SYSSGETDVI) system service to obtain the unit number and the physical device name.

On VAX systems, channels assigned to mailboxes can be either bidirectional or unidirectional. Bidirectional channels (read/write) allow both SYSSQIO read and SYSSQIO write requests to be issued to the channel. Unidirectional channels (read-only or write-only) allow only a read request or a write request to the channel. The unidirectional channels and unidirectional SQIO function modifiers provide for greater synchronization between users of the mailbox.

On VAX systems, the Create Mailbox and Assign Channel (SYSSCREMBX) and Assign I/O Channel (SYSSASSIGN) system services use the **flags** argument to enable unidirectional channels. If the **flags** argument is not specified or is zero, then the channel assigned to the mailbox is bidirectional (read/write). For more information, see the discussion and programming examples in the mailbox driver chapter in the *OpenVMS I/O User's Reference Manual*. Chapter 3 of this manual also discusses the use of mailboxes.

Mailboxes are either temporary or permanent. You need the user privileges TMPMBX and PRMMBX to create temporary and permanent mailboxes, respectively.

For a temporary mailbox, the SYSSCREMBX service enters the logical name and equivalence name in the logical name table LNM\$TEMPORARY_MAILBOX. This logical name table name usually specifies the LNM\$JOB logical name table name. The system deletes a temporary mailbox when no more channels are assigned to it.

For a permanent mailbox, the SYSSCREMBX service enters the logical name and equivalence name in the logical name table LNM\$PERMANENT_MAILBOX. This logical name table name usually specifies the LNM\$SYSTEM logical name table name. Permanent mailboxes continue to exist until they are specifically marked for deletion with the Delete Mailbox (SYSSDELMBX) system service.

The following example shows how processes can communicate by means of a mailbox:

```
/* Process ORION */
#include <descrip.h>
#include <iodef.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>
#define MBXBUFSIZ 128
#define MBXBUFQUO 384

/* I/O status block */
struct {
    unsigned short iostat, iolen;
    unsigned int remainder;
}mbxiosb;
```


System Service Input/Output Operations 23.20 Mailboxes

```

main() {
    void *p1, mbxast();
    char mbuffer[MBXBUFSIZ], prmflg=0;
    unsigned short mbxchan, mbxiosb;
    unsigned int status, outlen;
    unsigned int mbuflen=MBXBUFSIZ, bufquo=MBXBUFQUO, promsk=0;
    $DESCRIPTOR(mblognam, "GROUP100_MAILBOX");

    /* Create a mailbox */
    status = SYS$CREMBX( prmflg,          /* Permanent or temporary */ ❶
                        &mbxchan,      /* chan - channel number */
                        mbuflen,        /* maxmsg - buffer length */
                        bufquo,         /* bufquo - quota */
                        promsk,         /* promsk - protection mask */
                        0,               /* acmode - access mode */
                        &mblognam,     /* lognam - mailbox logical name */
                        0);             /* flags - options */
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL(status);
    .
    .
    .
    /* Request I/O */
    status = SYS$QIO(0,                  /* efn - event flag */ ❷
                    mbxchan,            /* chan - channel number */
                    IO$_READVBLK,      /* func - function modifier */
                    &mbxiosb,          /* iosb - I/O status block */
                    &mbxast,           /* astadr - AST routine */
                    &mbuffer,         /* p1 - output buffer */
                    mbuflen);          /* p2 - length of buffer */
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL(status);
    .
    .
    .
}

void mbxast(void) { ❸
    if (mbxiosb.iostat != SS$_NORMAL)
        status = SYS$QIOW( . . . , &mbuffer, &outlen, . . . )
    if (!$VMS_STATUS_SUCCESS(status))
        LIB$SIGNAL(status);

    return;
}

/* Process Cygnus */
#include <descrip.h>
#include <iodef.h>
#include <lib$routines.h>
#include <ssdef.h>
#include <starlet.h>
#include <stdio.h>
#include <stsdef.h>
#define MBXBUFSIZ 128

main() {
    unsigned short int mailchan;
    unsigned int status, outlen;
    char outbuf[MBXBUFSIZ];
    $DESCRIPTOR(mailbox, "GROUP100_MAILBOX");

```

System Service Input/Output Operations

23.20 Mailboxes

```
status = SYSS$ASSIGN(&mailbox, &mailchan, 0, 0, 0); ④
if (!$VMS_STATUS_SUCCESS(status))
    LIB$SIGNAL(status);
.
.
.

status = SYSS$QIOW(0, mailchan, 0, 0, 0, 0, &outbuf, outlen, 0, 0, 0, 0)
if (!$VMS_STATUS_SUCCESS(status))
    LIB$SIGNAL(status);
.
.
.
}
```

- ① Process ORION creates the mailbox and receives the channel number at MBXCHAN.

The **prnflg** argument indicates that the mailbox is a temporary mailbox. The logical name is entered in the LNM\$TEMPORARY_MAILBOX 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 SYSS\$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 allocated for buffering messages is subtracted from the process's buffer quota. Use the **bufquo** argument to specify how much of the process quota should 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.)

- ② After creating the mailbox, process ORION calls the SYSS\$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 is received.
- ③ When a message is sent to the mailbox (by CYGNUS), the AST is delivered and ORION responds to the message. Process 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 SYSS\$QIOW_S.
- ④ Process CYGNUS assigns a channel to the mailbox, specifying the logical name the process ORION gave the mailbox. The SYSS\$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 SYSS\$QIOW (without the IO\$M_NOW function modifier) is used to write the message, the process will not continue executing until another process reads the message.

23.20.1 Mailbox Name

The **lognam** argument to the SYS\$CREMBX service specifies a descriptor that points to a character string for the mailbox name.

Translation of the **lognam** argument proceeds as follows:

1. The current name string is prefixed with MBX\$ and the result is subject to logical name translation.
2. If the result is a logical name, step 1 is repeated until translation does not succeed or until the number of translations performed exceeds the number specified by the SYSGEN parameter LNM\$C_MAXDEPTH.
3. The MBX\$ prefix is stripped from the current name string that could not be translated. This current string is made a logical name with an equivalence name MBAn (*n* is a number assigned by the system).

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

```
$ DEFINE MBX$CHKPNT CHPNT_001
```

Assume also that your program contains the following statements:

```
    $DESCRIPTOR(mbxdesc, "CHKPNT");  
    .  
    .  
    .  
    status = SYS$CREMBX( . . . , &mbxdesc, . . . );
```

The following logical name translation takes place:

1. MBX\$ is prefixed to CHPNT.
2. MBX\$CHKPNT is translated to CHPNT_001.

Because further translation is unsuccessful, the logical name CHPNT_001 is created with the equivalence name MBAn (*n* is a number assigned by the system).

There are two exceptions to the logical name translation method discussed in this section:

- If the name string starts with an underscore (_), the operating system strips the underscore and considers the resultant string to be the actual name (that is, further translation is not performed).
- If the name string is the result of a logical name translation, then the name string is checked to see whether it has the **terminal** attribute. If the name string is marked with the **terminal** attribute, the operating system considers the resultant string to be the actual name (that is, further translation is not performed).

23.20.2 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 following format:

```
MSG$_sender
```

System Service Input/Output Operations

23.20 Mailboxes

The symbolic names included in the \$MSGDEF macro and their meanings are as follows:

Symbolic Name	Meaning
MSG\$_TRMUNSOLIC	Unsolicited terminal data
MSG\$_CRUNSOLIC	Unsolicited card reader data
MSG\$_ABORT	Network partner aborted link
MSG\$_CONFIRM	Network connect confirm
MSG\$_CONNECT	Network inbound connect initiate
MSG\$_DISCON	Network partner disconnected
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
MSG\$_NETSHUT	Network shutting down
MSG\$_NODEACC	Node has become accessible
MSG\$_NODEINACC	Node has become inaccessible
MSG\$_EVTAVL	Events available to DECnet Event Logger
MSG\$_EVTRCVCHG	Event receiver database change
MSG\$_INCDAT	Unsolicited incoming data available
MSG\$_RESET	Request to reset the virtual circuit
MSG\$_LINUP	PVC line up
MSG\$_LINDWN	PVC line down
MSG\$_EVTXMTCHG	Event transmitter database change

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.

23.20.3 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 you delete the created process, the system sends a message to the specified termination mailbox.

You cannot use a mailbox in memory shared by multiple processors as a process termination mailbox.

23.21 Example of Using I/O Services

In the following Fortran example, the first program, SEND.FOR, creates a mailbox named MAIL_BOX, writes data to it, and then indicates the end of the data by writing an end-of-file message.

The second program, RECEIVE.FOR, creates a mailbox with the same logical name, MAIL_BOX. It reads the messages from the mailbox into an array. It stops the read operations when a read operation generates an end-of-file message and the second longword of the I/O status block is nonzero. By checking that the I/O status block is nonzero, the second program confirms that the writing process sent the end-of-file message.

The processes use common event flag number 64 to ensure that SEND.FOR does not exit until RECEIVE.FOR has established a channel to the mailbox. (If RECEIVE.FOR executes first, an error occurs because SYS\$ASSIGN cannot find the mailbox.)

```

                                SEND.FOR
INTEGER STATUS

! Name and channel number for mailbox
CHARACTER*(*) MBX_NAME
PARAMETER (MBX_NAME = 'MAIL_BOX')
INTEGER*2 MBX_CHAN

! Mailbox message
CHARACTER*80 MBX_MESSAGE
INTEGER LEN

CHARACTER*80 MESSAGES (255)
INTEGER MESSAGE_LEN (255)
INTEGER MAX_MESSAGE
PARAMETER (MAX_MESSAGE = 255)

! I/O function codes and status block
INCLUDE '($IODEF)'
INTEGER*4 WRITE_CODE
INTEGER*2 IOSTAT,
2      MSG_LEN
INTEGER READER_PID
COMMON /IOBLOCK/ IOSTAT,
2      MSG_LEN,
2      READER_PID

! System routines
INTEGER SYS$CREMBX,
2      SYS$ASCEFC,
2      SYS$WAITFR,
2      SYS$QIOW

! Create the mailbox.
STATUS = SYS$CREMBX (,
2      MBX_CHAN,
2      ' ',
2      MBX_NAME)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

! Fill MESSAGES array
.
.
.

```

System Service Input/Output Operations

23.21 Example of Using I/O Services

```

! Write the messages.
DO I = 1, MAX_MESSAGE
  WRITE_CODE = IO$_WRITEVBLK .OR. IO$_M_NOW
  MBX_MESSAGE = MESSAGES(I)
  LEN = MESSAGE_LEN(I)
  STATUS = SYS$QIOW (,
2          %VAL(MBX_CHAN),      ! Channel
2          %VAL(WRITE_CODE),    ! I/O code
2          IOSTAT,              ! Status block
2          ' ',
2          %REF(MBX_MESSAGE),    ! P1
2          %VAL(LEN),           ! P2
  IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
  IF (.NOT. IOSTAT) CALL LIB$SIGNAL (%VAL(STATUS))
END DO

! Write end of file
WRITE_CODE = IO$_WRITEOF .OR. IO$_M_NOW
STATUS = SYS$QIOW (,
2          %VAL(MBX_CHAN),      ! Channel
2          %VAL(WRITE_CODE),    ! End of file code
2          IOSTAT,              ! Status block
2          ' ',
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
IF (.NOT. IOSTAT) CALL LIB$SIGNAL (%VAL(ISTAT))
.
.
.

! Make sure cooperating process can read the information
! by waiting for it to assign a channel to the mailbox.

STATUS = SYS$ASCEFC (%VAL(64),
2          'CLUSTER',)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = SYS$WAITFR (%VAL(64))
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

END

                                RECEIVE.FOR

INTEGER STATUS

INCLUDE '($IODEF)'
INCLUDE '($SDEF)'

! Name and channel number for mailbox
CHARACTER*(*) MBX_NAME
PARAMETER (MBX_NAME = 'MAIL_BOX')
INTEGER*2 MBX_CHAN

! QIO function code
INTEGER READ_CODE

! Mailbox message
CHARACTER*80 MBX_MESSAGE
INTEGER*4    LEN

! Message arrays
CHARACTER*80 MESSAGES (255)
INTEGER*4    MESSAGE_LEN (255)

! I/O status block
INTEGER*2 IOSTAT,
2        MSG_LEN
INTEGER READER_PID
COMMON /IOBLOCK/ IOSTAT,
2              MSG_LEN,
2              READER_PID

```

System Service Input/Output Operations

23.21 Example of Using I/O Services

```

! System routines
INTEGER SYS$ASSIGN,
2     SYS$ASCEFC,
2     SYS$SETEF,
2     SYS$QIOW

! Create the mailbox and let the other process know
STATUS = SYS$ASSIGN (MBX_NAME,
2     MBX_CHAN,,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = SYS$ASCEFC (%VAL(64),
2     'CLUSTER',,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = SYS$SETEF (%VAL(64))
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

! Read first message
READ_CODE = IO$_READVBLK .OR. IO$_M_NOW
LEN = 80
STATUS = SYS$QIOW (,
2     %VAL(MBX_CHAN),      ! Channel
2     %VAL(READ_CODE),    ! Function code
2     IOSTAT,              ! Status block
2     '',
2     %REF(MBX_MESSAGE),  ! P1
2     %VAL(LEN),,,,)      ! P2
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
IF ((.NOT. IOSTAT) .AND.
2 (IOSTAT .NE. SS$_ENDOFFILE)) THEN
    CALL LIB$SIGNAL (%VAL(IOSTAT))
ELSE IF (IOSTAT .NE. SS$_ENDOFFILE) THEN
    I = 1
    MESSAGES(I) = MBX_MESSAGE
    MESSAGE_LEN(I) = MSG_LEN
END IF

! Read messages until cooperating process writes end-of-file
DO WHILE (.NOT. ((IOSTAT .EQ. SS$_ENDOFFILE) .AND.
2 (READER_PID .NE. 0)))

    STATUS = SYS$QIOW (,
2     %VAL(MBX_CHAN),      ! Channel
2     %VAL(READ_CODE),    ! Function code
2     IOSTAT,              ! Status block
2     '',
2     %REF(MBX_MESSAGE),  ! P1
2     %VAL(LEN),,,,)      ! P2

    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
    IF ((.NOT. IOSTAT) .AND.
2 (IOSTAT .NE. SS$_ENDOFFILE)) THEN
        CALL LIB$SIGNAL (%VAL(IOSTAT))
    ELSE IF (IOSTAT .NE. SS$_ENDOFFILE) THEN
        I = I + 1
        MESSAGES(I) = MBX_MESSAGE
        MESSAGE_LEN(I) = MSG_LEN
    END IF
END DO

```

.

.

.

System Service Input/Output Operations

23.22 Fast I/O and Fast Path Features (Alpha Only)

23.22 Fast I/O and Fast Path Features (Alpha Only)

Fast I/O and Fast Path are two optional features that can provide improved I/O performance. Performance improvement is achieved by reducing the CPU cost per I/O request, and improving symmetric multiprocessing (SMP) scaling of I/O operations. The CPU cost per I/O is reduced by optimizing code for high-volume I/O and by using better SMP CPU memory cache. SMP scaling of I/O is increased by reducing the number of spinlocks taken per I/O and by substituting finer-granularity spinlocks for global spinlocks.

The improvements follow a division that already exists between the device-independent and device-dependent layers in the OpenVMS I/O subsystem. The device-independent overhead is addressed by Fast I/O, which is a set of system services that can substitute for certain \$QIO operations. Using these services requires some coding changes in existing applications, but the changes are usually modest and well contained. The device-dependent overhead is addressed by Fast Path, which is an optional performance feature that creates a “fast path” to the device. It requires no application changes.

Fast I/O and Fast Path can be used independently. However, together they can provide a reduction in CPU cost per I/O on uniprocessor and on multiprocessor systems.

23.22.1 Fast I/O (Alpha Only)

Fast I/O is a set of three system services, SYSSIO_SETUP, SYSSIO_PERFORM, and SYSSIO_CLEANUP, that were developed as an alternative to \$QIO. These services are not a \$QIO replacement; \$QIO is unchanged, and \$QIO interoperability with these services is fully supported. Rather, the services substitute for a subset of \$QIO operations, namely, only the high-volume read/write I/O requests.

The Fast I/O services support 64-bit addresses for data transfers to and from disk and tape devices.

While Fast I/O services are available on OpenVMS VAX, the performance advantage applies only to OpenVMS Alpha. OpenVMS VAX has a run-time library (RTL) compatibility package that translates the Fast I/O service requests to \$QIO system service requests, so one set of source code can be used on both VAX and Alpha systems.

23.22.1.1 Fast I/O Benefits

The performance benefits of Fast I/O result from streamlining high-volume I/O requests. The Fast I/O system service interfaces are optimized to avoid the overhead of general-purpose services. For example, I/O request packets (IRPs) are now permanently allocated and used repeatedly for I/O rather than allocated and deallocated anew for each I/O.

The greatest benefits stem from having user data buffers and user I/O status structures permanently locked down and mapped using system space. This allows Fast I/O to do the following:

- Avoid per-I/O buffer lockdown or unlocking for direct I/O.
- Avoid allocation and deallocation for buffered I/O of a separate system buffer, because the user buffer is always addressable.

System Service Input/Output Operations

23.22 Fast I/O and Fast Path Features (Alpha Only)

- Complete Fast I/O operations at IPL 8, thereby avoiding the interrupt chaining usually required by the more general-purpose \$QIO system service. For each I/O, this eliminates the IPL 4 IOPOST interrupt and a kernel AST.

In total, Fast I/O services eliminate four spinlock acquisitions per I/O (two for the MMG spinlock and two for the SCHED spinlock). The reduction in CPU cost per I/O is 20% for uniprocessor systems and 10% for multiprocessor systems.

23.22.1.2 Buffer Objects

Buffer objects accomplish the lockdown of user-process data structures. Buffer objects are process entities that are associated with a process's virtual address range. When a buffer object is created, all its physical pages in its address range are locked in memory and can be double-mapped into system space. These locked pages in a process's address range cannot be freed until the buffer object has been deleted. The Fast I/O environment uses this feature by locking the buffer object itself during \$IO_SETUP. This prevents the buffer object and its associated pages from being deleted. The buffer object is unlocked during \$IO_CLEANUP, or at image rundown. After creating a buffer object, the process remains fully pageable and swappable and the process retains normal virtual memory access to its pages in the buffer object.

If the buffer object contains process data structures to be passed to an OpenVMS system service, the OpenVMS system can use the buffer object to avoid any probing, lockdown, and unlocking overhead associated with these process data structures. Additionally, if the buffer object has performed double-mapping into system space, this allows the OpenVMS system direct access to the process memory from system context.

To date, only the Fast I/O services are supported with buffer objects. For example, a buffer object allows a programmer to eliminate I/O memory management overhead. On each I/O, each page of a user data buffer is probed and then locked down on I/O initiation and unlocked on I/O completion. Instead of incurring this overhead for each I/O, it can be done once at buffer object creation time. Subsequent I/O operations involving the buffer object can completely avoid this memory management overhead.

System Space Window Buffer Objects

The system space window buffer object allows several I/O related tasks to be performed entirely from system context at high IPL, without having to assume process context. When a buffer object is created, the system maps by default a section of system space (S2) to process pages associated with the buffer object. This protected system space window allows read and write access only from kernel mode. Because all of system space is equally accessible from within any context, it is now possible to avoid the context switch to assume the original user's process context. Optionally, the system space window can be in S0/S1 space, or it can be suppressed.

Buffer Object System Services

Two system services are used to create and delete buffer objects: `SYSS$CREATE_BUFOBJ_64` and `SYSS$DELETE_BUFOBJ`. Both services can be called from any access mode. To create a buffer object, the `SYSS$CREATE_BUFOBJ_64` system service is called. This service expects as inputs an existing process memory range and returns a handle for the buffer object. The handle is an opaque identifier used to identify the buffer object on future requests. The `SYSS$DELETE_BUFOBJ` system service is used to delete the buffer object and accepts as input the handle. Although image rundown deletes all existing buffer objects, it is good practice for the application to clean up properly.

System Service Input/Output Operations

23.22 Fast I/O and Fast Path Features (Alpha Only)

Buffer Object Management

Buffer objects require system management. Because buffer objects tie up physical memory, extensive use of buffer objects require system management planning. All the bytes of memory in the buffer object are deducted from the systemwide SYSGEN parameter MAXBOBMEM (maximum buffer object memory). System managers must set this parameter correctly for the application loads that run on their systems. Additionally, two other SYSGEN parameters MAXBOBS0S1 and MAXBOBS2 are available for system managers. Table 23–5 shows these three parameters and their meanings.

Table 23–5 SYSGEN Buffer Object Parameters

Parameter	Meaning
MAXBOBMEM	<p>Defines the maximum amount of physical memory, measured in pagelets, that can be associated with buffer objects.</p> <p>A page associated with a buffer object is counted against this parameter only once, even if it is associated with more than one buffer object at the same time.</p> <p>Memory resident pages are not counted against this parameter. However, pages locked in memory through the SYSSLCKPAG system service are counted.</p> <p>This is a DYNAMIC parameter.</p>
MAXBOBS0S1	<p>Defines the maximum amount of 32-bit system space, measured in pagelets, that can be used as windows to buffer objects.</p> <p>This is a DYNAMIC parameter.</p>
MAXBOBS2	<p>Defines the maximum amount of 64-bit system space, measured in pagelets, that can be used as windows to buffer objects.</p> <p>This is a DYNAMIC parameter.</p>

The MAXBOBMEM, MAXBOBS0S1, and MAXBOBS2 parameters default to 100 Alpha pages, but for applications with large buffer pools it can be set much larger. To prevent user-mode code from tying up excessive physical memory, user-mode callers of \$CREATE_BUFOBJ_64 must have a new system identifier, VMS\$BUFFER_OBJECT_USER, assigned. The system manager can assign this identifier with the DCL command SET ACL command to a protected subsystem or application that creates buffer objects from user mode. It may also be appropriate to grant the identifier to a particular user with the Authorize utility command GRANT/IDENTIFIER, for example, to a programmer who is working on a development system.

Buffer Object Restrictions

There are several buffer object restrictions which are listed as follows:

- Buffer objects can only be associated with process space (P0, P1, or P2) pages.
- PFN-mapped pages cannot be associated with buffer objects.
- The special buffer object type without associated system space can only be used to describe Fast I/O data buffers. The IOSA must always be associated with a full buffer object with system space.

System Service Input/Output Operations

23.22 Fast I/O and Fast Path Features (Alpha Only)

Further Fast I/O Information

For complete information about using Fast I/O, the Fast I/O system services, and the buffer objects system services that are in the following list, see the *OpenVMS I/O User's Reference Manual*, and the *OpenVMS System Services Reference Manual: A-GETUAI* and the *OpenVMS System Services Reference Manual: GETUTC-Z*:

```
SYSSCREATE_BUFOBJ_64
SYSSDELETE_BUFOBJ
SYSSIO_SETUP
SYSSIO_PERFORM
SYSSIO_CLEANUP
```

23.22.2 Fast Path (Alpha Only)

Like Fast I/O, Fast Path is an optional, high-performance feature designed to improve I/O performance. By restructuring and optimizing class and port device driver code around high-volume I/O code paths, Fast Path creates a streamlined path to the device. Fast Path is of interest to any application where enhanced I/O performance is desirable. Two examples are database systems and real-time applications, where the speed of transferring data to disk is often a vital concern.

Using Fast Path features does not require source-code changes. Minor interface changes are available for expert programmers who want to maximize Fast Path benefits.

At this time, Fast Path is not available on the OpenVMS VAX operating system.

23.22.2.1 Fast Path Features and Benefits

Fast Path achieves performance gains by reducing CPU time for I/O requests on both uniprocessor and SMP systems. The performance benefits are produced by:

- Reducing code paths through streamlining for the case of high-volume I/O
- Substituting port-specific spinlocks for global I/O subsystem spinlocks
- Affinitizing an I/O request for a given port to a specific CPU

The performance improvement can best be seen by contrasting the current OpenVMS I/O scheme to the new Fast Path scheme. While transparent to an OpenVMS user, each disk and tape device is tied to a specific port interconnect. All I/O for a device is sent out over its assigned port. Under the current OpenVMS I/O scheme, a multiprocessor I/O can be initiated on any CPU, but I/O completion must occur on the primary CPU. Under Fast Path, all I/O for a given port is affinitized to a specific CPU, eliminating the requirement for completing the I/O on the primary CPU. This means that the entire I/O can be initiated and completed on a single CPU. Because I/O operations are no longer split among different CPUs, performance increases as memory cache thrashing between CPUs decreases.

Fast Path also removes a possible SMP bottleneck on the primary CPU. If the primary CPU must be involved in all I/O, then once this CPU becomes saturated, no further increase in I/O throughput is possible. Spreading the I/O load evenly among CPUs in a multiprocessor system provides greater maximum I/O throughput on a multiprocessor system.

With most of the I/O code path executing under port-specific spinlocks and with each port assigned to a specific CPU, a scalable SMP model of parallel operation exists. Given multiple port and CPUs, I/O can be issued in parallel to a large degree.

System Service Input/Output Operations

23.22 Fast I/O and Fast Path Features (Alpha Only)

23.22.2.2 Additional Information About Fast Path

For complete information about using Fast Path, see the *OpenVMS I/O User's Reference Manual*.

Using Run-Time Library Routines to Access Operating System Components

This chapter describes the run-time library (RTL) routines that allow access to various operating system components and it contains the following sections:

Section 24.1 describes how to use RTL routines to make system services return different types of strings.

Section 24.2 describes how to use RTL routines to provide access to the command language interpreter.

Section 24.3 describes how to use RTL routines to allow high-level language programs to use most VAX machine instructions or their Alpha equivalent.

Section 24.4 describes how to use RTL routines to allocate processwide resources to a single operating system process.

Section 24.5 describes how to use RTL routines to measure performance.

Section 24.6 describes how to use RTL routines to control output formatting.

Section 24.7 describes how to use RTL routines for miscellaneous interface routines.

Run-time library routines allow access to the following operating system components:

- System services
- Command language interpreter
- Some VAX machine instructions

24.1 System Service Access Routines

You can usually call the OpenVMS system services directly from your program. However, system services return only fixed-length strings. In some applications, you may want the result of a system service to be returned as a character array, dynamic string, or variable-length string. For this reason, the RTL provides **jacket** routines for the system services that return strings.

You call jacket routines exactly as you would the corresponding system service, but you can pass an output argument of any valid string class. The routines write the output string using the semantics (fixed, varying, or dynamic) associated with the string's descriptor.

The jacket routines follow the conventions established for all RTL routines, except that the arguments are listed in the order of the arguments for the corresponding system service. Thus, they may not be listed in the standard RTL order (read, modify, write).

Using Run-Time Library Routines to Access Operating System Components

24.1 System Service Access Routines

For example, the LIB\$\$SYS_ASCTIM routine calls the SY\$\$ASCTIM system service to convert a binary date and time value to ASCII text. It returns the resulting string using the semantics that the calling program specifies in the destination string argument.

For further information about the operations of the system services, see the *OpenVMS System Services Reference Manual*.

The RTL routines provide access to only the system services that produce output strings, which are listed in Table 24–1. The corresponding RTL routines recognize all VAX string classes.

The RTL does not provide jacket routines for all the system services that accept strings as input. Your program should pass only fixed-length or dynamic input strings to all system services and RTL jacket routines.

Table 24–1 System Service Access Routines

Entry Point	System Service	Function
LIB\$\$SYS_ASCTIM	\$ASCTIM	Converts system time in binary form to ASCII text
LIB\$\$SYS_FAO	\$FAO	Converts a binary value to ASCII text
LIB\$\$SYS_FAOL	\$FAOL	Converts a binary value to ASCII text, using a list argument
LIB\$\$SYS_GETMSG	\$GETMSG	Obtains a system or user-defined message text
LIB\$\$SYS_TRNLOG	\$TRNLOG	Returns the translation of the specified logical name

24.2 Access to the Command Language Interpreter

Two command language interpreters (CLIs) are available on the operating system: DCL and MCR. The run-time library provides several routines that provide access to the CLI callback facility. These routines allow your program to call the current CLI. In most cases, these routines are called from programs that execute as part of a command procedure. They allow the command procedure and the CLI to exchange information.

These routines call the CLI associated with the current process to perform the specified function. In some cases, however, a CLI is not present. For example, the program may be running directly as a subprocess or as a detached process. If a CLI is not present, these routines return the status LIB\$_NOCLI. Therefore, you should be sure that these routines are called when a CLI is active. Table 24–2 lists the RTL routines that access the CLI.

Table 24–2 CLI Access Routines

Entry Point	Function
LIB\$GET_FOREIGN	Gets a command line
LIB\$DO_COMMAND	Executes a command line after exiting the current program

(continued on next page)

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

Table 24–2 (Cont.) CLI Access Routines

Entry Point	Function
LIBSRUN_PROGRAM	Runs another program after exiting the current program (chain)
LIB\$GET_SYMBOL	Returns the value of a CLI symbol as a string
LIB\$DELETE_SYMBOL	Deletes a CLI symbol
LIB\$SET_SYMBOL	Defines or redefines a CLI symbol
LIB\$DELETE_LOGICAL	Deletes a supervisor-mode process logical name
LIB\$SET_LOGICAL	Defines or redefines a supervisor-mode process logical name
LIB\$DISABLE_CTRL	Disables CLI interception of control characters
LIB\$ENABLE_CTRL	Enables CLI interception of control characters
LIB\$ATTACH	Attaches a terminal to another process
LIB\$SPAWN	Creates a subprocess of the current process

The following routines execute only when the current CLI is DCL:

```
LIB$GET_SYMBOL
LIB$SET_SYMBOL
LIB$DELETE_SYMBOL
LIB$DISABLE_CTRL
LIB$ENABLE_CTRL
LIB$SPAWN
LIB$ATTACH
```

24.2.1 Obtaining the Command Line

The LIB\$GET_FOREIGN routine returns the contents of the command line that you use to activate an image. You can use it either to give your program access to the qualifiers of a foreign command or to prompt for further command line text.

A **foreign command** is a command that you can define and then use, as if it were a DCL or MCR command to run a program. When you use the foreign command at command level, the CLI parses the foreign command only and activates the image. It ignores any options or qualifiers that you have defined for the foreign command. Once the CLI has activated the image, the program can call LIB\$GET_FOREIGN to obtain and parse the remainder of the command line (after the command itself) for whatever options it may contain.

The *OpenVMS DCL Dictionary* describes how to define a foreign command.

The action of LIB\$GET_FOREIGN depends on the environment in which the image is activated:

- If you use a foreign command to invoke the image, you can call LIB\$GET_FOREIGN to obtain the command qualifiers following the foreign command. You can also use LIB\$GET_FOREIGN to prompt repeatedly for more qualifiers after the command. This technique is illustrated in the following example.
- If the image is in the SYSSYSTEM: directory, the image can be invoked by the DCL command MCR or by the MCR CLI. In this case, LIB\$GET_FOREIGN returns the command line text following the image name.

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

- If the image is invoked by the DCL command RUN, you can use LIB\$GET_FOREIGN to prompt for additional text.
- If the image is not invoked by a foreign command or by MCR, or if there is no information remaining on the command line, and the user-supplied prompt is present, LIB\$GET_INPUT is called to prompt for a command line. If the prompt is not present, LIB\$GET_FOREIGN returns a zero-length string.

Example

The following PL/I example illustrates the use of the optional **force-prompt** argument to permit repeated calls to LIB\$GET_FOREIGN. The command line text is retrieved on the first pass only; after this, the program prompts from SYSSINPUT.

```
EXAMPLE: ROUTINE OPTIONS (MAIN);
%INCLUDE $STSDEF;          /* Status-testing definitions */
DECLARE COMMAND_LINE CHARACTER(80) VARYING,
        PROMPT_FLAG FIXED BINARY(31) INIT(0),
        LIB$GET_FOREIGN ENTRY (CHARACTER(*) VARYING,
                                CHARACTER(*) VARYING,
                                FIXED BINARY(15),
                                FIXED BINARY(31))
                                OPTIONS(VARIABLE) RETURNS (FIXED BINARY(31)),
        RMS$_EOF GLOBALREF FIXED BINARY(31) VALUE;
/* Call LIB$GET_FOREIGN repeatedly to obtain and print
   subcommand text. Exit when end-of-file is found. */
DO WHILE ('1'B);          /* Do while TRUE */
    STS$VALUE = LIB$GET_FOREIGN
                (COMMAND_LINE, 'Input: ', ,
                PROMPT_FLAG);
    IF STS$SUCCESS THEN
        PUT LIST (' Command was ',COMMAND_LINE);
    ELSE DO;
        IF STS$VALUE ^= RMS$_EOF THEN
            PUT LIST ('Error encountered');
        RETURN;
    END;
    PUT SKIP;             /* Skip to next line */
END;                      /* End of DO WHILE loop */
END;
```

Assuming that this program is present as SYSSSYSTEM:EXAMPLE.EXE, you can define the foreign command EXAMPLE to invoke it, as follows:

```
$ EXAM*PLE ::= $EXAMPLE
```

Note the optional use of the asterisk in the symbol name to denote an abbreviated command name. This permits the command name to be abbreviated as EXAM, EXAMP, EXAMPL or to be specified fully as EXAMPLE. See the *OpenVMS DCL Dictionary* for information about abbreviated command names.

Note that the use of the dollar sign (\$) before the image name is required in foreign commands.

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

Now assume that a user runs the image by typing the foreign command and giving “subcommands” that the program displays:

```
$ EXAMP Subcommand 1
  Command was      SUBCOMMAND 1
Input: Subcommand 2
  Command was      SUBCOMMAND 2
Input: ^Z
$
```

In this example, Subcommand 1 was obtained from the command line; the program prompts the user for the second subcommand. The program terminated when the user pressed the Ctrl/Z key sequence (displayed as ^Z) to indicate end-of-file.

24.2.2 Chaining from One Program to Another

The LIB\$RUN_PROGRAM routine causes the current image to exit at the point of the call and directs the CLI, if present, to start running another program. If LIB\$RUN_PROGRAM executes successfully, control passes to the second program; if not, control passes to the CLI. The calling program cannot regain control. This technique is called **chaining**.

This routine is provided primarily for compatibility with PDP-11 systems, on which chaining is used to extend the address space of a system. Chaining may also be useful in an operating system environment where address space is severely limited and large images are not possible. For example, you can use chaining to perform system generation on a small virtual address space because disk space is lacking.

With LIB\$RUN_PROGRAM, the calling program can pass arguments to the next program in the chain only by using the common storage area. One way to do this is to direct the calling program to call LIB\$PUT_COMMON to pass the information into the common area. The called program then calls LIB\$GET_COMMON to retrieve the data.

In general, this practice is not recommended. There is no convenient way to specify the order and type of arguments passed into the common area, so programs that pass arguments in this way must know about the format of the data before it is passed. Fortran COMMON or BASIC MAP/Common areas are global OWN storage. When you use this type of storage, it is very difficult to keep your program modular and AST reentrant. Further, you cannot use LIB\$RUN_PROGRAM if a CLI is present, as with image subprocesses and detached subprocesses.

Examples

The following PL/I example illustrates the use of LIB\$RUN_PROGRAM. It prompts the user for the name of a program to run and calls the RTL routine to execute the specified program.

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

```
CHAIN:  ROUTINE OPTIONS (MAIN) RETURNS (FIXED BINARY (31));
DECLARE LIB$RUN_PROGRAM ENTRY (CHARACTER (*)) /* Address of string
/* descriptor */
        RETURNS (FIXED BINARY (31)); /* Return status */
%INCLUDE $STSDEF; /* Include definition of return status values */
DECLARE COMMAND CHARACTER (80);
        GET LIST (COMMAND) OPTIONS (PROMPT('Program to run: '));
        STS$VALUE = LIB$RUN_PROGRAM (COMMAND);
/*
   If the function call is successful, the program will terminate
   here. Otherwise, return the error status to command level.
*/
        RETURN (STS$VALUE);
END CHAIN;
```

The following COBOL program also demonstrates the use of LIB\$RUN_PROGRAM. When you compile and link these two programs, the first calls LIB\$RUN_PROGRAM, which activates the executable image of the second. This call results in the following screen display:

```
THIS MESSAGE DISPLAYED BY PROGRAM PROG2
WHICH WAS RUN BY PROGRAM PROG1
USING LIB$RUN_PROGRAM

IDENTIFICATION DIVISION.
PROGRAM-ID.  PROG1.

ENVIRONMENT DIVISION.

DATA DIVISION.

WORKING-STORAGE SECTION.

01  PROG-NAME  PIC X(9)    VALUE "PROG2.EXE".
01  STAT      PIC 9(9)    COMP.
      88  SUCCESSFUL      VALUE 1.

ROUTINE DIVISION.

001-MAIN.
      CALL "LIB$RUN_PROGRAM"
          USING BY DESCRIPTOR PROG-NAME
          GIVING STAT.
      IF NOT SUCCESSFUL
          DISPLAY "ATTEMPT TO CHAIN UNSUCCESSFUL"
          STOP RUN.

IDENTIFICATION DIVISION.
PROGRAM-ID.  PROG2.

ENVIRONMENT DIVISION.

DATA DIVISION.

ROUTINE DIVISION.

001-MAIN.
      DISPLAY " ".
      DISPLAY "THIS MESSAGE DISPLAYED BY PROGRAM PROG2".
      DISPLAY " ".
      DISPLAY "WHICH WAS RUN BY PROGRAM PROG1".
      DISPLAY " ".
      DISPLAY "USING LIB$RUN_PROGRAM".
      STOP RUN.
```

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

24.2.3 Executing a CLI Command

The LIB\$DO_COMMAND routine stops program execution and directs the CLI to execute a command. The routine's argument is the text of the command line that you want to execute.

This routine is especially useful when you want to execute a CLI command after your program has finished executing. For example, you could set up a series of conditions, each associated with a different command. You could also use the routine to execute a SUBMIT or PRINT command to handle a file that your program creates.

Because of the following restrictions on LIB\$DO_COMMAND, you should be careful when you incorporate it in your program:

- After the call to LIB\$DO_COMMAND, the current image exits, and control cannot return to it.
- The text of the command is passed to the current CLI. Because you can define your own CLI in addition to DCL and MCR, you must make sure that the command is handled by the intended CLI.
- If the routine is called from a subprocess and a CLI is not associated with that subprocess, the routine executes correctly.

You can also use LIB\$DO_COMMAND to execute a DCL command file. To do this, include the at sign (@) along with a command file specification as the input argument to the routine.

Some DCL CLIS routines perform the functions of LIB\$DO_COMMAND. See the *OpenVMS DCL Dictionary* for more information.

Example

The following PL/I example prompts the user for a DCL command to execute after the program exits:

```
EXECUTE: ROUTINE OPTIONS (MAIN) RETURNS (FIXED BINARY (31));
DECLARE LIB$DO_COMMAND ENTRY (CHARACTER (*)) /* Pass DCL command */
                                           /* by descriptor */
                                           RETURNS (FIXED BINARY (31)); /* Return status */
%INCLUDE $STSDEF; /* Include definition of return status values */
DECLARE COMMAND CHARACTER (80);
GET LIST (COMMAND) OPTIONS (PROMPT('DCL command to execute: '));
STS$VALUE = LIB$DO_COMMAND (COMMAND);
/*
  If the call to LIB$DO_COMMAND is successful, the program will terminate
  here. Otherwise, it will return the error status to command level.
*/
RETURN (STS$VALUE);
END EXECUTE;
```

This example displays the following prompt:

DCL command to execute:

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

What you type after this prompt determines the action of LIB\$DO_COMMAND. LIB\$DO_COMMAND executes any command that is entered as a valid string according to the syntax of PL/I. If the command you enter is incomplete, you are prompted for the rest of the command. For example, if you enter the SHOW command, you receive the following prompt:

```
$_Show what?:
```

24.2.4 Using Symbols and Logical Names

The RTL provides a number of routines that give you access to the CLI callback facility. These routines allow a program to “call back” to the CLI to perform functions that normally are performed by CLI commands. These routines perform the following functions:

LIB\$GET_SYMBOL	Returns the value of a CLI symbol as a string. Optionally, this routine also returns the length of the returned value and a value indicating whether the symbol was found in the local or global symbol table. This routine executes only when the current CLI is DCL.
LIB\$SET_SYMBOL	Causes the CLI to define or redefine a CLI symbol. The optional argument specifies whether the symbol is to be defined in the local or global symbol table; the default is local. This routine executes only when the current CLI is DCL.
LIB\$DELETE_SYMBOL	Causes the CLI to delete a symbol. An optional argument specifies the local or global symbol table. If the argument is omitted, the symbol is deleted from the local symbol table. This routine executes only when the current CLI is DCL.
LIB\$SET_LOGICAL	Defines or redefines a supervisor-mode process logical name. Supervisor-mode logical names are not deleted when an image exits. This routine is equivalent to the DCL command DEFINE. LIB\$SET_LOGICAL allows the calling program to define a supervisor-mode process logical name without itself executing in supervisor mode.
LIB\$DELETE_LOGICAL	Deletes a supervisor-mode process logical name. This routine is equivalent to the DCL command DEASSIGN. LIB\$DELETE_LOGICAL does not require the calling program to be executing in supervisor mode to delete a supervisor-mode logical name.

For information about using logical names, see Chapter 32.

24.2.5 Disabling and Enabling Control Characters

Two run-time library routines, LIB\$ENABLE_CTRL and LIB\$DISABLE_CTRL, allow you to call the CLI to enable or disable control characters. These routines take a longword bit mask argument that specifies the control characters to be disabled or enabled. Acceptable values for this argument are LIB\$M_CLI_CTRLY and LIB\$M_CLI_CTRLT.

Using Run-Time Library Routines to Access Operating System Components

24.2 Access to the Command Language Interpreter

LIB\$DISABLE_CTRL	<p>Disables CLI interception of control characters.</p> <p>This routine performs the same function as the DCL command SET NOCONTROL=<i>n</i>, where <i>n</i> is T or Y.</p> <p>It prevents the currently active CLI from intercepting the control character specified during an interactive session.</p> <p>For example, you might use LIB\$DISABLE_CTRL to disable CLI interception of Ctrl/Y. Normally, Ctrl/Y interrupts the current command, command procedure, or image. If LIB\$DISABLE_CTRL is called with LIB\$M_CLI_CTRLY specified as the control character to be disabled, Ctrl/Y is treated like Ctrl/U followed by a carriage return.</p>
LIB\$ENABLE_CTRL	<p>Enables CLI interception of control characters.</p> <p>This routine performs the same function as the DCL command SET CONTROL=<i>n</i>, where <i>n</i> is T or Y.</p> <p>LIB\$ENABLE_CTRL restores the normal operation of Ctrl/Y or Ctrl/T.</p>

24.2.6 Creating and Connecting to a Subprocess

You can use LIB\$SPAWN and LIB\$ATTACH together to spawn a subprocess and attach the terminal to that subprocess. These routines execute correctly only if the current CLI is DCL. For more information on the SPAWN and ATTACH commands, see the *OpenVMS DCL Dictionary*. For more information on creating processes, see Chapter 2.

LIB\$SPAWN	<p>Spawns a subprocess.</p> <p>This routine is equivalent to the DCL command SPAWN. It requests the CLI to spawn a subprocess for executing CLI commands.</p>
LIB\$ATTACH	<p>Attaches the terminal to another process.</p> <p>This routine is equivalent to the DCL command ATTACH. It requests the CLI to detach the terminal from the current process and reattach it to a different process.</p>

24.3 Access to VAX Machine Instructions

The VAX instruction set was designed for efficient use by high-level languages and, therefore, contains many functions that are directly useful in your programs. However, some of these functions cannot be used directly by high-level languages.

The run-time library provides routines that allow your high-level language program to use most VAX machine instructions that are otherwise unavailable. On Alpha machines, these routines execute a series of Alpha instructions that emulate the operation of the VAX instructions. In most cases, these routines simply execute the instruction, using the arguments you provide. Some routines that accept string arguments, however, provide some additional functions that make them easier to use.

These routines fall into the following categories:

- Variable-length bit field instruction routines (Section 24.3.1)
- Integer and floating-point instructions (Section 24.3.2)
- Queue instructions (Section 24.3.3)
- Character string instructions (Section 24.3.4)

Using Run-Time Library Routines to Access Operating System Components

24.3 Access to VAX Machine Instructions

- Routine call instructions (Section 24.3.5)
- Cyclic redundancy check (CRC) instruction (Section 24.3.5)

The *VAX Architecture Reference Manual* describes the VAX instruction set in detail.

24.3.1 Variable-Length Bit Field Instruction Routines

The variable-length bit field is a VAX data type used to store small integers packed together in a larger data structure. It is often used to store single flag bits.

The run-time library contains five routines for performing operations on variable-length bit fields. These routines give higher-level languages that do not have the inherent ability to manipulate bit fields direct access to the bit field instructions in the VAX instruction set. Further, if a program calls a routine written in a different language to perform some function that also involves bit manipulation, the called routine can include a call to the run-time library to perform the bit manipulation.

Table 24–3 lists the run-time library variable-length bit field routines.

Table 24–3 Variable-Length Bit Field Routines

Entry Point	Function
LIB\$EXTV	Extracts a field from the specified variable-length bit field and returns it in sign-extended longword form.
LIB\$EXTZV	Extracts a field from the specified variable-length bit field and returns it in zero-extended longword form.
LIB\$FFC	Searches the specified field for the first clear bit. If it finds one, it returns <code>SS\$NORMAL</code> and the bit position (find-pos argument) of the clear bit. If not, it returns a failure status and sets the find-pos argument to the start position plus the size.
LIB\$FFS	Searches the specified field for the first set bit. If it finds one, it returns <code>SS\$NORMAL</code> and the bit position (find-pos argument) of the set bit. If not, it returns a failure status and sets the find-pos argument to the start position plus the size.
LIB\$INSV	Replaces the specified field with bits 0 through [size - 1] of the source (src argument). If the size argument is 0, nothing is inserted.

Three scalar attributes define a variable bit field:

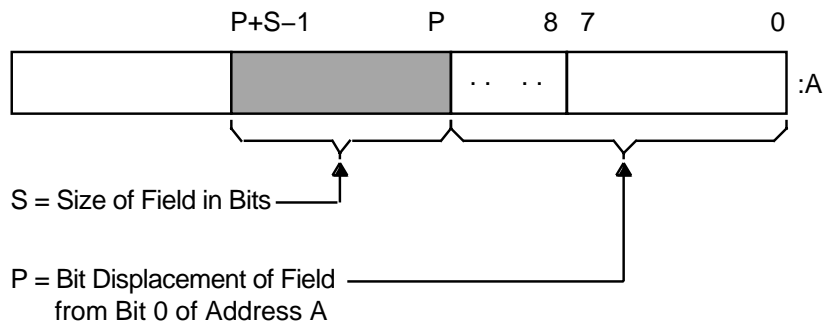
- Base address—The address of the byte in memory that serves as a reference point for locating the bit field.
- Bit position—The signed longword containing the displacement of the least significant bit of the field with respect to bit 0 of the base address.
- Size—A byte integer indicating the size of the bit field in bits (in the range $0 \leq \text{size} \leq 32$). That is, a bit field can be no more than one longword in length.

Figure 24–1 shows the format of a variable-length bit field. The shaded area indicates the field.

Using Run-Time Library Routines to Access Operating System Components

24.3 Access to VAX Machine Instructions

Figure 24–1 Format of a Variable-Length Bit Field



ZK-1981-GE

Bit fields are zero-origin, which means that the routine regards the first bit in the field as being the zero position. For more detailed information about VAX bit numbering and data formats, see the *VAX Architecture Reference Manual*.

The attributes of the bit field are passed to an RTL routine in the form of three arguments in the following order:

pos

Operating system usage: longword_signed
type: longword integer (signed)
access: read only
mechanism: by reference

Bit position relative to the base address. The **pos** argument is the address of a signed longword integer that contains this bit position.

size

Operating system usage: byte_unsigned
type: byte (unsigned)
access: read only
mechanism: by reference

Size of the bit field. The **size** argument is the address of an unsigned byte that contains this size.

base

Operating system usage: longword_unsigned
type: longword (unsigned)
access: read only
mechanism: by reference

Base address. The **base** argument contains the address of the base address.

Example

The following BASIC example illustrates three RTL routines. It opens the terminal as a file and specifies HEX> as the prompt. This prompt allows you to obtain input from the terminal without the question mark that VAX BASIC normally adds to the prompt in an INPUT statement. The program calls OTSSCVT_TZ_L to convert the character string input to a longword. It then calls LIB\$EXTZV once for each position in the longword to extract the bit in that position. Because LIB\$EXTVZ is called with a function reference within the PRINT statement, the bits are displayed.

Using Run-Time Library Routines to Access Operating System Components

24.3 Access to VAX Machine Instructions

```
10      EXTERNAL LONG FUNCTION
        OTS$CVT_TZ_L,          ! Convert hex text to LONG
        LIB$EXTZV             ! Extract zero-ended bit field

20      OPEN "TT:" FOR INPUT AS FILE #1%      ! Open terminal as a file
        INPUT #1%, "HEX>"; HEXIN$          ! Prompt for input
        STAT%=OTS$CVT_TZ_L(HEXIN$, BINARY%) ! Convert to longword
        IF (STAT% AND 1%) <> 1%           ! Failed?
        THEN
            PRINT "Conversion failed, decimal status ";STAT%
            GO TO 20                        ! Try again
        ELSE
            PRINT HEXIN$,
            PRINT STR$(LIB$EXTZV(N%, 1%, BINARY%));
            FOR N%=31% TO 0% STEP -1%
```

24.3.2 Integer and Floating-Point Routines

Integer and floating-point routines give a high-level language program access to the corresponding machine instructions. For a complete description of these instructions, see the *VAX Architecture Reference Manual*. Table 24-4 lists the integer and floating-point routines once up front.

Table 24-4 Integer and Floating-Point Routines

Entry Point	Function
LIBSEMUL	Multiplies integers with extended precision
LIB\$EDIV	Divides integers with extended precision

24.3.3 Queue Access Routines

A queue is a doubly linked list. A run-time library routine specifies a queue entry by its address. Two longwords, a forward link and a backward link, define the location of the entry in relation to the preceding and succeeding entries. A self-relative queue is a queue in which the links between entries are displacements; the two longwords represent the displacements of the current entry's predecessor and successor. The VAX instructions INSQHI, INSQTI, REMQHI, and REMQTI allow you to insert and remove an entry at the head or tail of a self-relative queue. Each queue instruction has a corresponding RTL routine.

The self-relative queue instructions are interlocked and cannot be interrupted, so that other processes cannot insert or remove queue entries while the current program is doing so. Because the operation requires changing two pointers at the same time, a high-level language cannot perform this operation without calling the RTL queue access routines.

When you use these routines, cooperating processes can communicate without further synchronization and without danger of being interrupted, either on a single processor or in a multiprocessor environment. The queue access routines are also useful in an AST environment; they allow you to add or remove an entry from a queue without being interrupted by an asynchronous system trap.

The remove queue instructions (REMQHI or REMQTI) return the address of the removed entry. Some languages, such as BASIC, COBOL, and Fortran, do not provide a mechanism for accessing an address returned from a routine. Further, BASIC and COBOL do not allow routines to be arguments.

Using Run-Time Library Routines to Access Operating System Components

24.3 Access to VAX Machine Instructions

Table 24–5 lists the queue access routines.

Table 24–5 Queue Access Routines

Entry Point	Function
LIB\$INSQHI	Inserts queue entry at head
LIB\$INSQTI	Inserts queue entry at tail
LIB\$REMQHI	Removes queue entry at head
LIB\$REMQTI	Removes queue entry at tail

Examples

LIB\$INSQHI

In BASIC and Fortran, queues can be quadword aligned in a named COMMON block by using a linker option file to specify alignment of program sections. The LIB\$GET_VM routine returns memory that is quadword aligned. Therefore, you should use LIB\$GET_VM to allocate the virtual memory for a queue. For instance, to create a COMMON block called QUEUES, use the LINK command with the FILE/OPTIONS qualifier, where FILE.OPT is a linker option file containing the line:

```
PSECT = QUEUES, QUAD
```

A Fortran application using processor-shared memory follows:

```
INTEGER*4 FUNCTION INSERT_Q (QENTRY)
COMMON/QUEUES/QHEADER
INTEGER*4 QENTRY(10), QHEADER(2)
INSERT_Q = LIB$INSQHI (QENTRY, QHEADER)
RETURN
END
```

A BASIC application using processor-shared memory follows:

```
COM (QUEUES) QENTRY%(9), QHEADER%(1)
EXTERNAL INTEGER FUNCTION LIB$INSQHI
IF LIB$INSQHI (QENTRY%() BY REF, QHEADER%() BY REF) AND 1%
THEN GOTO 1000
:
:
:
1000 REM INSERTED OK
```

LIB\$REMQHI

In Fortran, the address of the removed queue entry can be passed to another routine as an array using the %VAL built-in function.

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24.3 Access to VAX Machine Instructions

In the following example, queue entries are 10 longwords, including the two longword pointers at the beginning of each entry:

```
COMMON/QUEUES/QHEADER
INTEGER*4 QHEADER(2), ISTAT
ISTAT = LIB$REMQHI (QHEADER, ADDR)
IF (ISTAT) THEN
    CALL PROC (%VAL (ADDR)) ! Process removed entry
    GO TO ...
ELSE IF (ISTAT .EQ. %LOC(LIB$_QUEWASEMP)) THEN
    GO TO ... ! Queue was empty
ELSE IF
    ... ! Secondary interlock failed
END IF
.
.
.
END
SUBROUTINE PROC (QENTRY)
INTEGER*4 QENTRY(10)
.
.
.
RETURN
END
```

24.3.4 Character String Routines

The character string routines listed in Table 24–6 give a high-level language program access to the corresponding VAX machine instructions. For a complete description of these instructions, see the *VAX Architecture Reference Manual*. For each instruction, the *VAX Architecture Reference Manual* specifies the contents of all the registers after the instruction executes. The corresponding RTL routines do not make the contents of all the registers available to the calling program.

Table 24–6 lists the LIB\$ character string routines and their functions.

Table 24–6 Character String Routines

Entry Point	Function
LIB\$LOCC	Locates a character in a string
LIB\$MATCHC	Returns the relative position of a substring
LIB\$SCANC	Scans characters
LIB\$SKPC	Skips characters
LIB\$SPANC	Spans characters
LIB\$MOVC3	Moves characters
LIB\$MOVC5	Moves characters and fills
LIB\$MOVTC	Moves translated characters
LIB\$MOVTUC	Move translated characters until specified character is found

The *OpenVMS RTL String Manipulation (STR\$) Manual* describes STR\$ string manipulation routines.

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24.3 Access to VAX Machine Instructions

Example

This COBOL program uses LIB\$LOCC to return the position of a given letter of the alphabet.

```
IDENTIFICATION DIVISION.
PROGRAM-ID.          LIBLOC.

ENVIRONMENT DIVISION.

DATA DIVISION.

WORKING-STORAGE SECTION.

01  SEARCH-STRING  PIC X(26)
                                VALUE "ABCDEFGHIJKLMNOPQRSTUVWXYZ".
01  SEARCH-CHAR    PIC X.
01  IND-POS        PIC 9(9) USAGE IS COMP.
01  DISP-IND       PIC 9(9).

ROUTINE DIVISION.

001-MAIN.
    MOVE SPACE TO SEARCH-CHAR.
    DISPLAY " ".
    DISPLAY "ENTER SEARCH CHARACTER: " WITH NO ADVANCING.
    ACCEPT SEARCH-CHAR.
    CALL "LIB$LOCC"
        USING BY DESCRIPTOR SEARCH-CHAR, SEARCH-STRING
        GIVING IND-POS.
    IF IND-POS = ZERO
        DISPLAY
            "CHAR ENTERED ( " SEARCH-CHAR " ) NOT A VALID SEARCH CHAR"
        STOP RUN.
    MOVE IND-POS TO DISP-IND.
    DISPLAY
        "SEARCH CHAR ( " SEARCH-CHAR " ) WAS FOUND IN POSITION "
        DISP-IND.
    GO TO 001-MAIN.
```

24.3.5 Miscellaneous Instruction Routines

Table 24-7 lists additional routines that you can use.

Table 24-7 Miscellaneous Instruction Routines

Entry Point	Function
LIB\$CALLG	Calls a routine using an array argument list
LIB\$CRC	Computes a cyclic redundancy check
LIB\$CRC_TABLE	Constructs a table for a cyclic redundancy check

LIB\$CALLG

The LIB\$CALLG routine gives your program access to the CALLG instruction. This instruction calls a routine using an argument list stored as an array in memory, as opposed to the CALLS instruction, in which the argument list is pushed on the stack.

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24.3 Access to VAX Machine Instructions

LIB\$CRC

The LIB\$CRC routine allows your high-level language program to use the CRC instruction, which calculates the cyclic redundancy check. This instruction checks the integrity of a data stream by comparing its state at the sending point and the receiving point. Each character in the data stream is used to generate a value based on a polynomial. The values for each character are then added together. This operation is performed at both ends of the data transmission, and the two result values are compared. If the results disagree, then an error occurred during the transmission.

LIB\$CRC_TABLE

The LIB\$CRC_TABLE routine takes a polynomial as its input and builds the table that LIB\$CRC uses to calculate the CRC. You must specify the polynomial to be used.

For more details, see the *VAX Architecture Reference Manual*.

24.4 Processwide Resource Allocation Routines

This section discusses routines that allocate processwide resources to a single operating system process. The processwide resources discussed here are:

- Local event flags
- BASIC and Fortran logical unit numbers (LUNs)

The resource allocation routines are provided so that user routines can use the processwide resources without conflicting with one another.

In general, you must use run-time library resource allocation routines when your program needs processwide resources. This allows RTL routines supplied by Compaq, and user routines that you write to perform together within a process.

If your called routine includes a call to any RTL routine that frees a processwide resource, and that called routine fails to execute normally, the resource will not be freed. Thus, your routine should establish a condition handler that frees the allocated resource before resignaling or unwinding. For information about condition handling, see Chapter 9.

Table 24–8 list routines that perform processwide resource allocation.

Table 24–8 Processwide Resource Allocation Routines

Entry Point	Function
LIB\$FREE_LUN	Deallocates a specific logical unit number
LIB\$GET_LUN	Allocates next arbitrary logical unit number
LIB\$FREE_EF	Frees a local event flag
LIB\$GET_EF	Allocates a local event flag
LIB\$RESERVE_EF	Reserves a local event flag

24.4.1 Allocating Logical Unit Numbers

BASIC and Fortran use a **logical unit number** (LUN) to define the file or device a program uses to perform input and output. For a routine to be modular, it does not need to know the LUNs being used by other routines that are running at the same time. For this reason, logical units are allocated and deallocated at run time. You can use LIB\$GET_LUN and LIB\$FREE_LUN to obtain the next

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24.4 Processwide Resource Allocation Routines

available number. This ensures that your BASIC or Fortran routine does not use a logical unit that is already being used by a calling program. Therefore, you should use this routine whenever your program calls or is called by another program that also allocates LUNs. Logical unit numbers 100 to 119 are available to modular routines through these entry points.

To allocate an LUN, call `LIB$GET_LUN` and use the value returned as the LUN for your I/O statements. If no LUNs are available, an error status is returned and the logical unit is set to `-1`. When the program unit exits, it should use `LIB$FREE_LUN` to free any LUNs that have been allocated by `LIB$GET_LUN`. If it does not free any LUNs, the available pool of numbers is freed for use.

If your called routine contains a call to `LIB$FREE_LUN` to free the LUNs upon exit, and your routine fails to execute normally, the LUNs will not be freed. For this reason, you should make sure to establish a condition handler to call `LIB$FREE_LUN` before resignaling or unwinding. Otherwise, the allocated LUN is lost until the image exits.

24.4.2 Allocating Event Flag Numbers

The `LIB$GET_EF` and `LIB$FREE_EF` routines operate in a similar way to `LIB$GET_LUN` and `LIB$FREE_LUN`. They cause local event flags to be allocated and deallocated at run time, so that your routine remains independent of other routines executing in the same process.

Local event flags numbered 32 to 63 are available to your program. These event flags allow routines to communicate and synchronize their operations. If you use a specific event flag in your routine, another routine may attempt to use the same flag, and the flag will no longer function as expected. Therefore, you should call `LIB$GET_EF` to obtain the next arbitrary event flag and `LIB$FREE_EF` to return it to the storage pool. You can obtain a specific event flag number by calling `LIB$RESERVE_EF`. This routine takes as its argument the event flag number to be allocated.

For information about using event flags, see Chapter 3 and Chapter 6.

24.5 Performance Measurement Routines

The run-time library timing facility consists of four routines to store count and timing information, display the requested information, and deallocate the storage. Table 24–9 lists these routines and their functions.

Table 24–9 Performance Measurement Routines

Entry Point	Function
<code>LIB\$INIT_TIMER</code>	Stores the values of the specified times and counts in units of static or heap storage, depending on the value of the routine's argument
<code>LIB\$SHOW_TIMER</code>	Obtains and formats for output the specified times and counts that are accumulated since the last call to <code>LIB\$INIT_TIMER</code>
<code>LIB\$STAT_TIMER</code>	Obtains one of the times and counts since the last call to <code>LIB\$INIT_TIMER</code> and returns it as an unsigned quadword or longword
<code>LIB\$FREE_TIMER</code>	Frees the storage allocated by <code>LIB\$INIT_TIMER</code>

Using these routines, you can access the following statistics:

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24.5 Performance Measurement Routines

- Elapsed time
- CPU time
- Buffered I/O count
- Direct I/O count
- Page faults

The LIB\$SHOW_TIMER and LIB\$STAT_TIMER routine are relatively simple tools for testing the performance of a new application. To obtain more detailed information, use the system services SYS\$GETTIM (Get Time) and SYS\$GETJPI (Get Job/Process Information).

The simplest way to use the run-time library routines is to call LIB\$INIT_TIMER with no arguments at the beginning of the portion of code to be monitored. This causes the statistics to be placed in OWN storage. To get the statistics from OWN storage, call LIB\$SHOW_TIMER (with no arguments) at the end of the portion of code to be monitored.

If you want a particular statistic, you must include a **code** argument with a call to LIB\$SHOW_TIMER or LIB\$STAT_TIMER. LIB\$SHOW_TIMER returns the specified statistic(s) in formatted form and sends them to SYS\$OUTPUT. On each call, LIB\$STAT_TIMER returns one statistic to the calling program as an unsigned longword or quadword value.

Table 24–10 shows the **code** argument in LIB\$SHOW_TIMER or LIB\$STAT_TIMER.

Table 24–10 The Code Argument in LIB\$SHOW_TIMER and LIB\$STAT_TIMER

Argument Value	Meaning	LIB\$SHOW_TIMER Format	LIB\$STAT_TIMER Format
1	Elapsed real time	<i>dddd hh:mm:ss.cc</i>	Quadword, in system time format
2	Elapsed CPU time	<i>hhhh:mm:ss.cc</i>	Longword, in 10-millisecond increments
3	Number of buffered I/O operations	<i>nnnn</i>	Longword
4	Number of direct I/O operations	<i>nnnn</i>	Longword
5	Number of page faults	<i>nnnn</i>	Longword

When you call LIB\$INIT_TIMER, you must use the optional **handler** argument only if you want to keep several sets of statistics simultaneously. This argument points to a block in heap storage where the statistics are to be stored. You need to call LIB\$FREE_TIMER only if you have specified **handler** in LIB\$INIT_TIMER and you want to deallocate all heap storage resources. In most cases, the implicit deallocation when the image exits is sufficient.

The LIB\$STAT_TIMER routine returns only one of the five statistics for each call, and it returns that statistic in the form of an unsigned quadword or longword. LIB\$SHOW_TIMER returns the virtual address of the stored information, which BASIC cannot directly access. Therefore, a BASIC program must call

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24.5 Performance Measurement Routines

LIB\$STAT_TIMER and format the returned statistics, as the following example demonstrates.

Example

The following BASIC example uses the run-time library performance analysis routines to obtain timing statistics. It then calls the \$ASCTIM system service to translate the 64-bit binary value returned by LIB\$STAT_TIMER into an ASCII text string.

```
100  EXTERNAL INTEGER FUNCTION LIB$INIT_TIMER
     EXTERNAL INTEGER FUNCTION LIB$STAT_TIMER
     EXTERNAL INTEGER FUNCTION LIB$FREE_TIMER
     EXTERNAL INTEGER CONSTANT SS$_NORMAL

200  DECLARE LONG COND_VALUE, RANDOM_SLEEP
     DECLARE LONG CODE, HANDLE
     DECLARE STRING TIME_BUFFER
     HANDLE = 0
     TIME_BUFFER = SPACE$(50%)

300  MAP (TIMER) LONG ELAPSED_TIME, FILL
     MAP (TIMER) LONG CPU_TIME
     MAP (TIMER) LONG BUFIO
     MAP (TIMER) LONG DIRIO
     MAP (TIMER) LONG PAGE_FAULTS

400  PRINT "This program returns information about:"
     PRINT "Elapsed time (1)"
     PRINT "CPU time (2)"
     PRINT "Buffered I/O (3)"
     PRINT "Direct I/O (4)"
     PRINT "Page faults (5)"
     PRINT "Enter zero to exit program"
     PRINT "Enter a number from one to"
     PRINT "five for performance information"
     INPUT "One, two, three, four, or five"; CODE
     PRINT

450  GOTO 32766 IF CODE = 0

500  COND_VALUE = LIB$INIT_TIMER( HANDLE )

550  IF (COND_VALUE <> SS$_NORMAL) THEN PRINT @
     "Error in initialization"
     GOTO 32767

650  A = 0 !
     FOR I = 1 to 100000 ! This code merely uses some CPU time
     A = A + 1 !
     NEXT I !

700  COND_VALUE = LIB$STAT_TIMER( CODE, ELAPSED_TIME, HANDLE )

750  IF (COND_VALUE <> SS$_NORMAL) THEN PRINT @
     "Error in statistics routine"
     GOTO 32767

800  GOTO 810 IF CODE <> 1%
     CALL SYS$ASCTIM ( , TIME_BUFFER, ELAPSED_TIME, 1% BY VALUE)
     PRINT "Elapsed time: "; TIME_BUFFER

810  PRINT "CPU time in seconds: "; .01 * CPU_TIME IF CODE = 2%
     PRINT "Buffered I/O: "; BUFIO IF CODE = 3%
     PRINT "Direct I/O: "; DIRIO IF CODE = 4%
     PRINT "Page faults: "; PAGE_FAULTS IF CODE = 5%
     PRINT

900  GOTO 400
```

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24.5 Performance Measurement Routines

```
32765 COND_VALUE = LIB$FREE_TIMER( HANDLE )
32766 IF (COND_VALUE <> SS$_NORMAL) THEN PRINT @
      "Error in LIB$FREE_TIMER"
      GOTO 32767

32767 END
```

For information about using system time, see Chapter 27.

24.6 Output Formatting Control Routines

Table 24–11 lists the run-time library routines that customize output.

Table 24–11 Routines for Customizing Output

Entry Point	Function
LIB\$CURRENCY	Defines the default currency symbol for process
LIB\$DIGIT_SEP	Defines the default digit separator for process
LIB\$LP_LINES	Defines the process default size for a printed page
LIB\$RADIX_POINT	Defines the process default radix point character

The LIB\$CURRENCY, LIB\$DIGIT_SEP, LIB\$LP_LINES, and LIB\$RADIX_POINT routines allow you to customize output. Using them, you can define the logical names SY\$\$CURRENCY, SY\$\$DIGIT_SEP, SY\$\$LP_LINES, and SY\$\$RADIX_POINT to specify your own currency symbol, digit separator, radix point, or number of lines per printed page. Each routine works by attempting to translate the associated logical name as a process, group, or system logical name. If you have redefined a logical name for a specific local application, then the translation succeeds, and the routine returns the value that corresponds to the option you have chosen. If the translation fails, the routine returns a default value provided by the run-time library, as follows:

```
$ SY$$CURRENCY
. SY$$DIGIT_SEP
. SY$$RADIX_POINT
66 SY$$LP_LINES
```

For example, if you want to use the British pound sign (£) as the currency symbol within your process, but you want to leave the dollar sign (\$) as the system default, define SY\$\$CURRENCY to be in your process logical name table. Then, any calls to LIB\$CURRENCY within your process return “£”, while any calls outside your process return “\$”.

You can use LIB\$LP_LINES to monitor the current default length of the line printer page. You can also supply your own default length for the current process. United States standard paper size permits 66 lines on each physical page.

If you are writing programs for a utility that formats a listing file to be printed on a line printer, you can use LIB\$LP_LINES to make your utility independent of the default page length. Your program can use LIB\$LP_LINES to obtain the current length of the page. It can then calculate the number of lines of text per page by subtracting the lines used for margins and headings.

The following is one suggested format:

- Three lines for the top margin
- Three lines for the bottom margin

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24.6 Output Formatting Control Routines

- Three lines for listing heading information, consisting of:
 - Language-processor identification line
 - Source program identification line
 - One blank line

24.7 Miscellaneous Interface Routines

There are several other RTL routines that permit high-level access to components of the operating system. Table 24–12 lists these routines and their functions. The sections that follow give further details about some of these routines.

Table 24–12 Miscellaneous Interface Routines

Entry Point	Function
LIB\$AST_IN_PROG	Indicates whether an asynchronous system trap is in progress
LIB\$ASN_WTH_MBX	Assigns an I/O channel and associates it with a mailbox
LIB\$CREATE_DIR	Creates a directory or subdirectory
LIB\$FIND_IMAGE_SYMBOL	Reads a global symbol from the shareable image file and dynamically activates a shareable image into the P0 address space of a process
LIB\$ADDX	Performs addition on signed two's complement integers of arbitrary length (multiple-precision addition)
LIB\$SUBX	Performs subtraction on signed two's complement integers of arbitrary length (multiple-precision subtraction)
LIB\$FILE_SCAN	Finds file names given OpenVMS RMS file access block (FAB)
LIB\$FILE_SCAN_END	Specifies end-of-file scan
LIB\$FIND_FILE	Finds file names given string
LIB\$FIND_FILE_END	Specifies the end-of-find file
LIB\$INSERT_TREE	Inserts an element in a binary tree
LIB\$LOOKUP_TREE	Finds an element in a binary tree
LIB\$TRAVERSE_TREE	Traverses a binary tree
LIB\$GET_COMMON	Gets a record from the process's COMMON storage area
LIB\$PUT_COMMON	Puts a record to the process's COMMON storage area

24.7.1 Indicating Asynchronous System Trap in Progress

An asynchronous system trap (AST) is a mechanism for providing a software interrupt when an external event occurs, such as when a user presses the Ctrl/C key sequence. When an external event occurs, the operating system interrupts the execution of the current process and calls a routine that you supply. While that routine is active, the AST is said to be in progress, and the process is said to be executing at AST level. When your AST routine returns control to the original process, the AST is no longer active and execution continues where it left off.

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24.7 Miscellaneous Interface Routines

The LIB\$AST_IN_PROG routine indicates to the calling program whether an AST is currently in progress. Your program can call LIB\$AST_IN_PROG to determine whether it is executing at AST level, and then take appropriate action. This routine is useful if you are writing AST-reentrant code.

For information about using ASTs, see Chapter 8.

24.7.2 Create a Directory or Subdirectory

The LIB\$CREATE_DIR routine creates a directory or a subdirectory. The calling program must specify the directory specification in standard OpenVMS RMS format. This directory specification may also contain a disk specification.

In addition to the required directory specification argument, LIB\$CREATE_DIR takes the following five optional arguments:

- The user identification code (UIC) of the owner of the created directory or subdirectory
- The protection enable mask
- The protection value mask
- The maximum number of versions allowed for files created in this directory or subdirectory
- The relative volume number within the volume set on which the directory or subdirectory is created

See the *OpenVMS RTL Library (LIB\$) Manual* for a complete description of LIB\$CREATE_DIR.

24.7.3 File Searching Routines

The run-time library provides two routines that your program can call to search for a file and two routines that your program can call to end a search sequence:

- When you call LIB\$FILE_SCAN with a wildcard file specification and an action routine, the routine calls the action routine for each file or error, or both, found in the wildcard sequence. LIB\$FILE_SCAN allows the search sequence to continue even though certain errors are present.
- When you call LIB\$FIND_FILE with a wildcard file specification, it finds the next file specification that matches the wildcard specification.

In addition to the wildcard file specification, which is a required argument, LIB\$FIND_FILE takes the following four optional arguments:

- The default specification.
- The related specification.
- The OpenVMS RMS secondary status value from a failing RMS operation.
- A longword containing two flag bits. If bit 1 is set, LIB\$FIND_FILE performs temporary defaulting for multiple input files and the related specification argument is ignored. See the *OpenVMS RTL Library (LIB\$) Manual* for a complete description of LIB\$FIND_FILE in template format.

The LIB\$FIND_FILE_END routine is called once after each call to LIB\$FIND_FILE in interactive use. LIB\$FIND_FILE_END prevents the temporary default values retained by the previous call to LIB\$FIND_FILE from affecting the next file specification.

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24.7 Miscellaneous Interface Routines

The LIB\$FILE_SCAN routine uses an optional context argument to perform temporary defaulting for multiple input files. For example, a command such as the following would specify A, B, and C in successive calls, retaining context, so that portions of one file specification would affect the next file specification:

```
$ COPY [smith]A,B,C *
```

The LIB\$FILE_SCAN_END routine is called once after each sequence of calls to LIB\$FILE_SCAN. LIB\$FILE_SCAN_END performs a parse of the null string to deallocate saved OpenVMS RMS context and to prevent the temporary default values retained by the previous call to LIB\$FILE_SCAN from affecting the next file specification. For instance, in the previous example, LIB\$FILE_SCAN_END should be called after the C file specification is parsed, so that specifications from the \$COPY files do not affect file specifications in subsequent commands.

The following BLISS example illustrates the use of LIB\$FIND_FILE. It prompts for a file specification and default specification. The default specification indicates the default information for the file for which you are searching. Once the routine has searched for one file, the resulting file specification determines both the related file specification and the default file specification for the next search. LIB\$FIND_FILE_END is called at the end of the following BLISS program to deallocate the virtual memory used by LIB\$FIND_FILE.

```
%TITLE 'FILE_EXAMPLE1 - Sample program using LIB$FIND_FILE'
MODULE FILE_EXAMPLE1(          ! Sample program using LIB$FIND_FILE
    IDENT = '1-001',
    MAIN = EXAMPLE_START
) =

BEGIN

%SBTTL 'Declarations'
!+
! SWITCHES:
!-

SWITCHES ADDRESSING_MODE (EXTERNAL = GENERAL, NONEXTERNAL = WORD_RELATIVE);

!+
! TABLE OF CONTENTS:
!-

FORWARD ROUTINE
    EXAMPLE_START;                ! Main program

!+
! INCLUDE FILES:
!-

LIBRARY 'SYS$LIBRARY:STARLET.L32';    ! System symbols

!+
! Define facility-specific messages from shared system messages.
!-
$SHR_MSGDEF(CLI,3,LOCAL,
    (PARSEFAIL,WARNING));

!+
! EXTERNAL REFERENCES:
!-

EXTERNAL ROUTINE
    LIB$GET_INPUT,                ! Read from SYS$INPUT
    LIB$FIND_FILE,                ! Wildcard scanning routine
    LIB$FIND_FILE_END,           ! End find file
    LIB$PUT_OUTPUT,              ! Write to SYS$OUTPUT
    STR$COPY_DX;                 ! String copier
```

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24.7 Miscellaneous Interface Routines

```

LITERAL
    TRUE = 1,                ! Success
    FALSE = 0;              ! Failure

%SBTTL 'EXAMPLE_START - Sample program main routine';
ROUTINE EXAMPLE_START =
BEGIN
!+
! This program reads a file specification and default file
! specification from SYS$INPUT. It then prints all the files that
! match that specification and prompts for another file specification.
! After the first file specification no default specification is requested,
! and the previous resulting file specification becomes the related
! file specification.
!-
LOCAL
    LINEDESC : $BBLOCK[DSC$C_S_BLN], ! String desc. for input line
    RESULT_DESC : $BBLOCK[DSC$C_S_BLN], ! String desc. for result file
    CONTEXT, ! LIB$FIND_FILE context pointer
    DEFAULT_DESC : $BBLOCK[DSC$C_S_BLN], ! String desc. for default spec
    RELATED_DESC : $BBLOCK[DSC$C_S_BLN], ! String desc. for related spec
    HAVE_DEFAULT,
    STATUS;

!+
! Make all string descriptors dynamic.
!-
CH$FILL(0,DSC$C_S_BLN,LINEDESC);
LINEDESC[DSC$B_CLASS] = DSC$K_CLASS_D;
CH$MOVE(DSC$C_S_BLN,LINEDESC,RESULT_DESC);
CH$MOVE(DSC$C_S_BLN,LINEDESC,DEFAULT_DESC);
CH$MOVE(DSC$C_S_BLN,LINEDESC,RELATED_DESC);
HAVE_DEFAULT = FALSE;
CONTEXT = 0;

!+
! Read file specification, default file specification, and
! related file specification.
!-

WHILE (STATUS = LIB$GET_INPUT(LINEDESC,
    $DESCRIPTOR('FILE SPECIFICATION: '))) NEQ RMS$_EOF
DO BEGIN
    IF NOT .STATUS
        THEN SIGNAL_STOP(.STATUS);

    !+
    ! If default file specification was not obtained, do so now.
    !-
    IF NOT .HAVE_DEFAULT
    THEN BEGIN
        STATUS = LIB$GET_INPUT(DEFAULT_DESC,
            $DESCRIPTOR('DEFAULT FILE SPECIFICATION: '));
        IF NOT .STATUS
            THEN SIGNAL_STOP(.STATUS);
        HAVE_DEFAULT = TRUE;
    END;

    !+
    ! CALL LIB$FIND_FILE until RMS$_NMF (no more files) is returned.
    ! If an error other than RMS$_NMF is returned, it is signaled.
    ! Print out the file specification if the call is successful.
    !-
    WHILE (STATUS = LIB$FIND_FILE(LINEDESC,RESULT_DESC,CONTEXT,
        DEFAULT_DESC,RELATED_DESC)) NEQ RMS$_NMF
    DO IF NOT .STATUS
        THEN SIGNAL(CLI$_PARSEFAIL,1,RESULT_DESC,.STATUS)
        ELSE LIB$PUT_OUTPUT(RESULT_DESC);

    !+
    ! Make this resultant file specification the related file

```

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24.7 Miscellaneous Interface Routines

```
! specification for next file.
!-
STR$COPY_DX(RELATED_DESC,LINEDESC);
END;                                     ! End of loop
                                         ! reading file specification

!+
! Call LIB$FIND_FILE_END to deallocate the virtual memory used by LIB$FIND_FILE.
! Note that we do this outside of the loop. Since the MULTIPLE bit of the
! optional user flags argument to LIB$FIND_FILE wasn't used, it is not
! necessary to call LIB$FIND_FILE_END after each call to LIB$FIND_FILE.
! (The MULTIPLE bit would have caused temporary defaulting for multiple input
! files.)
!-
STATUS = LIB$FIND_FILE_END (CONTEXT);
IF NOT .STATUS
    THEN SIGNAL_STOP (.STATUS);

RETURN TRUE
END;                                     ! End of main program
END                                       ! End of module

ELUDOM
```

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24.7 Miscellaneous Interface Routines

The following BLISS example illustrates the use of LIB\$FILE_SCAN and LIB\$FILE_SCAN_END.

```
%TITLE 'FILE_EXAMPLE2 - Sample program using LIB$FILE_SCAN'
MODULE FILE_EXAMPLE1(          ! Sample program using LIB$FILE_SCAN
    IDENT = '1-001',
    MAIN = EXAMPLE_START
) =
BEGIN

%SBTTL 'Declarations'
!+
! SWITCHES:
!-

SWITCHES ADDRESSING_MODE (EXTERNAL = GENERAL,
    NONEXTERNAL = WORD_RELATIVE);

!+
! TABLE OF CONTENTS:
!-

FORWARD ROUTINE
    EXAMPLE_START,          ! Main program
    SUCCESS_RTN,           ! Success action routine
    ERROR_RTN;             ! Error action routine

!+
! INCLUDE FILES:
!-

LIBRARY 'SYS$LIBRARY:STARLET.L32';      ! System symbols

!+
! Define VMS block structures (BLOCK[,BYTE]).
!-
STRUCTURE
    BBLOCK [O, P, S, E; N] =
        [N]
        (BBLOCK + O) <P, S, E>;

!+
! EXTERNAL REFERENCES:
!-

EXTERNAL ROUTINE
    LIB$GET_INPUT,          ! Read from SYS$INPUT
    LIB$FILE_SCAN,         ! Wildcard scanning routine
    LIB$FILE_SCAN_END,    ! End of file scan
    LIB$PUT_OUTPUT;       ! Write to SYS$OUTPUT
```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

%SBTTL 'EXAMPLE_START - Sample program main routine';
ROUTINE EXAMPLE_START =
BEGIN
!+
! This program reads the file specification, default file specification,
! and related file specification from SYS$INPUT and then displays on
! SYS$OUTPUT all files which match the specification.
!-
LOCAL
    RESULT_BUFFER : VECTOR[NAM$C_MAXRSS,BYTE], !Buffer for resultant
                                                ! name string
    EXPAND_BUFFER : VECTOR[NAM$C_MAXRSS,BYTE], !Buffer for expanded
                                                ! name string
    LINEDESC      : BBLOCK[DSC$C_S_BLN],      !String descriptor
                                                ! for input line
    RESULT_DESC   : BBLOCK[DSC$C_S_BLN],      !String descriptor
                                                ! for result file
    DEFAULT_DESC  : BBLOCK[DSC$C_S_BLN],      !String descriptor
                                                ! for default specification
    RELATED_DESC  : BBLOCK[DSC$C_S_BLN],      !String descriptor
                                                ! for related specification
    IFAB          : $FAB_DECL,                !FAB for file_scan
    INAM          : $NAM_DECL,                ! and a NAM block
    RELNAM        : $NAM_DECL,                ! and a related NAM block
    STATUS;

!+
! Make all descriptors dynamic.
!-
CH$FILL(0,DSC$C_S_BLN,LINEDESC);
LINEDESC[DSC$B_CLASS] = DSC$K_CLASS_D;
CH$MOVE(DSC$C_S_BLN,LINEDESC,RESULT_DESC);
CH$MOVE(DSC$C_S_BLN,LINEDESC,DEFAULT_DESC);
CH$MOVE(DSC$C_S_BLN,LINEDESC,RELATED_DESC);
!+
! Read file specification, default file specification, and related
! file specification
!-
STATUS = LIB$GET_INPUT(LINEDESC,
    $DESCRIPTOR('File specification: '));
IF NOT .STATUS
    THEN SIGNAL_STOP(.STATUS);
STATUS = LIB$GET_INPUT(DEFAULT_DESC,
    $DESCRIPTOR('Default file specification: '));
IF NOT .STATUS
    THEN SIGNAL_STOP(.STATUS);
STATUS = LIB$GET_INPUT(RELATED_DESC,
    $DESCRIPTOR('Related file specification: '));
IF NOT .STATUS
    THEN SIGNAL_STOP(.STATUS);
!+
! Initialize the FAB, NAM, and related NAM blocks.
!-
$FAB_INIT(FAB=IFAB,
    FNS=.LINEDESC[DSC$W_LENGTH],
    FNA=.LINEDESC[DSC$A_POINTER],
    DNS=.DEFAULT_DESC[DSC$W_LENGTH],
    DNA=.DEFAULT_DESC[DSC$A_POINTER],
    NAM=INAM);
$NAM_INIT(NAM=INAM,
    RSS=NAM$C_MAXRSS,
    RSA=RESULT_BUFFER,
    ESS=NAM$C_MAXRSS,
    ESA=EXPAND_BUFFER,
    RLF=RELNAM);

```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

$NAM_INIT(NAM=RELNAM);
RELNAM[NAM$B_RSL] = .RELATED_DESC[DSC$W_LENGTH];
RELNAM[NAM$L_RSA] = .RELATED_DESC[DSC$A_POINTER];
!+
! Call LIB$FILE_SCAN. Note that errors need not be checked
! here because LIB$FILE_SCAN calls error_rtn for all errors.
!-
LIB$FILE_SCAN(IFAB,SUCCESS_RTN,ERROR_RTN);

!+
! Call LIB$FILE_SCAN_END to deallocate virtual memory used for
! file scan structures.
!-
STATUS = LIB$FILE_SCAN_END (IFAB);

IF NOT .STATUS
    THEN SIGNAL_STOP (.STATUS);

RETURN 1
END;                                     ! End of main program

ROUTINE SUCCESS_RTN (IFAB : REF BBLOCK) =
BEGIN
!+
! This routine is called by LIB$FILE_SCAN for each file that it
! successfully finds in the search sequence.
!
! Inputs:
!
!     IFAB    Address of a fab
!
! Outputs:
!
!     file specification printed on SYS$OUTPUT
!-
LOCAL
    DESC : BBLOCK[DSC$C_S_BLN];    ! A local string descriptor
BIND
    INAM = .IFAB[FAB$L_NAM] : BBLOCK;    ! Find NAM block
                                         ! from pointer in FAB
CH$FILL(0,DSC$C_S_BLN,DESC);           ! Make static
                                         ! string descriptor
DESC[DSC$W_LENGTH] = .INAM[NAM$B_RSL]; ! Get string length
                                         ! from NAM block
DESC[DSC$A_POINTER] = .INAM[NAM$L_RSA]; ! Get pointer to the string
RETURN LIB$PUT_OUTPUT(DESC)             ! Print name on SYS$OUTPUT
                                         ! and return

END;

ROUTINE ERROR_RTN (IFAB : REF BBLOCK) =
BEGIN
!+
! This routine is called by LIB$FILE_SCAN for each file specification that
! produces an error.
!
! Inputs:
!
!     ifab    Address of a fab
!
! Outputs:
!
!     Error message is signaled
!-
LOCAL
    DESC : BBLOCK[DSC$C_S_BLN];    ! A local string descriptor

```


Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

BIND
    INAM = .IFAB[FAB$L_NAM] : BBLOCK;          ! Get NAM block pointer
                                           !   from FAB

    CH$FILL(0,DSC$C_S_BLN,DESC);             ! Create static
                                           !   string descriptor

    DESC[DSC$W_LENGTH] = .INAM[NAM$B_RSL];
    DESC[DSC$A_POINTER] = .INAM[NAM$L_RSA];
    !+
    ! Signal the error using the shared message PARSEFAIL
    ! and the CLI facility code. The second part of the SIGNAL
    ! is the RMS STS and STV error codes.
    !-
    RETURN SIGNAL((SHR$_PARSEFAIL+3^16),1,DESC,
                 .IFAB[FAB$L_STS],.IFAB[FAB$L_STV])

    END;
    END                      ! End of module

    ELUDOM

```

24.7.4 Inserting an Entry into a Balanced Binary Tree

Three routines allow you to manipulate the contents of a balanced binary tree:

- LIB\$INSERT_TREE adds an entry to a balanced binary tree.
- LIB\$LOOKUP_TREE looks up an entry in a balanced binary tree.
- LIB\$TRAVERSE_TREE calls an action routine for each node in the tree.

Example

The following BLISS example illustrates all three routines. The program prompts for input from SYSS\$INPUT and stores each data line as an entry in a binary tree. When the user enters the end-of-file character (Ctrl/Z), the tree is printed in sorted order. The program includes three subroutines:

- The first subroutine allocates virtual memory for a node.
- The second subroutine compares a key with a node.
- The third subroutine is called during the tree traversal. It prints out the left and right subtree pointers, the current node balance, and the name of the node.

```

%TITLE 'TREE_EXAMPLE - Sample program using binary tree routines'
MODULE TREE_EXAMPLE(                                ! Sample program using trees
    IDENT = '1-001',
    MAIN = TREE_START
) =

BEGIN

%SBTTL 'Declarations'
!+
! SWITCHES:
!-
SWITCHES ADDRESSING_MODE (EXTERNAL = GENERAL, NONEXTERNAL = WORD_RELATIVE);

!+
! LINKAGES:
!
!     NONE
!
! TABLE OF CONTENTS:
!-

```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

FORWARD ROUTINE
    TREE_START,           ! Main program
    ALLOC_NODE,          ! Allocate memory for a node
    COMPARE_NODE,        ! Compare two nodes
    PRINT_NODE;          ! Print a node (action routine
                        ! for LIB$TRAVERSE_TREE)

!+
! INCLUDE FILES:
!-

LIBRARY 'SYS$LIBRARY:STARLET.L32';           ! System symbols

!+
! Define VMS block structures (BLOCK[,BYTE]).
!-
STRUCTURE
    BBLOCK [0, P, S, E; N] =
        [N]
        (BBLOCK + 0) <P, S, E>;

!+
! MACROS:
!-
MACRO
    NODE$L_LEFT = 0,0,32,0%,           ! Left subtree pointer in node
    NODE$L_RIGHT = 4,0,32,0%,          ! Right subtree pointer
    NODE$W_BAL = 8,0,16,0%,            ! Balance this node
    NODE$B_NAMLNG = 10,0,8,0%,         ! Length of name in this node
    NODE$T_NAME = 11,0,0,0%;           ! Start of name (variable length)

LITERAL
    NODE$C_LENGTH = 11;                ! Length of fixed part of node

!+
! EXTERNAL REFERENCES:
!-

EXTERNAL ROUTINE
    LIB$GET_INPUT,           ! Read from SYS$INPUT
    LIB$GET_VM,              ! Allocate virtual memory
    LIB$INSERT_TREE,        ! Insert into binary tree
    LIB$LOOKUP_TREE,        ! Lookup in binary tree
    LIB$PUT_OUTPUT,         ! Write to SYS$OUTPUT
    LIB$TRAVERSE_TREE,      ! Traverse a binary tree
    STR$UPCASE,             ! Convert string to all uppercase
    SYS$FAO;                ! Formatted ASCII output routine

%SBTTL 'TREE_START - Sample program main routine';
ROUTINE TREE_START =
BEGIN
!+
! This program reads from SYS$INPUT and stores each data line
! as an entry in a binary tree.  When end-of-file character (CTRL/Z)
! is entered, the tree will be printed in sorted order.
!-
LOCAL
    NODE : REF BBLOCK,           ! Address of allocated node
    TREEHEAD,                    ! List head of binary tree
    LINEDESC : BBLOCK[DSC$C_S_BLN], ! String descriptor for input line
    STATUS;

```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

TREEHEAD = 0;                                ! Zero binary tree head
CH$FILL(0,DSC$C_S_BLN,LINEDESC);             ! Make a dynamic descriptor
LINEDESC[DSC$B_CLASS] = DSC$K_CLASS_D;      ! ...
!+
! Read input lines until end of file seen.
!-
WHILE (STATUS = LIB$GET_INPUT(LINEDESC,      ! Read input line
                             $DESCRIPTOR('Text: ')) ! with this prompt
      NEQ RMS$_EOF
DO IF NOT .STATUS                          ! Report any errors found
  THEN SIGNAL(.STATUS)
  ELSE BEGIN
    STR$UPCASE(LINEDESC,LINEDESC);          ! Convert string
                                           ! to uppercase
    IF NOT (STATUS = LIB$INSERT_TREE(
            TREEHEAD,                       ! Insert good data into the tree
            LINEDESC,                       ! Data to insert
            %REF(1),                        ! Insert duplicate entries
            COMPARE_NODE,                   ! Addr. of compare routine
            ALLOC_NODE,                     ! Addr. of node allocation routine
            NODE,                           ! Return addr. of
            0))                             ! allocated node here
    THEN SIGNAL(.STATUS);
  END;
!+
! End of file character encountered. Print the whole tree and exit.
!-
IF NOT (STATUS = LIB$TRAVERSE_TREE(
      TREEHEAD,                             ! Listhead of tree
      PRINT_NODE,                           ! Action routine to print a node
      0))
  THEN SIGNAL(.STATUS);

RETURN SS$_NORMAL
END;                                          ! End of routine tree_start

ROUTINE ALLOC_NODE (KEYDESC,RETDESC,CONTEXT) =
BEGIN
!+
! This routine allocates virtual memory for a node.
!
! INPUTS:
!
!   KEYDESC      Address of string descriptor for key
!                 (this is the linedesc argument passed
!                 to LIB$INSERT_TREE)
!   RETDESC      Address of location to return address of
!                 allocated memory
!   CONTEXT      Address of user context argument passed
!                 to LIB$INSERT_TREE (not used in this
!                 example)
!
! OUTPUTS:
!
!   Memory address returned in longword pointed to by retdesc
!-
MAP
  KEYDESC : REF BBLOCK,
  RETDESC : REF VECTOR[,LONG];

LOCAL
  NODE : REF BBLOCK,
  STATUS;

```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```

STATUS = LIB$GET_VM(%REF(NODE$C_LENGTH+.KEYDESC[DSC$W_LENGTH]),NODE);
IF NOT .STATUS
    THEN RETURN .STATUS
    ELSE BEGIN
        NODE[NODE$B_NAMLNG] = .KEYDESC[DSC$W_LENGTH]; ! Set name length
        CH$MOVE(.KEYDESC[DSC$W_LENGTH],                ! Copy in the name
            .KEYDESC[DSC$A_POINTER],
            NODE[NODE$T_NAME]);
        RETDESC[0] = .NODE;                            ! Return address to caller
    END;
RETURN .STATUS

END;

ROUTINE COMPARE_NODE (KEYDESC,NODE,CONTEXT) =
BEGIN
!+
! This routine compares a key with a node.
!
! INPUTS:
!
!     KEYDESC      Address of string descriptor for new key
!                  (This is the linedesc argument passed to
!                  LIB$INSERT_TREE)
!     NODE         Address of current node
!     CONTEXT      User context data (Not used in this example)
!-
MAP
    KEYDESC : REF BBLOCK,
    NODE : REF BBLOCK;

RETURN CH$COMPARE(.KEYDESC[DSC$W_LENGTH],                ! Compare key with
    .KEYDESC[DSC$A_POINTER],                            ! current node
    .NODE[NODE$B_NAMLNG],
    NODE[NODE$T_NAME])

END;

ROUTINE PRINT_NODE (NODE,CONTEXT) =
BEGIN
!+
! This routine is called during the tree traversal. It
! prints out the left and right subtree pointers, the
! current node balance, and the name of the node.
!-
MAP
    NODE : REF BBLOCK;

```

Using Run-Time Library Routines to Access Operating System Components

24.7 Miscellaneous Interface Routines

```
LOCAL
  OUTBUF : BBLOCK[512],                ! FAO output buffer
  OUTDESC : BBLOCK[DSC$C_S_BLN],      ! Output buffer descriptor
  STATUS;
CH$FILL(0,DSC$C_S_BLN,OUTDESC);      ! Zero descriptor
OUTDESC[DSC$W_LENGTH] = 512;
OUTDESC[DSC$A_POINTER] = OUTBUF;
IF NOT (STATUS = SYS$FAO($DESCRIPTOR('!XL !XL !XL !XW !AC'),
                        OUTDESC,OUTDESC,
                        .NODE,.NODE[NODE$L_LEFT],
                        .NODE[NODE$L_RIGHT],
                        .NODE[NODE$W_BAL],
                        NODE[NODE$B_NAMLNG]))
  THEN SIGNAL(.STATUS)
  ELSE BEGIN
    STATUS = LIB$PUT_OUTPUT(OUTDESC);  ! Output the line
    IF NOT .STATUS
      THEN SIGNAL(.STATUS);
  END;
RETURN SS$_NORMAL
END;
END                                     ! End of module TREE_EXAMPLE
ELUDOM
```

Using Cross-Reference Routines

The cross-reference routines are contained in a separate, shareable image capable of creating a cross-reference analysis of symbols. They accept cross-reference data, summarize it, and format it for output. Two facilities that use the cross-reference routines are the VMS Linker and the MACRO assembler. They are sufficiently general, however, to be used by any native-mode utility.

Table 25–1 lists the entry points and functions of the cross-reference routines.

Table 25–1 Cross-Reference Routines

Entry Point	Function
LIB\$CRF_INS_KEY	Inserts key information
LIB\$CRF_INS_REF	Inserts reference information
LIB\$CRF_OUTPUT	Summarizes and formats cross-reference information

The interface to the cross-reference routines is by way of a set of control blocks, format definition tables, and a set of callable entry points. Macros are provided for assembly language and BLISS initialization of the control blocks and format definition tables.

25.1 How to Use the Cross-Reference Routines

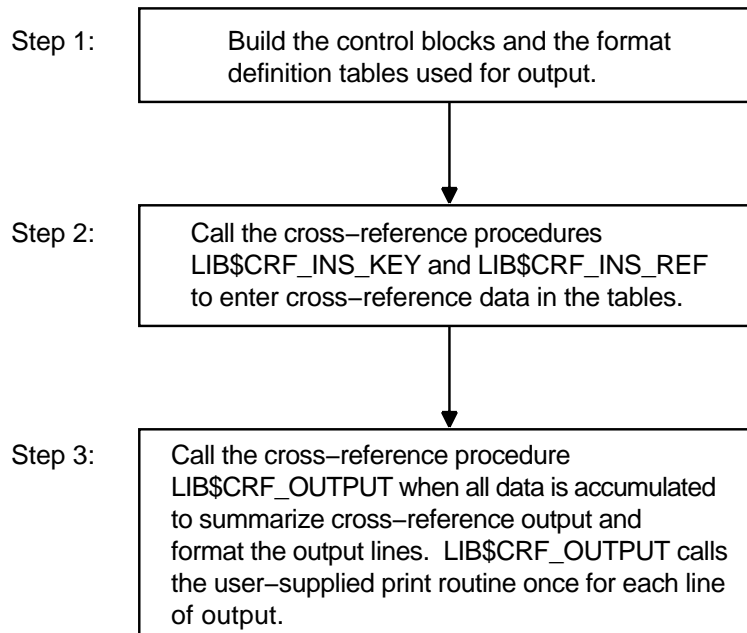
Using the cross-reference routines involves the following steps:

1. Define a table of control information, using the \$CRFCTLTABLE macro.
2. Define each field of the output line, using the \$CRFFIELD macro.
3. Specify the end of each set of macros that define a field in the output line, using the \$CRFFIELDEND macro.
4. Provide data by calling one of the two following cross-reference entry points:
 - LIB\$CRF_INS_KEY inserts an entry for the specified key in the specified symbol table.
 - LIB\$CRF_INS_REF inserts a reference to a key in the specified symbol table.
5. Call LIB\$CRF_OUTPUT, the cross-reference output routine, to summarize and format the data.
6. Supply a routine that the output routine calls to print each line in the output file. Because you supply this routine, you can control the number of lines per page and the header lines.

Using Cross-Reference Routines

25.1 How to Use the Cross-Reference Routines

Figure 25–1 Using Cross-Reference Routines



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Figure 25–1 illustrates the steps required in using the cross-reference routines.

The Run-Time Library provides three macros to initialize the data structures used by the cross-reference routines:

1. `SCRFCTLTABLE` defines a table of control information.
2. `SCRFFIELD` defines each field of the output format definition table. Multiple `SCRFFIELD` macro instructions can be issued in defining one particular field.
3. `SCRFFIELDEND` ends a set of `SCRFFIELD` macro instructions (a format table).

25.2 \$CRFCTLTABLE Macro

`SCRFCTLTABLE` initializes a cross-reference control table. Your program must issue one `SCRFCTLTABLE` macro for each cross-reference table you build. You can accumulate information for more than one cross-reference table at a time. For this reason, you must define a table for each set of cross-references, and include the address of that table each time you call a cross-reference routine to insert data.

The `SCRFCTLTABLE` macro instruction has the following format:

```
label: $CRFCTLTABLE keytype, output, error, memexp, key1table,  
key2table, val1table, val2table,  
ref1table, ref2table
```


label

The address of the control table. You must specify a control table address in all calls to the cross-reference routines.

keytype

The type of key to enter into the table. The following key types are defined:

- | | |
|---------|---|
| ASCIC | Keys are counted ASCII strings, with a maximum of 31 characters (symbol name). |
| BIN_U32 | Keys are 32-bit unsigned binary values. The binary-to-ASCII conversion is done by \$FAO using the format string for the KEY1 field. |

output

The address of the routine that you supply to print a formatted output line. The output line is passed to the output routine by descriptor.

error

The address of an error routine to execute if the called cross-reference routine encounters an error. The error code (longword) is passed to the error routine by value. In other words, it is a copy of the constant on the stack. A value of zero indicates that no error routine is supplied.

memexp

The number of pages by which to expand region when needed. The default is 50.

key1table

The address of the field descriptor table for the KEY1 field. A value of zero indicates that the field is not to be included in the output line.

The remaining arguments provide the address of the field descriptor tables for the KEY2, VAL1, VAL2, REF1, and REF2 fields, respectively, of the output line. You can use these argument names as keywords in the macros. For example, you can use KEYTYPE as a keyword when issuing the \$CRFCTLTABLE macro.

25.3 \$CRFFIELD Macro

For each field in the output line, you must issue a \$CRFFIELD instruction to identify the field, supply an \$FAO command string to control the printing of the field, and provide flag information. See the program example and the description of \$FAO (formatted ASCII output) in the *OpenVMS System Services Reference Manual*. The \$CRFFIELD macro has the following format:

label: \$CRFFIELD bit_mask, fao_string, field_width, set_clear

label

The address of the field descriptor table generated as a result of this set of \$CRFFIELD macro instructions. The label field can be omitted after the first macro of the set. These addresses correspond to the field descriptor table addresses in the \$CRFCTLTABLE macro.

bit_mask

A 16-bit mask. When the user enters a key or reference, the cross-reference routine stores flag information with the entry. When preparing the output line, LIB\$CRF_OUTPUT performs an AND operation on the 16-bit mask in the field descriptor table with the flag stored with the entry. Any number of bit masks can be defined for a field. \$CRFFIELD macro instructions are used to define multiple bit patterns for a flag field. The high-order bit is reserved to the cross-reference routines.

Using Cross-Reference Routines

25.3 \$CRFFIELD Macro

fao_string

The \$FAO command string. LIB\$CRF_OUTPUT uses this string to determine the \$FAO format when formatting this field for output.

field_width

The maximum width of the output field.

set_clear

The indicator used to determine whether the bit mask is to be tested as set or clear when determining which flag to use. SET indicates test for set; CLEAR indicates test for clear.

You can use the argument names shown here as keywords in your program.

In the following example, one bit pattern is defined twice; once indicating a string that is to be printed if the pattern is set, and once indicating that spaces are to appear if the pattern is clear.

```
$CRFFIELD      BIT_MASK=SYM$M_REL, FAO_STRING=3_\\##_\\,-  
                SET_CLEAR=CLEAR, FIELD_WIDTH=2  
$CRFFIELD      BIT_MASK=SYM$M_REL, FAO_STRING=_\\-R_\\,-  
                SET_CLEAR=SET, FIELD_WIDTH=2
```

If more than one set of flags is defined for a field, each FAO string must print the same number of characters; otherwise, the output is not aligned in columns.

The fields for the symbol name, symbol value, and references are always formatted using the first descriptor in the corresponding table.

25.4 \$CRFFIELDEND Macro

The \$CRFFIELDEND macro instruction marks the end of a set of macros that describe one field of the output line. It is used once to end each set of field descriptors. It has the following format:

```
$CRFFIELDEND
```

25.5 Cross-Reference Output

LIB\$CRF_OUTPUT can format output lines for three types of cross-reference listings:

1. A summary of symbol names and their values, as illustrated in Figure 25-2.
2. A summary of symbol names, their values, and the names of modules that refer to the symbol, as illustrated in Figure 25-3.
3. A summary of symbol names, their values, the name of the defining module, and the names of those modules that refer to the symbol, as illustrated in Figure 25-4.

Figure 25–2 Summary of Symbol Names and Values

Symbol	Value	Symbol	Value
-----	-----	-----	-----
BAS\$INSTR	000020B0-RU	BAS\$SCRATCH	00002308-RU
BAS\$IN_D_R	000021F0-RU	BAS\$STATUS	00002338-RU
BAS\$IN_F_R	000021E8-RU	BAS\$STR_D	000020C0-RU
BAS\$IN_L_R	000021E0-RU	BAS\$STR_F	000020B8-RU
BAS\$IN_T_DX	000021F8-RU	BAS\$STR_L	000020C8-RU
BAS\$IN_W_R	000021D8-RU	BAS\$UNLOCK	00002310-RU
BAS\$IO_END	000021D0-RU	BAS\$UPDATE	000022E8-RU
BAS\$LINKAGE	00001674-R	BAS\$UPDATE_COUN	000022F0-RU
BAS\$LINPUT	000021A8-RU	BAS\$VAL_D	00002110-RU
BAS\$MAT_INPUT	00002268-RU	BAS\$VAL_F	00002108-RU

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Figure 25–3 Summary of Symbol Names, Values, and Name of Referring Modules

Symbol	Value	Referenced By ...
-----	-----	-----
BAS\$K_DIVBY_ZER	0000003D	ALLGBL BAS\$ERROR BAS\$POWDJ BAS\$POWII BAS\$POWRJ BAS\$POWRR
BAS\$K_DUPKEYDET	00000086	ALLGBL BAS\$\$SIGNAL_IO
BAS\$K_ENDFILDEV	0000000B	ALLGBL BAS\$\$REC_PROC
BAS\$K_ENDOF_STA	0000006C	BAS\$\$UDF_RL ALLGBL

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Figure 25–4 Summary Indicating Defining Module

Symbol	Value	Defined By	Referenced By ...
-----	-----	-----	-----
LIB\$FREE_VM	0001E185-R	LIB\$VM	ALLGBL BAS\$MARGIN BAS\$XLATE FOR\$VM STR\$APPEND STR\$DUPL_CHAR STR\$REPLACE
LIB\$GET_COMMAND	0001E2B0-R	LIB\$GET_INPUT	ALLGBL
LIB\$GET_COMMON	0001E4D6-R	LIB\$COMMON	ALLGBL

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Regardless of the format of the output, LIB\$CRF_OUTPUT considers the output line to consist of the following six different field types:

1. KEY1 is the first field in the line. It contains a symbol name.
2. KEY2 is the second field in the line. It contains a set of flags (for example, -R) providing information about the symbol.
3. VAL1 is the third field in the line. It contains the value of the symbol.
4. VAL2 is the fourth field in the line. It contains a set of flags describing VAL1.
5. REF1 and REF2 fields. Within each REF1 and REF2 pair, REF1 provides a set of flags and REF2 provides the name of a module that references the symbol.

Using Cross-Reference Routines

25.5 Cross-Reference Output

Figure 25-5 shows that any of these fields can be omitted from the output.

Figure 25-5 Output Line for LIB\$CRF_OUTPUT

Symbol ----- BAS\$INSTR ↑ KEY1	Value ----- 000020B0-RU ↑ ↑ VAL1 VAL2	Symbol ----- BAS\$SCRATCH ↑ KEY1	Value ----- 00002308-RU ↑ ↑ VAL1 VAL2
Symbol ----- LIB\$FREE_VM ↑ KEY1	Value ----- 0001E185-R ↑ ↑ VAL1 VAL2	Defined By ----- LIB\$VM ↑ REF2 (CRF\$K_DEF)	Referenced By ... ----- ALLGBL ↑ REF2 (CRF\$K_REF)

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25.6 Example

The VAX Linker uses the cross-reference routines to generate cross-reference listings. This section uses the linker's code as an example of using the cross-reference routines in a MACRO program.

25.6.1 Defining Control Tables

Cross-reference routines use two control tables:

- The symbol-by-name table
- The symbol-by-value table

First, the linker uses the \$CRFCTLTABLE macro to set up the characteristics and fields of the symbol-by-name table. This table will list symbols by name and provide a cross-reference synopsis. The table is set up as follows:

```
LNK$NAMTAB:
    $CRFCTLTABLE  KEYTYPE=ASCIC,ERROR=LNK$ERR_RTN,
                  OUTPUT=LNK$MAPOUT,KEY1TABLE=LNK$KEY1,
                  KEY2TABLE=LNK$KEY2,VAL1TABLE=LNK$VAL1,
                  VAL2TABLE=LNK$VAL2,REF1TABLE=LNK$REF1,
                  REF2TABLE=LNK$REF2
```

LNK\$NAMTAB	Names the address of the control table
KEYTYPE=ASCIC	Specifies that the keys are counted ASCII strings (that is, symbol names)
ERROR=LNK\$ERR_RTN	Indicates that LNK\$ERR_RTN is the address of the routine to be executed in case of error
OUTPUT=LNK\$MAPOUT	Names LNK\$MAPOUT as the address of the user-supplied routine that prints the formatted table

The remaining arguments provide the addresses of the field descriptor tables.

Using Cross-Reference Routines 25.6 Example

After setting up the control tables, the linker defines each field of the cross-reference output line, using the `$CRFFIELD` macro. After each set of definitions for a field, it calls `$CRFFIELDEND` to mark the end of the field.

Note particularly the following two features of this set of definitions:

- The definition of `LNK$VAL2` describes a flag to be associated with `VAL1`. The definition contains alternative bit patterns, depending on the bit mask. When an entry is made to the table, the entry contains flag information. Then, when `LIB$CRF_OUTPUT` is called to format the data, the routine checks each entry, matching the flags argument against the bit masks specified in the control table. When `LIB$CRF_OUTPUT` finds a match, it uses that definition to determine the format of the entry in the output table. For example, `BIT_MASK=SYM$M_DEF` marks an entry as the defining reference. The corresponding `VAL1` entry is placed in the output table with an asterisk in its flags field.
- The `FAO` control strings are defined to produce an output of the maximum character size for each field. This ensures that the columns will line up correctly in the output. For example, `!15AC` produces the variable symbol name left-aligned and right-filled with spaces. Another example is the three sets of characters to be printed for field `VAL2`. Each `FAO` control string produces two characters, which is the maximum size of the field.

```
LNK$KEY1:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=!15AC\,-
                  SET_CLEAR=SET, FIELD_WIDTH=15
    $CRFFIELDEND
LNK$KEY2:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=\ \,-
                  SET_CLEAR=SET, FIELD_WIDTH=1
    $CRFFIELDEND
LNK$VAL1:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=!XL\,-
                  SET_CLEAR=SET, FIELD_WIDTH=8
    $CRFFIELDEND
LNK$VAL2:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=!2* \,-
                  SET_CLEAR=SET, FIELD_WIDTH=2
    $CRFFIELD      BIT_MASK=SYM$M_REL, FAO_STRING=!R\,-
                  SET_CLEAR=SET, FIELD_WIDTH=2
    $CRFFIELD      BIT_MASK=SYM$M_DEF, FAO_STRING=!*\,-
                  SET_CLEAR=CLEAR, FIELD_WIDTH=2
    $CRFFIELDEND
LNK$REF1:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=!6* \,-
                  SET_CLEAR=SET, FIELD_WIDTH=6
    $CRFFIELD      BIT_MASK=SYM$M_WEAK, FAO_STRING=!3* WK-\,-
                  SET_CLEAR=SET, FIELD_WIDTH=6
    $CRFFIELDEND
LNK$REF2:
    $CRFFIELD      BIT_MASK=0, FAO_STRING=!16AC\,-
                  SET_CLEAR=SET, FIELD_WIDTH=16
    $CRFFIELDEND
```

After initializing the symbol-by-name table, the linker sets up a second control table. This table defines the output for a symbol-by-value synopsis. For this output, the value fields are eliminated. The symbols having this value are entered as reference indicators. None is specified as the defining reference. The control table uses the field descriptors set up previously. The following macro instructions are used:

Using Cross-Reference Routines

25.6 Example

```
LNK$VALTAB:
    $CRFCTLTABLE    KEYTYPE=BIN_U32, ERROR=LNK$ERR_RTN, -
                   OUTPUT=LNK$MAPOUT, KEY1TABLE=LNK$VAL1, -
                   KEY2TABLE=LNK$VAL2, VAL1TABLE=0, -
                   VAL2TABLE=0, REF1TABLE=LNK$REF1, -
                   REF2TABLE=LNK$REF2
```

25.6.2 Inserting Table Information

After initializing the format data for the symbol tables, the linker enters data into the cross-reference tables by calling `LIB$CRF_INS_KEY`.

As the linker processes the first object module, `MAPINITIAL`, it encounters a symbol definition for `$MAPFLG`. The following is an example of a call to enter the symbol `MAPINITIAL` as a key in the cross-reference symbol table:

```
PUSHAB    VALUE_FLAGS
PUSHAB    VALUE_ADDR
PUSHAB    SYMBOL_ADDR
PUSHAB    LNK$NAMTAB
CALLS     #4, G^LIB$CRF_INS_KEY
```

<code>LNK\$NAMTAB</code>	Is the address of the control table
<code>SYMBOL_ADDR</code>	Is the address of the counted ASCII string <code>\$MAPFLG</code>
<code>VALUE_ADDR</code>	Is the address of the symbol value
<code>VALUE_FLAGS</code>	Is the address of a word whose bits are used to select special characters to print beside the value

The linker then calls `LIB$CRF_INS_REF` to process the defining reference indicator:

```
DEF:      .LONG    CRF$K_DEF
          PUSHAB   DEF
          PUSHAB   REF_FLAGS
          PUSHAB   REF_ADDR
          PUSHAB   SYMBOL_ADDR
          PUSHAB   LNK$NAMTAB
          CALLS    #5, G^LIB$CRF_INS_REF
```

<code>LNK\$NAMTAB</code>	Is the address of the control table
<code>SYMBOL_ADDR</code>	Is the address of the counted string <code>\$MAPFLG</code>
<code>REF_ADDR</code>	Is the address of the referrer's counted ASCII string
<code>REF_FLAGS</code>	Is the address of a word whose bits are used to select special characters to print beside the reference

Further on in the input module, the linker encounters a global symbol reference to `CSSGBL`. The call to store data for this reference is as follows:

```
REF:      .LONG    CRF$K_REF
          PUSHAB   REF
          PUSHAB   REF_FLAGS
          PUSHAB   REF_ADDR
          PUSHAB   SYMBOL_ADDR
          PUSHAB   LNK$NAMTAB
          CALLS    #5, G^LIB$CRF_INS_REF
```

The arguments are similar to the previous example, except for `CRF$K_REF`, which indicates that this is not the defining reference.

After it has performed symbol relocation for the module being linked, the linker calls LIB\$CRF_INS_REF to build a table ordered by value.

```
PUSHAB REF
PUSHAB REF_FLAGS
PUSHAB REF_ADDR
PUSHAB VAL_ADDR
PUSHAB LNK$VALTAB
CALLS #5,G^LIB$CRF_INS_REF
```

LNK\$VALTAB Is the address of the control table for the symbol synopsis by value
 VAL_ADDR Is the address of the value (binary longword key)
 REF_ADDR Is the address of the symbol name having the value contained in VAL_ADDR
 REF_FLAGS Is the address of a word whose bits are used to select special characters to print beside the value
 CRF\$K_REF Is the indicator that this is not a defining reference

25.6.3 Formatting Information for Output

After all input modules are processed, the linker requests the information for the map. It calls LIB\$CRF_OUTPUT once for each type of output. The following MACRO example illustrates a call to list the symbols and their values. Three calls are illustrated here.

```
LNWID: .LONG 132
LNSP1: .LONG LINES_PAGE1
LNSOP: .LONG LINES_OTHR_PAGE
SAVE: .LONG CRF$K_SAVE
VAL: .LONG CRF$K_VALUES
PUSHAB VAL
PUSHAB SAVE
PUSHAB LNSOP
PUSHAB LNSP1
PUSHAB LNWID
PUSHAB LNK$NAMTAB
CALLS #6,G^LIB$CRF_OUTPUT
```

In this example, CRF\$K_VALUES means that no reference indicators are to be printed, while CRF\$K_SAVE means that the cross-reference table is to be saved. It is also possible to list all cross-reference data. The type of output produced by this call is shown in Section 25.5, Figure 25–2.

The following call produces such a summary and releases the storage at the same time:

```
LNWID: .LONG 132
LNSP1: .LONG LINES_PAGE1
LNSOP: .LONG LINES_OTHR_PAGE
DELETE: .LONG CRF$K_DELETE
DEFREF: .LONG CRF$K_DEF_REF
PUSHAB DELETE
PUSHAB DEFREF
PUSHAB LNSOP
PUSHAB LNSP1
PUSHAB LNWID
PUSHAB LNK$NAMTAB
CALLS #6,G^LIB$CRF_OUTPUT
```

The type of output produced by this call is shown in Section 25.5, Figure 25–4.

CRF\$K_DEFS_REFS indicates that the first two reference fields are used for the defining references, and CRF\$K_DELETE indicates that the table is deleted.

Using Cross-Reference Routines

25.6 Example

Another call is made to list the symbol by value synopsis, as follows:

```
LNWID:      .LONG      132
LNSP1:      .LONG      LINES_PAGE1
LNSOP:      .LONG      LINES_OTHR_PAGE
VALREF:     .LONG      CRF$K_VALS_REF
DELETE:     .LONG      CRF$K_DELETE
            PUSHAB     DELETE
            PUSHAB     VALREF
            PUSHAB     LNSOP
            PUSHAB     LNSP1
            PUSHAB     LNWID
            PUSHAB     LNK$VALTAB
            CALLS      #6,G^LIB$CRF_OUTPUT
```

This is similar to the previous call in that it produces a complete cross-reference output by value, but it does not have the defining reference fields.

25.7 How to Link to the Cross-Reference Shareable Image

The cross-reference routines are located in a shareable image CRFSHR.EXE. This shareable image is part of the default system shareable image library, SYS\$LIBRARY:IMAGELIB.OLB. For this reason, the cross-reference routines are automatically included in your image, unless you specify /NOSYSHR in the LINK command. If you have specified /NOSYSHR and you want to include CRFSHR.EXE, your LINK command must include the following:

```
SYS$LIBRARY:IMAGELIB/INCLUDE=CRFSHR
```

Shareable Resources

This chapter describes the techniques available for sharing data and program code among programs. It contains the following sections:

Section 26.1 describes how to share code among programs.

Section 26.2 describes shareable images.

Section 26.3 defines and describes how to use local and global symbols to share images.

The operating system provides the following techniques for sharing data and program code among programs:

- DCL symbols and logical names
- Libraries
- Shareable images
- Global sections
- Common blocks installed in a shareable image
- OpenVMS Record Management Services (RMS) shared files

Symbols and logical names are also used for intraprocess and interprocess communication; therefore, they are discussed in Chapter 32.

Libraries and shareable images are used for sharing program code.

Global sections, common blocks stored in shareable images, and RMS shared files are used for sharing data. You can also use common blocks for interprocess communication. For more information, refer to Chapter 3.

26.1 Sharing Program Code

To share code among programs, you can use the following operating system resources:

- Text, macro, or object libraries that store sections of code. Text and macro libraries store source code; object libraries store object code. You can create and manage libraries using the Librarian utility (LIBRARIAN). Refer to the *OpenVMS Command Definition, Librarian, and Message Utilities Manual* for complete information about using the Librarian utility.
- Shareable images, which are images that have been compiled and linked but cannot be run independently. These images can also be stored in libraries.

Shareable Resources

26.1 Sharing Program Code

26.1.1 Object Libraries

You can use object libraries to store frequently used routines, thereby avoiding repeated recompiling, which allows you to minimize the number of files you must maintain, and simplify the linking process. The source code for the object modules can be in any VAX supported language, and the object modules can be linked with any other modules written in any VAX supported language.

Use the .OLB file extension for any object library. All modules stored in an object library must have the file extension .OBJ.

26.1.1.1 System- and User-Defined Default Object Libraries

The operating system provides a default system object library, STARLET.OLB. You can also define one or more default object libraries to be automatically searched before the system object library. The logical names for the default object libraries are LNK\$LIBRARY and LNK\$LIBRARY_1 through LNK\$LIBRARY_999. To use one of these default libraries, first define the logical name. The libraries are searched sequentially starting at LNK\$LIBRARY. Do not skip any numbers. If you store object modules in the default libraries, you do not have to specify them at link time. However, you do have to maintain and manage them as you would any library.

The following example defines the library in the file PROCEDURES.OLB (the file type defaults to .OLB, meaning object library) in \$DISK1:[DEV] as a default user library:

```
$ DEFINE LNK$LIBRARY $DISK1:[DEV]PROCEDURES
```

26.1.1.2 How the Linker Searches Libraries

When the linker is resolving global symbol references, it searches user default libraries at the process level first, then libraries at the group and system level. Within levels, the library defined as LNK\$LIBRARY is searched first, then LNK\$LIBRARY_1, LNK\$LIBRARY_2, and so on.

26.1.1.3 Creating an Object Library

To create an object library, invoke the Librarian utility by entering the LIBRARY command with the /CREATE qualifier and the name you are assigning the library. The following example creates a library in a file named INCOME.OLB (.OLB is the default file type):

```
$ LIBRARY/CREATE INCOME
```

26.1.1.4 Managing an Object Library

To add or replace modules in a library, enter the LIBRARY command with the /REPLACE qualifier followed by the name of the library (first parameter) and the names of the files containing the (second parameter). After you put object modules in a library, you can delete the object file. The following example adds or replaces the modules from the object file named GETSTATS.OBJ to the object library named INCOME.OLB and then deletes the object file:

```
$ LIBRARY/REPLACE INCOME GETSTATS
$ DELETE GETSTATS.OBJ;*
```

You can examine the contents of an object library with the /LIST qualifier. Use the /ONLY qualifier to limit the display. The following command displays all the modules in INCOME.OLB that start with GET:

```
$ LIBRARY/LIST/ONLY=GET* INCOME
```

Use the `/DELETE` qualifier to delete a library module and the `/EXTRACT` qualifier to recreate an object file. If you delete many modules, you should also compress (`/COMPRESS` qualifier) and purge (`PURGE` command) the library. Note that the `/ONLY`, `/DELETE`, and `/EXTRACT` qualifiers require the names of modules—not file names—and that the names are specified as qualifier values, not parameter values.

26.1.2 Text and Macro Libraries

Any frequently used routine can be stored in libraries as source code. Then, when you need the routine, it can be called in from your source program.

Source code modules are stored in text libraries. The file extension for a text library is `.TLB`.

When using VAX MACRO assembly language, any source code module can be stored in a macro library. The file extension for a macro library is `.MLB`. Any source code module stored in a macro library must have the file extension `.MAR`.

You also use `LIBRARIAN` to create and manage text and macro libraries. Refer to Section 26.1.1.3 and Section 26.1.1.4 for a summary of `LIBRARIAN` commands.

26.2 Shareable Images

A **shareable image** is a nonexecutable image that can be linked with executable images. If you have a program unit that is invoked by more than one program, linking it as a shareable image provides the following benefits:

- Saves disk space—The executable images to which the shareable image is linked do not physically include the shareable image. Only one copy of the shareable image exists.
- Simplifies maintenance—If you use transfer vectors and the `GSMATCH` (on VAX systems) or symbol vectors (on Alpha systems) option, you can modify, recompile, and relink a shareable image without having to relink any executable image that is linked with it.

Shareable images can also save memory, provided that they are installed as shared images. See the *OpenVMS Linker Utility Manual* for more information about creating shareable images and shareable image libraries.

26.3 Symbols

Symbols are names that represent locations (addresses) in virtual memory. More precisely, a symbol's value is the address of the first, or low-order, byte of a defined area of virtual memory, while the characteristics of the defined area provide the number of bytes referred to. For example, if you define `TOTAL_HOUSES` as an integer, the symbol `TOTAL_HOUSES` is assigned the address of the low-order byte of a 4-byte area in virtual memory. Some system components (for example, the debugger) permit you to refer to areas of virtual memory by their actual addresses, but symbolic references are always recommended.

26.3.1 Defining Symbols

A symbolic name can consist of up to 31 letters, digits, underscores (`_`), and dollar signs (`$`). Uppercase and lowercase letters are equivalent. By convention, dollar signs are restricted to symbols used in system components. (If you do not use the dollar sign in your symbolic names, you will never accidentally duplicate a system-defined symbol.)

Shareable Resources

26.3 Symbols

26.3.2 Local and Global Symbols

Symbols are either local or global in scope. A **local symbol** can only be referenced within the program unit in which it is defined. Local symbol names must be unique among all other local symbols within the program unit but not within other program units in the program. References to local symbols are resolved at compile time.

A **global symbol** can be referenced outside the program unit in which it is defined. Global symbol names must be unique among all other global symbols within the program. References to global symbols are not resolved until link time.

References to global symbols in the executable portion of a program unit are usually invocations of subprograms. If you reference a global symbol in any other capacity (as an argument or data value—see the following paragraph), you must define the symbol as external or intrinsic in the definition portion of the program unit.

System facilities, such as the Message utility and the VAX MACRO assembler, use global symbols to define data values.

The following program segment shows how to define and reference a global symbol, `RMS$_EOF` (a condition code that may be returned by `LIB$GET_INPUT`):

```
CHARACTER*255  NEW_TEXT
INTEGER        STATUS
INTEGER*2      NT_SIZ
INTEGER        LIB$GET_INPUT
EXTERNAL       RMS$_EOF
STATUS = LIB$GET_INPUT (NEW_TEXT,
2              'New text: ',
2              NT_SIZ)
IF ((.NOT. STATUS) .AND.
2  (STATUS .NE. %LOC (RMS$_EOF))) THEN
  CALL LIB$SIGNAL (RETURN_STATUS BY VALUE)
END IF
```

26.3.3 Resolving Global Symbols

References to global symbols are resolved by including the module that defines the symbol in the link operation. When the linker encounters a global symbol, it uses the following search method to find the defining module:

1. Explicitly named modules and libraries—Generally used to resolve user-defined global symbols, such as subprogram names and condition codes. These modules and libraries are searched in the order in which they are specified.
2. System default libraries—Generally used to resolve system-defined global symbols, such as procedure names and condition codes.
3. User default libraries—Generally used to avoid explicitly naming libraries, thereby simplifying linking.

If the linker cannot find the symbol, the symbol is said to be unresolved and a warning results. You can run an image containing unresolved symbols. The image runs successfully as long as it does not access any unresolved symbol. For example, if your code calls a subroutine but the subroutine call is not executed, the image runs successfully.

If an image accesses an unresolved global symbol, results are unpredictable. Usually the image fails with an access violation (attempting to access a physical memory location outside those assigned to the program's virtual memory addresses).

26.3.3.1 Explicitly Named Modules and Libraries

You can resolve a global symbol reference by naming the defining object module in the link command. For example, if the program unit INCOME references the subprogram GET_STATS, you can resolve the global symbol reference when you link INCOME by including the file containing the object module for GET_STATS, as follows:

```
$ LINK INCOME, GETSTATS
```

If the modules that define the symbols are in an object library, name the library in the link operation. In the following example, the GET_STATS module resides in the object module library INCOME.OLB:

```
$ LINK INCOME, INCOME/LIBRARY
```

26.3.3.2 System Default Libraries

Link operations automatically check the system object and shareable image libraries for any references to global symbols not resolved by your explicitly named object modules and libraries. The system object and shareable image libraries include the entry points for the RTL routines and system services, condition codes, and other system-defined values. Invocations of these modules do not require any explicit action by you at link time.

26.3.3.3 User Default Libraries

If you write general-purpose procedures or define general-purpose symbols, you can place them in a user default library. (You can also make your development library a user default library.) In this way, you can link to the modules containing these procedures and symbols without explicitly naming the library in the DCL LINK command. To name a single-user library, equate the file name of the library to the logical name LNK\$LIBRARY. For subsequent default libraries, use the logical names LNK\$LIBRARY_1 through LNK\$LIBRARY_999, as described in Section 26.1.1.

26.3.3.4 Making a Library Available for Systemwide Use

To make a library available to everyone using the system, define it at the system level. To restrict use of a library or to override a system library, define the library at the process or group level. The following command line defines the default user library at the system level:

```
$ DEFINE/SYSTEM LNK$LIBRARY $DISK1:[DEV]PROCEDURES
```

26.3.3.5 Macro Libraries

Some system symbols are not defined in the system object and shareable image libraries. In such cases, the *OpenVMS System Services Reference Manual* notes that the symbols are defined in the system macro library and tells you the name of the macro containing the symbols. To access these symbols, you must first assemble a macro routine with the following source code. The keyword GLOBAL must be in uppercase. The .TITLE directive is optional but recommended.

Shareable Resources

26.3 Symbols

```
.TITLE macro-name
macro-name      GLOBAL
.
.
.END
```

The following example is a macro program that includes two system macros:

LBRDEF.MAR

```
.TITLE $LBRDEF
$LBRDEF GLOBAL
$LHIDEF GLOBAL
.END
```

Assemble the routine containing the macros with the `MACRO` command. You can place the resultant object modules in a default library or in a library that you specify in the `LINK` command, or you can specify the object modules in the `LINK` command. The following example places the `$LBRDEF` and `$LHIDEF` modules in a library before performing a link operation:

```
$ MACRO LBRDEF
$ LIBRARY/REPLACE INCOME LBRDEF
$ DELETE LBRDEF.OBJ;*
$ LINK INCOME,INCOME/LIBRARY
```

The following `LINK` command uses the object file directly:

```
$ LINK INCOME,LBRDEF,INCOME/LIBRARY
```

26.3.4 Sharing Data

Typically, you use an installed common block either to facilitate interprocess communication or to allow two or more processes to access the same data simultaneously. However, you must have the `CMKRNL` privilege to install the common block. If you do not have the `CMKRNL` privilege, global sections allow you to perform the same operations.

26.3.4.1 Installed Common Blocks

To share data among processes by using a common block, you must install the common block as a shared shareable image and link each program that references the common block against that shareable image.

To install a common block as a shared image:

1. Define a common block—Write a program that declares the variables in the common block and defines the common block. This program should not contain executable code. The following Compaq Fortran program defines a common block:

```
INC_COMMON.FOR
INTEGER TOTAL_HOUSES
REAL PERSONS_HOUSE (2048),
2 ADULTS_HOUSE (2048),
2 INCOME_HOUSE (2048)
COMMON /INCOME_DATA/ TOTAL_HOUSES,
2 PERSONS_HOUSE,
2 ADULTS_HOUSE,
2 INCOME_HOUSE
END
```

2. Create the shareable image—Compile the program containing the common block. Use the LINK/SHAREABLE command to create a shareable image containing the common block.

```
$ FORTRAN INC_COMMON  
$ LINK/SHAREABLE INC_COMMON
```

For Alpha only, you need to specify a Linker options file (shown here as SYSSINPUT to allow typed input) to specify the PSECT attributes of the COMMON block PSECT and include it in the global symbol table:

```
$ LINK/SHAREABLE INC_COMMON ,SYSSINPUT/OPTION  
_ SYMBOL_VECTOR=(WORK_AREA=PSECT)  
_ PSECT_ATTR=WORK_AREA,SHR
```

With Compaq Fortran 90 on OpenVMS Alpha systems, the default PSECT attribute for a common block is NOSHR. To use a shared installed common block, you *must* specify one of the following:

- The SHR attribute in a cDEC\$ PSECT directive in the source file
- The SHR attribute in the Linker options file for the shareable image to be installed and for each executable image that references the installed common block

If the !DEC\$ PSECT (same as cDEC\$ PSECT) directive specified the SHR attribute, the LINK command is as follows:

```
$ LINK/SHAREABLE INC_COMMON ,SYSSINPUT/OPTION  
_ SYMBOL_VECTOR=(WORK_AREA=PSECT)
```

For Alpha only, copy the shareable image. Once created, you should copy the shareable image into SYSSSHARE before it is installed. The file protection of the .EXE file must allow write access for the processes running programs that will access the shareable image (shown for Group access in the following COPY command):

```
$ COPY/LOG DISK$:[INCOME.DEV]INC_COMMON.EXE SYSSSHARE:*.*  
_ /PROTECTION=G:RWE
```

On Alpha systems, if you do not copy the installed shareable image to SYSSSHARE, before running executable images that reference the installed shareable common image, you must define a logical name that specifies the location of that image.

On Alpha systems, when compiling the program that contains the common block declarations, consistently use the *same* /ALIGNMENT and /GRANULARITY qualifiers used to compile the common block data declaration program that has been installed as a shareable image. For more information, see Section 26.3.4.3.

3. Install the shareable image—Use the DCL command SET PROCESS /PRIVILEGE to give yourself CMKRNL privilege (required for use of the Install utility). Use the DCL command INSTALL to invoke the interactive Install utility. When the INSTALL prompt appears, enter CREATE, followed by the complete file specification of the shareable image that contains the common block (the file type defaults to .EXE) and the qualifiers /WRITEABLE and /SHARED. The Install utility installs your shareable image and reissues the INSTALL prompt. Enter EXIT to exit. Remember to remove CMKRNL privilege. (For complete documentation of the Install utility, see the *OpenVMS System Management Utilities Reference Manual*.)

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26.3 Symbols

The following example shows how to install a shareable image:

```
$ SET PROCESS/PRIVILEGE=CMKRNL
$ INSTALL
INSTALL> CREATE DISK$USER:[INCOME.DEV]INC_COMMON -
_INSTALL> /WRITEABLE/SHARED
INSTALL> EXIT
$ SET PROCESS/PRIVILEGE=NOCMKRNL
```

Note

A disk containing an installed image cannot be dismounted. To remove an installed image, invoke the Install utility and enter DELETE followed by the complete file specification of the image. The DELETE subcommand does not delete the file from the disk; it removes the file from the list of known installed images.

Perform the following steps to write or read the data in an installed common block from within any program:

1. Include the same variable and common block definitions in the program.
2. Compile the program.

For Alpha only, when compiling the program that contains the common block declarations, consistently use the *same* /ALIGNMENT and /GRANULARITY qualifiers used to compile the common block data declaration program that has been installed as a shareable image. For more information, see Section 26.3.4.3.

3. Link the program against the shareable image that contains the common block. (Linking against a shareable image requires an options file.)

```
$ LINK INCOME, DATA/OPTION
$ LINK REPORT, DATA/OPTION
```

DATA.OPT

```
INC_COMMON/SHAREABLE
```

For Alpha only, linking is as follows:

```
INC_COMMON/SHAREABLE
PSECT_ATTR=WORK_AREA, SHR
```

If a !DEC\$ PSECT (cDEC\$ PSECT) directive specified the SHR PSECT attribute, the linker options file INCOME.OPT would contain the following line:

```
INC_COMMON/SHAREABLE
```

The source line containing the !DEC\$ PSECT directive would be as follows:

```
!DEC$ PSECT /INC_COMMON/ SHR
```

4. Execute the program.

For Alpha only, if the installed image is not located in SYSS\$SHARE, you must define a logical name that specifies the location of that image. The logical name (in this example INC_COMMON) is the name of the installed base.

In the previous series of examples, the two programs INCOME and REPORT access the same area of memory through the installed common block INCOME_DATA (defined in INC_COMMON.FOR).

Typically, programs that access shared data use common event flag clusters to synchronize read and write access to the data. Refer to Chapter 7 for more information about using event flags for program synchronization.

26.3.4.2 Using Global Sections

To share data by using global sections, each process that plans to access the data includes a common block of the same name, which contains the variables for the data. The first process to reference the data declares the common block as a global section and, optionally, maps data to the section. (Data in global sections, as in private sections, must be page aligned.)

To create a global section, invoke SYSSCRMPSC and add the following:

- Additional argument—Specify the name of the global section (argument 5). A program uses this name to access a global section.
- Additional flag—Set the SECSV_GBL bit of the **flags** argument to indicate that the section is a global section.

As other programs need to reference the data, each can use either SYSSCRMPSC or SYSSMGBLSC to map data into the global section. If you know that the global section exists, the best practice is to use the SYSSMGBLSC system service.

The format for SYSSMGBLSC is as follows:

```
SYSSMGBLSC (inadr ,[retadr] ,[acmode] ,[flags] ,gsdnam ,[ident] ,[relpag])
```

Refer to the *OpenVMS System Services Reference Manual* for complete information about this system service.

In Example 26–1, one image, DEVICE.FOR, passes device names to another image, GETDEVINF.FOR. GETDEVINF.FOR returns the process name and the terminal associated with the process that allocated each device. The two processes use the global section GLOBAL_SEC to communicate. GLOBAL_SEC is mapped to the common block named DATA, which is page aligned by the options file DATA.OPT. Event flags are used to synchronize the exchange of information. UFO_CREATE.FOR, DATA.OPT, and DEVICE.FOR are included here for easy reference. Refer to Section 28.4 for additional information about global sections.

Example 26–1 Interprocess Communication Using Global Sections

```
!UFO_CREATE.FOR
.
.
.
INTEGER FUNCTION UFO_CREATE (FAB,
2                          RAB,
2                          LUN)

! Include RMS definitions
INCLUDE '($FABDEF)'
INCLUDE '($RABDEF)'
```

(continued on next page)

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26.3 Symbols

Example 26–1 (Cont.) Interprocess Communication Using Global Sections

```
! Declare dummy arguments
RECORD /FABDEF/ FAB
RECORD /RABDEF/ RAB
INTEGER LUN

! Declare channel
INTEGER*4 CHAN
COMMON /CHANNEL/ CHAN

! Declare status variable
INTEGER STATUS

! Declare system procedures
INTEGER SYS$CREATE

! Set useropen bit in the FAB options longword
FAB.FAB$L_FOP = FAB.FAB$L_FOP .OR. FAB$M_UFO
! Open file
STATUS = SYS$CREATE (FAB)

! Read channel from FAB status word
CHAN = FAB.FAB$L_STV

! Return status of open operation
UFO_CREATE = STATUS

END
```

DATA.OPT

```
PSECT_ATTR = DATA, PAGE
```

DEVICE.FOR

```
! Define global section flags
INCLUDE '($SECDEF)'
! Mask for section flags
INTEGER SEC_MASK
! Logical unit number for section file
INTEGER INFO_LUN
! Channel number for section file
INTEGER SEC_CHAN
COMMON /CHANNEL/ SEC_CHAN
! Length for the section file
INTEGER SEC_LEN
! Data for the section file
CHARACTER*12 DEVICE,
2          PROCESS
CHARACTER*6  TERMINAL
COMMON /DATA/ DEVICE,
2          PROCESS,
2          TERMINAL
! Location of data
INTEGER PASS_ADDR (2),
2          RET_ADDR (2)
! Two common event flags
INTEGER REQUEST_FLAG,
2          INFO_FLAG
DATA REQUEST_FLAG /70/
DATA INFO_FLAG /71/
```

(continued on next page)

Example 26–1 (Cont.) Interprocess Communication Using Global Sections

```

! User-open routines
INTEGER UFO_CREATE
EXTERNAL UFO_CREATE
.
.
! Open the section file
STATUS = LIB$GET_LUN (INFO_LUN)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
SEC_MASK = SEC$M_WRT .OR. SEC$M_DZRO .OR. SEC$M_GBL
! (last address -- first address + length of last element + 511)/512
SEC_LEN = ( (%LOC(TERMINAL) - %LOC(DEVICE) + 6 + 511)/512 )
OPEN (UNIT=INFO_LUN,
2     FILE='INFO.TMP',
2     STATUS='NEW',
2     INITIALSIZE = SEC_LEN,
2     USEROPEN = UFO_CREATE)
! Free logical unit number and map section
CLOSE (INFO_LUN)
! Get location of data
PASS_ADDR (1) = %LOC (DEVICE)
PASS_ADDR (2) = %LOC (TERMINAL)
STATUS = SYS$CRMPSC (PASS_ADDR,          ! Address of section
2                 RET_ADDR,            ! Addresses mapped
2
2                 ,
2                 %VAL(SEC_MASK), ! Section mask
2                 'GLOBAL_SEC', ! Section name
2
2                 ,,
2                 %VAL(SEC_CHAN), ! I/O channel
2                 ,,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
! Create the subprocess
STATUS = SYS$CREPRC (,
2                 'GETDEVINF', ! Image
2
2                 'GET_DEVICE', ! Process name
2                 %VAL(4),,,) ! Priority
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
! Write data to section
DEVICE = '$FLOPPY1'
! Get common event flag cluster and set flag
STATUS = SYS$ASCEFC (%VAL(REQUEST_FLAG),
2                 'CLUSTER',,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
STATUS = SYS$SETEF (%VAL(REQUEST_FLAG))
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
! When GETDEVINF has the information, INFO_FLAG is set
STATUS = SYS$WAITFR (%VAL(INFO_FLAG))
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
.
.
.

```

(continued on next page)

Shareable Resources

26.3 Symbols

Example 26–1 (Cont.) Interprocess Communication Using Global Sections

GETDEVINF.FOR

```
! Define section flags
INCLUDE '($SECDEF)'
! Mask for section flags
INTEGER SEC_MASK
! Data for the section file
CHARACTER*12 DEVICE,
2          PROCESS
CHARACTER*6  TERMINAL
COMMON /DATA/ DEVICE,
2          PROCESS,
2          TERMINAL
! Location of data
INTEGER PASS_ADDR (2),
2          RET_ADDR (2)
! Two common event flags
INTEGER REQUEST_FLAG,
2          INFO_FLAG
DATA REQUEST_FLAG /70/
DATA INFO_FLAG /71/
.
.
! Get common event flag cluster and wait
! for GBL1.FOR to set REQUEST_FLAG
STATUS = SYS$ASCEFC (%VAL(REQUEST_FLAG),
2          'CLUSTER',,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = SYS$WAITFR (%VAL(REQUEST_FLAG))
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
! Get location of data
PASS_ADDR (1) = %LOC (DEVICE)
PASS_ADDR (2) = %LOC (TERMINAL)
! Set write flag
SEC_MASK = SEC$M_WRT
! Map the section
STATUS = SYS$MGBLSC (PASS_ADDR,          ! Address of section
2          RET_ADDR,          ! Address mapped
2          ,
2          %VAL(SEC_MASK), ! Section mask
2          'GLOBAL_SEC',,) ! Section name
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
! Call GETDVI to get the process ID of the
! process that allocated the device, then
! call GETJPI to get the process name and terminal
! name associated with that process ID.
! Set PROCESS equal to the process name and
! set TERMINAL equal to the terminal name.
.
.
! After information is in GLOBAL_SEC
STATUS = SYS$SETEF (%VAL(INFO_FLAG))
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
END
```

By default, a global section is deleted when no image is mapped to it. Such global sections are called temporary global sections. If you have the PRMGBL privilege, you can create a permanent global section (set the SEC\$V_PERM bit of the **flags** argument when you invoke SYSSCRMPSC). A permanent global section is not deleted until after it is marked for deletion with the SYSSDGBLSC system service (requires PRMGBL). Once a permanent section is marked for deletion, it is like a temporary section; when no image is mapped to it, the section is deleted.

26.3.4.3 Synchronizing Access to Global Sections

On Alpha systems, if more than one process or thread will write to a shared global section containing COMMON block data, the user program may need to synchronize access to COMMON block variables.

On Alpha systems, compile all programs referencing the shared common area with the same value for the /ALIGNMENT and /GRANULARITY qualifiers, as shown in the following:

```
$ F90 /ALIGN=COMMONS=NATURAL /GRANULARITY=LONGWORD INC_COMMON
```

On Alpha systems, using /GRANULARITY=LONGWORD for 4-byte variables or /GRANULARITY=QUADWORD for 8-byte variables ensures that adjacent data is not accidentally effected. To ensure access to 1-byte variables, specify /GRANULARITY=BYTE. Because accessing data items less than four bytes slows run-time performance, you might want to considering synchronizing read and write access to the data on the same node.

One way for programs accessing shared data is to use common event flag clusters to synchronize read and write access to the data on the same node. In the simplest case, one event flag in a common event flag cluster might indicate that a program is writing data, and a second event flag in the cluster might indicate that a program is reading data. Before accessing the shared data, a program must examine the common event flag cluster to ensure that accessing the data does not conflict with an operation already in progress.

Other ways of synchronizing access on a single node include using the following OpenVMS system services:

- The lock manager system services (SYSS\$ENQ and SYSS\$DEQ)
- The hibernate and wake system services (SYSS\$HIBER and SYSS\$WAKE)

You could also use Assembler code for synchronization.

26.3.4.4 RMS Shared Files

RMS allows concurrent access to a file. Shared files can be one of the following formats:

- Indexed files
- Relative files
- Sequential files with 512-byte fixed-length records

To coordinate access to a file, RMS uses the lock manager. You can override the RMS lock manager by controlling access yourself. Refer to Chapter 7 for more information about synchronizing access to resources.

System Time Operations

This chapter describes the types of system time operations performed by the operating system and contains the following sections:

Section 27.1 describes the system time format.

Section 27.2 describes time conversion and date/time manipulation.

Section 27.3 describes how to get the current date and time and set the current time.

Section 27.4 describes how to set and cancel timer requests and how to schedule and cancel wakeups.

Section 27.5 describes using run-time library (RTL) routines to collect timer statistics.

Section 27.6 describes using date/time formatting routines.

Section 27.7 describes the Coordinated Universal Time (UTC) system.

27.1 System Time Format

The operating system maintains the current date and time in 64-bit format. The time value is a binary number in 100-nanosecond (ns) 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 astronomic calendar). Time values must be passed to or returned from system services as the address of a quadword containing the time in 64-bit format. A time value can be expressed as either of the following:

- An absolute time that is a specific date or time of day, or both. Absolute times are always positive values (or 0).
- A delta time that is an offset from the current time to a time or date in the future. Delta times are always expressed as negative values.

If you specify 0 as the address of a time value, the operating system supplies the current date and time.

27.1.1 Absolute Time Format

The operating system uses the following format for absolute time. The full date and time require a character string of 23 characters. The punctuation is required.

dd-*MMM*-*yyyy* hh:mm:ss.cc

<i>dd</i>	Day of the month (2 characters)
<i>MMM</i>	Month (first 3 characters of the month in uppercase)
<i>yyyy</i>	Year (4 characters)

System Time Operations

27.1 System Time Format

<i>hh</i>	Hours of the day in 24-hour format (2 characters)
<i>mm</i>	Minutes (2 characters)
<i>ss.cc</i>	Seconds and hundredths of a second (5 characters)

27.1.2 Delta Time Format

The operating system uses the following format for delta time. The full date and time require a character string of 16 characters. The punctuation is required.

dddd hh:mm:ss.cc

<i>dddd</i>	Day of the month (4 characters)
<i>hh</i>	Hour of the day (2 characters)
<i>mm</i>	Minutes (2 characters)
<i>ss.cc</i>	Seconds and hundredths of a second (5 characters)

A delta time is maintained as an integer value representing an amount of time in 100-ns units.

27.2 Time Conversion and Date/Time Manipulation

This section presents information about time conversion and date/time manipulation features, and the routines available to implement them.

27.2.1 Time Conversion Routines

Since the timer system services require you to specify the time in a 64-bit format, you can use time conversion run-time library and system service routines to work with time in a different format. Run-time library and system services do the following:

- 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

Table 27-1 shows time conversion run-time and system service routines.

System Time Operations

27.2 Time Conversion and Date/Time Manipulation

Table 27–1 Time Conversion Routines and System Services

Routine	Function
Time Conversion Run-Time Library (LIB\$) Routines	
LIB\$CONVERT_DATE_STRING	Converts an input date/time string to an operating system internal time.
LIB\$CVT_FROM_INTERNAL_TIME	Converts an operating system standard internal binary time value to an external integer value. The value is converted according to a selected unit of time operation.
LIB\$CVTF_FROM_INTERNAL_TIME	Converts an operating system standard internal binary time to an external F-floating point value. The value is converted according to a selected unit of time operation.
LIB\$CVT_TO_INTERNAL_TIME	Converts an external integer time value to an operating system standard internal binary time value. The value is converted according to a selected unit of time operation.
LIB\$CVTF_TO_INTERNAL_TIME	Converts an F-floating-point time value to an internal binary time value.
LIB\$CVT_VECTIM	Converts a seven-word array (as returned by the SYSSNUMTIM system service) to an operating system standard format internal time.
LIB\$FORMAT_DATE_TIME	Allows you to select at run time a specific output language and format for a date or time, or both.
LIB\$SYS_ASCTIM	Provides a simplified interface between higher-level languages and the SASCTIM system service.

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System Time Operations

27.2 Time Conversion and Date/Time Manipulation

Table 27–1 (Cont.) Time Conversion Routines and System Services

Routine	Function
Time Conversion System Service Routines	
SYSSASCTIM	Converts an absolute or delta time from 64-bit binary time format to an ASCII string.
SYSSASCUTC	Converts an absolute time from 128-bit Coordinated Universal Time (UTC) format to an ASCII string.
SYSSBINTIM	Converts an ASCII string to an absolute or delta time value in a binary time format.
SYSSBINUTC	Converts an ASCII string to an absolute time value in the 128-bit UTC format.
SYSSFAO	Converts a binary value into an ASCII character string in decimal, hexadecimal, or octal notation and returns the character string in an output string.
SYSSGETUTC	Returns the current time in 128-bit UTC format.
SYSSNUMTIM	Converts an absolute or delta time from 64-bit system time format to binary integer date and time values.
SYSSNUMUTC	Converts an absolute 128-bit binary time into its numeric components. The numeric components are returned in local time.
SYSSTIMCON	Converts 128-bit UTC to 64-bit system format or 64-bit system format to 128-bit UTC based on the value of the convert flag.

You can use the SYSSGETTIM system service to get the current time in internal format, or you can use SYSSBINTIM to convert a formatted time to an internal time, as shown in Section 27.3.2. You can also use the LIB\$DATE_TIME routine to obtain the time, LIB\$CVT_FROM_INTERNAL_TIME to convert an internal time to an external time, and LIB\$CVT_TO_INTERNAL to convert from an external time to an internal time.

27.2.1.1 Calculating and Displaying Time with SYSSGETTIM and LIB\$SUBX

Example 27–1 calculates differences between the current time and a time input in absolute format, and then displays the result as delta time. If the input time is later than the current time, the difference is a negative value (delta time) and can be displayed directly. If the input time is an earlier time, the difference is a positive value (absolute time) and must be converted to delta time before being displayed. To change an absolute time to a delta time, negate the time array by subtracting it from 0 (specified as an integer array) using the LIB\$SUBX routine, which performs subtraction on signed two's complement integers of arbitrary length. For the absolute or delta time format, see Section 27.1.1 and Section 27.1.2.

System Time Operations

27.2 Time Conversion and Date/Time Manipulation

Example 27–1 Calculating and Displaying the Time

```
.
.
! Internal times
! Input time in absolute format, dd-mmm-yyyy hh:mm:ss.ss
!
INTEGER*4 CURRENT_TIME (2),
2      PAST_TIME (2),
2      TIME_DIFFERENCE (2),
2      ZERO (2)
DATA ZERO /0,0/
! Formatted times
CHARACTER*23 PAST_TIME_F
CHARACTER*16 TIME_DIFFERENCE_F
! Status
INTEGER*4 STATUS
! Integer functions
INTEGER*4 SYS$GETTIM,
2      LIB$GET_INPUT,
2      SYS$BINTIM,
2      LIB$SUBX,
2      SYS$ASCTIM
! Get current time
STATUS = SYS$GETTIM (CURRENT_TIME)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Get past time and convert to internal format
STATUS = LIB$GET_INPUT (PAST_TIME_F,
2      'Past time (in absolute format): ')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
STATUS = SYS$BINTIM (PAST_TIME_F,
2      PAST_TIME)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Subtract past time from current time
STATUS = LIB$SUBX (CURRENT_TIME,
2      PAST_TIME,
2      TIME_DIFFERENCE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! If resultant time is in absolute format (positive value means
! most significant bit is not set), convert it to delta time
IF (.NOT. (BTEST (TIME_DIFFERENCE(2),31))) THEN
    STATUS = LIB$SUBX (ZERO,
2      TIME_DIFFERENCE,
2      TIME_DIFFERENCE)
END IF
! Format time difference and display
STATUS = SYS$ASCTIM (, TIME_DIFFERENCE_F,
2      TIME_DIFFERENCE,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
TYPE *, 'Time difference = ', TIME_DIFFERENCE_F
END
```

If you are ignoring the time portion of date/time (that is, working just at the date level), the `LIB$DAY` routine might simplify your calculations. `LIB$DAY` returns to you the number of days from the base system date to a given date.

System Time Operations

27.2 Time Conversion and Date/Time Manipulation

27.2.1.2 Obtaining Absolute Time with SYS\$ASCTIM and SYS\$BINTIM

The Convert Binary Time to ASCII String (SYS\$ASCTIM) system service is the converse of the Convert ASCII String to Binary Time (SYS\$BINTIM) system service. You provide the service with the time in the ASCII format shown in Section 27.3.2. The service then converts the string to a time value in 64-bit format. You can use this returned value as input to a timer scheduling service.

When you specify 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 SYS\$BINTIM service as shown in the following example. The two hyphens that are normally embedded in the date field must be included, and at least one blank must precede the time field.

```
#include <stdio.h>
#include <descrip.h>

/* Buffer to receive binary time */
struct {
    unsigned int buff1, buff2;
}binary_noon;

main() {
    unsigned int status;
    $DESCRIPTOR(ascii_noon,"-- 12:00:00.00"); /* noon (absolute time) */

/* Convert time */
    status = SYS$BINTIM(&ascii_noon,          /* timbuf - ASCII time */
                      &binary_noon);      /* timadr - binary time */
}
```

When the SYS\$BINTIM service completes, a 64-bit time value representing “noon today” is returned in the quadword at BINARY_NOON.

27.2.1.3 Obtaining Delta Time with SYS\$BINTIM

The SYS\$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 following format:

dddd hh:mm:ss.cc

The first field, indicating the number of days, must be specified as 0 if you are specifying a delta time for the current day.

The following example shows how to use the SYS\$BINTIM service to obtain a delta time in system format:

```
#include <stdio.h>
#include <descrip.h>

/* Buffer to receive binary time */
struct {
    unsigned int buff1, buff2;
}btenmin;

main() {
    unsigned int status;
    $DESCRIPTOR(atenmin,"0 00:10:00.00"); /* 10-min delta */

/* Convert time from ASCII to binary */
    status = SYS$BINTIM(&atenmin,          /* timbuf - time in ASCII */
                      &btenmin);        /* timadr - binary time */
}
```

System Time Operations

27.2 Time Conversion and Date/Time Manipulation

If you are programming in VAX MACRO, you can also specify approximate delta time values when you assemble a program, using two MACRO `.LONG` directives to represent a time value in 100-ns units. The arithmetic is based on the following formula:

```
1 second = 10 million * 100 ns
```

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-ns units that can be expressed in a longword. In time values this is slightly more than 7 minutes.

27.2.1.4 Obtaining Numeric and ASCII Time with `SYSS$NUMTIM`

The Convert Binary Time to Numeric Time (`SYSS$NUMTIM`) system service converts a time in the system format into binary integer values. The service returns each of the components of the time (year, month, day, hour, and so on) into a separate word of a 7-word buffer. The `SYSS$NUMTIM` system service and the format of the information returned are described in the *OpenVMS System Services Reference Manual*.

You use the `SYSS$ASCTIM` system service to format the time in ASCII for inclusion in an output string. The `SYSS$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 (`SYSS$FAO`) system service. The `SYSS$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 the *OpenVMS System Services Reference Manual*.

27.2.2 Date/Time Manipulation Routines

The run-time `LIB$` facility provides several date/time manipulation routines. These routines let you add, subtract, and multiply dates and times. Use the `LIB$ADDX` and `LIB$SUBX` routines to add and subtract times, since the times are defined in integer arrays. Use `LIB$ADD_TIMES` and `LIB$SUB_TIMES` to add and subtract two quadword times. When manipulating delta times, remember that they are stored as negative numbers. For example, to add a delta time to an absolute time, you must subtract the delta time from the absolute time. Use `LIB$MULT_DELTA_TIME` and `LIB$MULTF_DELTA_TIME` to multiply delta times by scalar and floating scalar.

Table 27-2 lists all the `LIB$` routines that perform date/time manipulation.

System Time Operations

27.2 Time Conversion and Date/Time Manipulation

Table 27–2 Date/Time Manipulation Routines

Routine	Function
LIB\$ADD_TIMES	Adds two quadword times
LIB\$FORMAT_DATE_TIME	Formats a date and/or time for output
LIB\$FREE_DATE_TIME_CONTEXT	Frees the date/time context
LIB\$GET_MAXIMUM_DATE_LENGTH	Returns the maximum possible length of an output date/time string
LIB\$GET_USERS_LANGUAGE	Returns the user's selected language
LIB\$INIT_DATE_TIME_CONTEXT	Initializes the date/time context with a user-specified format
LIB\$MULT_DELTA_TIME	Multiplies a delta time value by an integer scalar value
LIB\$MULTF_DELTA_TIME	Multiplies a delta time value by an F-floating point scalar value
LIB\$SUB_TIMES	Subtracts two quadword times

27.3 Timer Routines Used to Obtain and Set Current Time

This section presents information about obtaining the current date and time, and setting current time. The run-time library (LIB\$) facility provides date/time utility routines for languages that do not have built-in time and date functions. These routines return information about the current date and time or a date/time specified by the user. You can obtain the current time by using the LIB\$DATE_TIME routine or by implementing the SYSSGETTIM system service. To set the current time, use the SYSSSETTIME system service.

Table 27–3 describes the date/time routines.

Table 27–3 Timer RTLs and System Services

Routine	Function
Timer Run-Time Library (LIB\$) Routines	
LIB\$DATE_TIME	Returns, using a string descriptor, the operating system date and time in the semantics of a string that the user provides.

(continued on next page)

System Time Operations

27.3 Timer Routines Used to Obtain and Set Current Time

Table 27–3 (Cont.) Timer RTLs and System Services

Routine	Function
Timer Run-Time Library (LIB\$) Routines	
LIB\$DAY	Returns the number of days since the system zero date of November 17, 1858. This routine takes one required argument and two optional arguments: <ul style="list-style-type: none"> • The address of a longword to contain the number of days since the system zero date (required) • A quadword passed by reference containing a time in system time format to be used instead of the current system time (optional) • A longword integer to contain the number of 10-millisecond units since midnight (optional)
LIB\$DAY_OF_WEEK	Returns the numeric day of the week for an input time value. If the input time value is 0, the current day of the week is returned. The days are numbered 1 through 7: Monday is day 1 and Sunday is day 7.
System Service Routine	
SYSSSETIME	Changes the value of or recalibrates the system time.

27.3.1 Obtaining Current Time and Date with LIB\$DATE_TIME

The LIB\$DATE_TIME routine returns a character string containing the current date and time in absolute time format. The full string requires a declaration of 23 characters. If you specify a shorter string, the value is truncated. A declaration of 16 characters obtains only the date. The following example displays the current date and time:

```
! Formatted date and time
CHARACTER*23 DATETIME
! Status and library procedures
INTEGER*4 STATUS,
2      LIB$DATE_TIME
EXTERNAL LIB$DATE_TIME
STATUS = LIB$DATE_TIME (DATETIME)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
TYPE *, DATETIME
```

System Time Operations

27.3 Timer Routines Used to Obtain and Set Current Time

27.3.2 Obtaining Current Time and Date with SYSS\$GETTIM

You can obtain the current date and time in internal format with the SYSS\$GETTIM system service. You can convert from internal to character format with the SYSS\$ASCTIM system service or a directive to the SYSS\$FAO system service and convert back to internal format with the SYSS\$BINTIM system service. The Get Time (SYSS\$GETTIM) system service places the time into a quadword buffer. For example:

```
/* Buffer to receive the binary time */
struct {
    unsigned int buff1, buff2;
}time;

.
.
.
main() {
    unsigned status;
```

This call to SYSS\$GETTIM returns the current date and time in system format in the quadword buffer TIME.

The Convert Binary Time to ASCII String (SYSS\$ASCTIM) system service converts a time in system format to an ASCII string and returns the string in a 23-byte buffer. You call the SYSS\$ASCTIM system service as follows:

```
#include <stdio.h>
#include <descrip.h>

struct {
    unsigned int buff1, buff2;
}time_value;

main() {

    unsigned int status;
    char timestr[23];
    $DESCRIPTOR(atimenow, timestr);

/* Get binary time */
    status = SYSS$GETTIM(&time_value);
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

/* Convert binary time to ASCII */
    status = SYSS$ASCTIM(0, /* timlen - Length of ASCII string */
                        &atimenow, /* timbuf - ASCII time buffer */
                        &time_value, /* timadr - Binary time */
                        0); /* cvtflags - Conversion indicator */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

}
```

Because the address of a 64-bit time value is not supplied, the default value, 0, is used.

The string the service returns has the following format:

dd-MMM-yyyy hh:mm:ss.cc

System Time Operations

27.3 Timer Routines Used to Obtain and Set Current Time

<i>dd</i>	Day of the month
<i>MMM</i>	Month (a 3-character alphabetic abbreviation)
<i>yyyy</i>	Year
<i>hh:mm:ss.cc</i>	Time in hours, minutes, seconds, and hundredths of a second

27.3.3 Setting the Current Time with SYS\$SETIME

The Set System Time (SYS\$SETIME) system 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 bootstrapped. Normally you do not need to change the system time between system bootstrap operations; however, in certain circumstances you may want 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. Also, you may want 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 DCL command SET TIME calls the SYS\$SETIME system service.

If a process issues a delta time request and then the system time is changed, the interval remaining for the request does not change; the request executes after the specified time has elapsed. If a process issues an absolute time request and the system time is changed, the request executes at the specified time, relative to the new system time.

The following example shows the effect of changing the system time on an existing timer request. In this example, two set timer requests are scheduled: one is to execute after a delta time of 5 minutes and the other specifies an absolute time of 9:00.

```
#include <stdio.h>
#include <descrip.h>
#include <ssdef.h>
#include <stdlib.h>

void gemini (int x);
unsigned int status;

/* Buffers to receive binary times */
struct {
    unsigned int buff1, buff2;
}abs_binary, delta_binary;

main() {
    $DESCRIPTOR(abs_time,"-- 19:37:00.00");      /* 9 am absolute time */
    $DESCRIPTOR(delta_time,"0 :00:30");          /* 5-min delta time */

    /* Convert ASCII absolute time to binary format */
    status = SYS$BINTIM( &abs_time,             /* ASCII absolute time */
                        &abs_binary);          /* Converted to binary */
```

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27.3 Timer Routines Used to Obtain and Set Current Time

```
if (status == SS$NORMAL)
{
    status = SYS$SETIMR(0,          /* efn - event flag */
                      &abs_binary, /* daytim - expiration time */
                      &gemini,    /* astadr - AST routine */
                      1,          /* reqidt - timer request id */
                      0);        /* flags */
    if (status == SS$NORMAL)
        printf("Setting system timer A\n");
}
else
    LIB$SIGNAL( status );

/* Convert ASCII delta time to binary format */
status = SYS$BINTIM( &delta_time, /* ASCII delta time */
                   &delta_binary); /* Converted to binary */
if (status == SS$NORMAL)
{
    printf("Converting delta time to binary format\n");
    status = SYS$SETIMR(0,          /* efn - event flag */
                      &delta_binary, /* daytim - expiration time */
                      &gemini,    /* astadr - AST routine */
                      2,          /* reqidt - timer request id */
                      0);        /* flags */

    if (status == SS$NORMAL)
        printf("Setting system timer B\n");
    else
        LIB$SIGNAL( status );
}
else
    LIB$SIGNAL( status );

status = SYS$HIBER();
}

void gemini (int reqidt) {
    unsigned short outlen;
    unsigned int cvtflg=1;
    char timenow[12];
    char fao_str[80];
    $DESCRIPTOR(nowdesc, timenow);
    $DESCRIPTOR(fao_in, "Request ID !UB answered at !AS");
    $DESCRIPTOR(fao_out, fao_str);

    /* Returns and converts the current time */
    status = SYS$ASCTIM( 0,          /* timlen - length of ASCII string */
                      &nowdesc,    /* timbuf - receives ASCII string */
                      0,          /* timadr - time value to convert */
                      cvtflg);    /* cvtflg - conversion flags */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

    /* Receives the formatted output string */
    status = SYS$FAO(&fao_in,      /* srcstr - control FAO string */
                   &outlen,      /* outlen - length in bytes */
                   &fao_out,    /* outbuf - output buffer */
                   reqidt,       /* p1 - param needed for 1st FAO dir */
                   &nowdesc);   /* p2 - param needed for 2nd FAO dir */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

    status = LIB$PUT_OUTPUT( &fao_out );
    return;
}
```

System Time Operations

27.3 Timer Routines Used to Obtain and Set Current Time

The following example shows the output received from the preceding program. Assume the program starts execution at 8:45. Seconds later, the system time is set to 9:15. The timer request that specified an absolute time of 9:00 executes immediately, because 9:00 has passed. The request that specified a delta time of 5 minutes times out at 9:20.

```

$ SHOW TIME
  30-DEC-1993 8:45:04.56
$ RUN SCORPIO
<-----+-----+
Request ID number 1 executed at 09:15:00.00 | operator sets system
Request ID number 2 executed at 09:20:00.02 | time to 9:15
$
  
```

27.4 Routines Used for Timer Requests

This section presents information about setting and canceling timer requests, and scheduling and canceling wakeups. Since many applications require the scheduling of program activities based on clock time, the operating system allows an image to schedule events for a specific time of day or after a specified time interval. For example, you can use timer system services to schedule, convert, or cancel events. For example, you can use the timer system services to do the following:

- 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 processed
- Schedule a wakeup request for a hibernating process, or cancel a pending wakeup request that has not yet been processed
- Set or recalibrate the current system time, if the caller has the proper user privileges

Table 27–4 describes system services that set, cancel, and schedule timer requests.

Table 27–4 Timer System Services

Timer System Service Routine	Function
SYSSSETIMR	Sets the timer to expire at a specified time. This service sets a per-thread timer.
SYSSCANTIM	Cancels all or a selected subset of the Set Timer requests previously issued by the current image executing in a process. This service cancels all timers associated with the process.
SYSSSCHDWK	Schedules the awakening (restarting) of a kernel thread that has placed itself in a state of hibernation with the Hibernate (SYSSHIBER) service.
SYSSCANWAK	Removes all scheduled wakeup requests for a process from the timer queue, including those made by the caller or by other processes. The Schedule Wakeup (SSCHDWK) service makes scheduled wakeup requests.

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27.4 Routines Used for Timer Requests

27.4.1 Setting Timer Requests with SYS\$SETIMR

Timer requests made with the Set Timer (SYS\$SETIMR) system service are queued; that is, they are ordered for processing according to their expiration times. The quota for timer queue entries (TQELM quota) controls the number of entries a process can have pending in this timer queue.

When you call the SYS\$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 also passed as the AST parameter to the AST service routine, if one is specified, so that the AST service routine can identify the timer request.

Example 27–2 and Example 27–3 show timer requests using event flags and ASTs, respectively. Event flags, event flag services, and ASTs are described in more detail in Chapter 8.

Example 27–2 Setting an Event Flag

```
#include <stdio.h>
#include <ssdef.h>
#include <descrip.h>

/* Buffer to receive binary time */
struct {
    unsigned int buff1, buff2;
}b30sec;

main() {

    unsigned int efn = 4,status;
    $DESCRIPTOR(a30sec,"0 00:00:30.00");

    /* Convert time to binary format */
    status = SYS$BINTIM( &a30sec, /* timbuf - ASCII time */
                       &b30sec);/* timadr - binary time */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );
    else
        printf("Converting ASCII to binary time...\n");

    /* Set timer to wait */
    status = SYS$SETIMR( efn, /* efn - event flag */
                       &b30sec,/* daytim - binary time */
                       0,      /* astadr - AST routine */
                       0,      /* reqidt - timer request */
                       0);     /* flags */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );
    else
        printf("Request event flag be set in 30 seconds...\n");
```

(continued on next page)

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27.4 Routines Used for Timer Requests

Example 27–2 (Cont.) Setting an Event Flag

```
/* Wait 30 seconds */
status = SYS$WAITFR( efn );
if ((status & 1) != 1)
    LIB$SIGNAL( status );
else
    printf("Timer expires...\n");
}
```

- ❶ The call to `SYS$SETIMR` requests that event flag 4 be set in 30 seconds (expressed in the quadword `B30SEC`).
- ❷ The Wait for Single Event Flag (`SYS$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.

Example 27–3 Specifying an AST Service Routine

```
#include <stdio.h>
#include <descrip.h>
#define NOON 12
struct {
    unsigned int buff1, buff2;
}bnoon;
/* Define the AST routine */
void astserv( int );
main() {
    unsigned int status, reqidt=12;
    $DESCRIPTOR(anoon,"-- 12:00:00.00");
    /* Convert ASCII time to binary */
    status = SYS$BINTIM(&anoon, /* timbuf - ASCII time */ ❶
                       &bnoon); /* timadr - binary time buffer */
    if((status & 1) != 1)
        LIB$SIGNAL( status );
    else
        printf("Converting ASCII to binary...\n");
    /* Set timer */
    status = SYS$SETIMR(0, /* efn - event flag */ ❷
                       &bnoon, /* daytim - timer expiration */
                       &astserv, /* astadr - AST routine */
                       reqidt, /* reqidt - timer request id */
                       0); /* cvtflg - conversion flags */
    if((status & 1) != 1)
        LIB$SIGNAL( status );
    else
        printf("Setting timer expiration...\n");
    status = SYS$HIBER();
}
void astserv( int astprm ) {
```

(continued on next page)

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27.4 Routines Used for Timer Requests

Example 27–3 (Cont.) Specifying an AST Service Routine

```
/* Do something if it's a "noon" request */
   if (astprm == NOON)
       printf("This is a noon AST request\n");
   else
       printf("Handling some other request\n");
   status = SYSSCHDWK(0, /* pidadr - process id */
                     0); /* prcnam - process name */
   return;
}
```

- ❶ The call to SYSSBINTIM converts the ASCII string representing 12:00 noon to format. The value returned in BNOON is used as input to the SYSSSETIMR system service.
- ❷ The AST routine specified in the SYSSSETIMR request will be called when the timer expires, 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 Chapter 8.) 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.
- ❸ This AST service routine checks the parameter passed by the **reqidt** argument to determine 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.

27.4.2 Canceling a Timer Request with SYSSCANTIM

The Cancel Timer Request (SYSSCANTIM) system service cancels timer requests that have not been processed. The SYSSCANTIM system service removes the entries 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 27–3, you would use the following call to SYSSCANTIM:

```
unsigned int status, reqidt=12;
.
.
.
status = SYSSCANTIM( reqidt, 0);
```

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.

27.4.3 Scheduling Wakeups with SYSSWAKE

Example 27–2 shows a process placing itself in a wait state using the SYSSSETIMR and SYSSWAITFR services. A process can also make itself inactive by hibernating. A process hibernates by issuing the Hibernate (SYSSHIBER) system service. Hibernation is reversed by a wakeup request, which can be put into effect immediately with the SYSSWAKE system service or scheduled with the Schedule Wakeup (SYSSSCHDWK) system service. For more information about the SYSSHIBER and SYSSWAKE system services, see Chapter 4.

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27.4 Routines Used for Timer Requests

The following example shows a process scheduling a wakeup for itself prior to hibernating:

```
#include <stdio.h>
#include <descrip.h>

struct {
    unsigned int buff1, buff2;
}btensec;

main() {
    unsigned int status;
    $DESCRIPTOR(atensec,"0 00:00:10.00");

    /* Convert time */
    status = SYS$BINTIM(&atensec, /* timbuf - ASCII time */
                       &btensec);/* timadr - binary time */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

    /* Schedule wakeup */
    status = SYS$SCHDWK(0, /* pidadr - process id */
                       0, /* prcnam - process name */
                       &btensec, /* daytim - wake up time */
                       0); /* reptim - repeat interval */
    if ((status & 1) != 1)
        LIB$SIGNAL( status );

    /* Sleep ten seconds */
    status = SYS$HIBER();
    if ((status & 1) != 1)
        LIB$SIGNAL( status );
}
```

Note that a suitably privileged process can wake or schedule a wakeup request for another process; thus, cooperating processes can synchronize activity using hibernation and scheduled wakeups. Moreover, when you use the SYS\$SCHDWK system service in a program, you can specify that the wakeup request be repeated at fixed time intervals. See Chapter 4 for more information on hibernation and wakeup.

27.4.4 Canceling a Scheduled Wakeup with SYS\$CANWAK

You can cancel scheduled wakeup requests that are pending but have not yet been processed with the Cancel Wakeup (SYS\$CANWAK) system service. This service cancels a wakeup request for a specific kernel thread, if a process ID is specified. If a process name is specified, then the initial thread's wakeup request is canceled.

The following example shows the scheduling of wakeup requests for the process CYGNUS and the subsequent cancellation of the wakeups. The SYS\$SCHDWK system service in this example specifies a delta time of 1 minute and an interval time of 1 minute; the wakeup is repeated every minute until the requests are canceled.

```
#include <stdio.h>
#include <descrip.h>

/* Buffer to hold one minute */
struct {
    unsigned int buff1, buff2;
}interval;

main() {
```

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27.4 Routines Used for Timer Requests

```
    unsigned int status;
    $DESCRIPTOR(one_min,"0 00:01:00.00"); /* One minute delta */
    $DESCRIPTOR(cygnus, "CYGNUS");      /* Process name */

/* Convert time to binary */
    status = SYSS$BINTIM(&one_min, /* timbuf - ASCII delta time */
                       &interval); /* timadr - Buffer to hold binary time */
    if((status & 1) != 1)
        LIB$SIGNAL( status );
    else
        printf("Converting time to binary format...\n");

/* Schedule wakeup */
    status = SYSS$SCHDWK(0, /* pidadr - process id */
                       &cygnus, /* prcnam - process name */
                       &interval, /* daytim - time to be awakened */
                       &interval); /* reptim - repeat interval */
    if((status & 1) != 1)
        LIB$SIGNAL( status );
    }
    else
        printf("Scheduling wakeup...\n");

/* Cancel wakeups */
    status = SYSS$CANWAK(0, /* pidadr - process id */
                       &cygnus); /* prcnam - process name */
}
}
```

27.4.5 Executing a Program at Timed Intervals

To execute a program at timed intervals, you can use either the LIB\$SPAWN routine or the SYSS\$CREPRC system service. With LIB\$SPAWN, you can create a subprocess that executes a command procedure containing three commands: the DCL command WAIT, the command that invokes the desired program, and a GOTO command that directs control back to the WAIT command. To prevent the parent process from remaining in hibernation until the subprocess executes, you should execute the subprocess concurrently; that is, you should specify CLISM_NOWAIT.

For more information about using LIB\$SPAWN and SYSS\$CREPRC, see Chapter 4.

27.5 Routines Used for Timer Statistics

This section presents information about the LIB\$INIT_TIMER, LIB\$SHOW_TIMER, LIB\$STAT_TIMER, and LIB\$FREE_TIMER routines. By calling these run-time library routines, you can collect the following timer statistics from the system:

- Elapsed time—Actual time that has passed since setting a timer
- CPU time—CPU time that has passed since setting a timer
- Buffered I/O—Number of buffered I/O operations that have occurred since setting a timer
- Direct I/O—Number of direct I/O operations that have occurred since setting a timer
- Page faults—Number of page faults that have occurred since setting a timer

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27.5 Routines Used for Timer Statistics

Following are descriptions of each routine:

- **LIB\$INIT_TIMER**—Allocates and initializes space for collecting the statistics. You should specify the **handle-adr** argument as a variable with a value of 0 to ensure the modularity of your program. When you specify the argument, the system collects the information in a specially allocated area in dynamic storage. This prevents conflicts with other timers used by the application.
- **LIB\$SHOW_TIMER**—Obtains one or all of five statistics (elapsed time, CPU time, buffered I/O, direct I/O, and page faults); the statistics are formatted for output. The **handle-adr** argument must be the same value as specified for **LIB\$INIT_TIMER** (do not modify this variable). Specify the **code** argument to obtain one particular statistic rather than all the statistics.

You can let the system write the statistics to **SYSS\$OUTPUT** (the default), or you can process the statistics with your own routine. To process the statistics yourself, specify the name of your routine in the **action-rtn** argument. You can pass one argument to your routine by naming it in the **user-arg** argument. If you use your own routine, it must be written as an integer function and return an error code (return a value of 1 for success). This error code becomes the error code returned by **LIB\$SHOW_TIMER**. Two arguments are passed to your routine: the first is a passed-length character string containing the formatted statistics, and the second is the value of the fourth argument (if any) specified to **LIB\$SHOW_TIMER**.
- **LIB\$STAT_TIMER**—Obtains one of five unformatted statistics. Specify the statistic you want in the **code** argument. Specify a storage area for the statistic in **value**. The **handle-adr** argument must be the same value as you specified for **LIB\$INIT_TIMER**.
- **LIB\$FREE_TIMER**—Ensures the modularity of your program. Invoke this procedure when you are done with the timer. The value in the **handle-adr** argument must be the same as that specified for **LIB\$INIT_TIMER**.

You must invoke **LIB\$INIT_TIMER** to allocate storage for the timer. You should invoke **LIB\$FREE_TIMER** before you exit from your program unit. In between, you can invoke **LIB\$SHOW_TIMER** or **LIB\$STAT_TIMER**, or both, as often as you want. Example 27–4 invokes **LIB\$SHOW_TIMER** and uses a user-written subprogram either to display the statistics or to write them to a file.

Example 27–4 Displaying and Writing Timer Statistics

```
.
.
.
! Timer arguments
INTEGER*4 TIMER_ADDR,
2      TIMER_DATA,
2      TIMER_ROUTINE
EXTERNAL TIMER_ROUTINE
! Declare library procedures as functions
INTEGER*4 LIB$INIT_TIMER,
2      LIB$SHOW_TIMER
EXTERNAL LIB$INIT_TIMER,
2      LIB$SHOW_TIMER
```

(continued on next page)

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27.5 Routines Used for Timer Statistics

Example 27–4 (Cont.) Displaying and Writing Timer Statistics

```
! Work variables
CHARACTER*5 REQUEST
INTEGER*4 STATUS
! User request - either WRITE or FILE
INTEGER*4 WRITE,
2 FILE
PARAMETER (WRITE = 1,
2 FILE = 2)
! Get user request
WRITE (UNIT=*, FMT='($,A)') ' Request: '
ACCEPT *, REQUEST
IF (REQUEST .EQ. 'WRITE') TIMER_DATA = WRITE
IF (REQUEST .EQ. 'FILE') TIMER_DATA = FILE
! Set timer
STATUS = LIB$INIT_TIMER (TIMER_ADDR)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
! Get statistics
STATUS = LIB$SHOW_TIMER (TIMER_ADDR,,
2 TIMER_ROUTINE,
2 TIMER_DATA)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
! Free timer
STATUS = LIB$FREE_TIMER (TIMER_ADDR)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
.
.
INTEGER FUNCTION TIMER_ROUTINE (STATS,
2 TIMER_DATA)
! Dummy arguments
CHARACTER*(*) STATS
INTEGER TIMER_DATA
! Logical unit number for file
INTEGER STATS_FILE
! User request
INTEGER WRITE,
2 FILE
PARAMETER (WRITE = 1,
2 FILE = 2)
! Return code
INTEGER SUCCESS,
2 FAILURE
PARAMETER (SUCCESS = 1,
2 FAILURE = 0)
```

(continued on next page)

Example 27–4 (Cont.) Displaying and Writing Timer Statistics

```
! Set return status to success
TIMER_ROUTINE = SUCCESS
! Write statistics or file them in STATS.DAT
IF (TIMER_DATA .EQ. WRITE) THEN
  TYPE *, STATS
ELSE IF (TIMER_DATA .EQ. FILE) THEN
  CALL LIB$GET_LUN (STATS_FILE)
  OPEN (UNIT=STATS_FILE,
2     FILE='STATS.DAT')
  WRITE (UNIT=STATS_FILE,
2     FMT='(A)') STATS
ELSE
  TIMER_ROUTINE = FAILURE
END IF
END
```

You can use the SYSSGETSYI system service to obtain more detailed system information about boot time, the cluster, processor type, emulated instructions, nodes, paging files, swapping files, and hardware and software versions. With SYSSGETQUI and LIB\$GETQUI, you can obtain queue information.

27.6 Date/Time Formatting Routines

This section provides information about using date/time formatting routines that allow you to specify input and output formats other than the standard operating system format for dates and times. These include international formats with appropriate language spellings for days and months.

If the desired language is English (the default language) and the desired format is the standard operating system format, then initialization of logical names is not required in order to use the date/time input and output routines. However, if the desired language and format are not the defaults, the system manager (or any user having CMEXEC, SYSNAM, and SYSPRV privileges) must initialize the required logical names.

27.6.1 Performing Date/Time Logical Initialization

Note

You must complete the initialization steps outlined in this section before you can use any of the date/time input and output routines with languages and formats other than the defaults.

As an alternative to the standard operating system format, the command procedure SYSSMANAGER:LIB\$DT_STARTUP.COM defines several output formats for dates and times. This command procedure must be executed by the system manager before using any of the run-time library date/time routines for input or output formats other than the default. Ideally, this command procedure should be executed from a site-specific startup procedure.

In addition to defining the date/time formats, the LIB\$DT_STARTUP.COM command procedure also defines spellings for date and time elements in languages other than English. If different language spellings are required, the system manager must define the logical name SYSSLANGUAGES before

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27.6 Date/Time Formatting Routines

invoking LIB\$DT_STARTUP.COM. The translation of SYSSLANGUAGES is then used to select which languages are defined.

Table 27–5 shows the available languages and their logical names.

Table 27–5 Available Languages for Date/Time Formatting

Language	Logical Name
Austrian	AUSTRIAN
Danish	DANISH
Dutch	DUTCH
Finnish	FINNISH
French	FRENCH
French Canadian	CANADIAN
German	GERMAN
Hebrew	HEBREW
Italian	ITALIAN
Norwegian	NORWEGIAN
Portuguese	PORTUGUESE
Spanish	SPANISH
Swedish	SWEDISH
Swiss French	SWISS_FRENCH
Swiss German	SWISS_GERMAN

For example, if the system managers want the spellings for French, German, and Italian languages to be defined, they must define SYSSLANGUAGES as shown, prior to invoking LIB\$DT_STARTUP.COM:

```
$ DEFINE SYSSLANGUAGES FRENCH, GERMAN, ITALIAN
```

If the user requires an additional language, for example FINNISH, then the system manager must add FINNISH to the definition of SYSSLANGUAGES and reexecute the command procedure.

Date/Time Manipulation Option

The Date/Time Manipulation option provides date/time spelling support for four new languages. Users or application programmers can select the desired language by defining the logical name SYSSLANGUAGES. The new languages and their equivalent names are as follows:

Language	Equivalent Name
Chinese (simplified character)	Hanzi
Chinese (traditional character)	Hanyu
Korean	Hangul
Thai	Thai

Defining Date/Time Spelling

To define the spelling for Hanzi and Hanyu, define SYSSLANGUAGES as shown below, prior to invoking LIB\$DT_STARTUP.COM:

```
$ DEFINE SYSSLANGUAGES HANZI, HANYU
$ @SYSS$MANAGER:LIB$DT_STARTUP
```

Predefined Output Formats

Figure 27–1 lists the new predefined date format logical names in the first column, their formats in the second column, and examples of the output generated using these formats in the third column.

Figure 27–1 Predefined Output Date Formats

LIB\$DATE_FORMAT_042	!Y4年!MNB月!DB日 !WAU	1994年3月7日 (一)
LIB\$DATE_FORMAT_043	!Y4年!MNB月!DB日 !WU	1994年3月7日 星期一
LIB\$DATE_FORMAT_044	!Y4年!MNB月!DB日 !WAU	1994年3月7日 (一)
LIB\$DATE_FORMAT_045	!Y4年!MNB月!DB日 !WU	1994年3月7日 星期一
LIB\$DATE_FORMAT_046	!Y4年!MNB月!DB日 !WAU	1994年3月7日 (一)
LIB\$DATE_FORMAT_047	!Y4年!MNB月!DB日 !WU	1994年3月7日 星期一

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Note

LIB\$DATE_FORMAT_042 and LIB\$DATE_FORMAT_043 support the DEC Hanzi coded character set.

LIB\$DATE_FORMAT_044 and LIB\$DATE_FORMAT_045 support the DEC Hanyu coded character set.

LIB\$DATE_FORMAT_046 and LIB\$DATE_FORMAT_047 support the DEC Hangul coded character set.

Figure 27–2 lists the new predefined time format logical names in the first column, their formats in the second column, and examples of the output generated using these formats in the third column.

Figure 27–2 Predefined Output Time Formats

LIB\$TIME_FORMAT_021	!MIU!HB2时!MB分!SB秒	上午3时3分6秒
LIB\$TIME_FORMAT_022	!MIU!HB2时!MB分!SB秒	上午3时3分6秒
LIB\$TIME_FORMAT_023	!MIU !HB2 시 !MB 분 !SB 초	오전 3 시 3 분 6 초

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27.6 Date/Time Formatting Routines

Note

LIB\$TIME_FORMAT_021 supports the DEC Hanzi coded character set.
LIB\$TIME_FORMAT_022 supports the DEC Hanyu coded character set.
LIB\$TIME_FORMAT_023 supports the DEC Hangul coded character set.

Thus, to select a particular format for a date or time, or both, you can define the LIB\$DT_FORMAT logical name using the following logicals:

- LIB\$DATE_FORMAT_*nnn*, where *nnn* can range from 001 to 047
- LIB\$TIME_FORMAT_*nnn*, where *nnn* can range from 001 to 023

27.6.2 Selecting a Format

There are two methods by which date/time input and output formats can be selected:

- The language and format are determined at run time through the translation of the logical names SYSSLANGUAGE, LIB\$DT_FORMAT, and LIB\$DT_INPUT_FORMAT.
- The language and format are programmable at compile time through the use of the LIB\$INIT_DATE_TIME_CONTEXT routine.

In general, if an application accepts text from a user or formats text for presentation to a user, you should use the logical name method of specifying language and format. With this method, the user assigns equivalence names to the logical names SYSSLANGUAGE, LIB\$DT_FORMAT, and LIB\$DT_INPUT_FORMAT, thereby selecting the language and input or output format of the date and time at run time.

If an application reads text from internal storage or formats text for internal storage or transmission, the language and format should be specified at compile time. If this is the case, the routine LIB\$INIT_DATE_TIME_CONTEXT specifies the language and format of choice.

27.6.2.1 Formatting Run-Time Mnemonics

The format mnemonics listed in Table 27–6 define both input and output formats at run time.

Table 27–6 Format Mnemonics

Date	Explanation
!D0	Day; zero-filled
!DD	Day; no fill
!DB	Day; blank-filled
!WU	Weekday; uppercase
!WAU	Weekday; abbreviated, uppercase
!WC	Weekday; capitalized

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27.6 Date/Time Formatting Routines

Table 27–6 (Cont.) Format Mnemonics

Date	Explanation
!WAC	Weekday; abbreviated, capitalized
!WL	Weekday; lowercase
!WAL	Weekday; abbreviated, lowercase
!MAU	Month; alphabetic, uppercase
!MAAU	Month; alphabetic, abbreviated, uppercase
!MAC	Month; alphabetic, capitalized
!MAAC	Month; alphabetic, abbreviated, capitalized
!MAL	Month; alphabetic, lowercase
!MAAL	Month; alphabetic, abbreviated, lowercase
!MN0	Month; numeric, zero-filled
!MNM	Month; numeric, no fill
!MNB	Month; numeric, blank-filled
!Y4	Year; 4 digits
!Y3	Year; 3 digits
!Y2	Year; 2 digits
!Y1	Year; 1 digit
!Z4	Year; 4 digits
!Z3	Year; 3 digits
!Z2	Year; 2 digits (see LIB\$CONVERT_DATE_STRING)
!Z1	Year; 1 digit
Time	Explanation
!H04	Hours; zero-filled, 24-hour clock
!HH4	Hours; no fill, 24-hour clock
!HB4	Hours; blank-filled, 24-hour clock
!H02	Hours; zero-filled, 12-hour clock
!HH2	Hours; no fill, 12-hour clock
!HB2	Hours; blank-filled, 12-hour clock
!M0	Minutes; zero-filled
!MM	Minutes; no fill
!MB	Minutes; blank-filled
!S0	Seconds; zero-filled
!SS	Seconds; no fill
!SB	Seconds; blank-filled
!C7	Fractional seconds; 7 digits
!C6	Fractional seconds; 6 digits
!C5	Fractional seconds; 5 digits
!C4	Fractional seconds; 4 digits

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27.6 Date/Time Formatting Routines

Table 27–6 (Cont.) Format Mnemonics

Time	Explanation
!C3	Fractional seconds; 3 digits
!C2	Fractional seconds; 2 digits
!C1	Fractional seconds; 1 digit
!MIU	Meridiem indicator; uppercase
!MIC	Meridiem indicator; capitalized (mixed case)
!MIL	Meridiem indicator; lowercase

27.6.2.2 Specifying Formats at Run Time

If an application accepts text from a user or formats text for presentation to a user, you should use the logical name method of specifying language and format. With this method, the user assigns equivalence names to the logical names `SYSSLANGUAGE`, `LIB$DT_FORMAT`, and `LIB$DT_INPUT_FORMAT`, thereby selecting the language and format of the date and time at run time. `LIB$DT_INPUT_FORMAT` must be defined using the mnemonics listed in Table 27–6. The possible choices for `SYSSLANGUAGE` and `LIB$DT_FORMAT` are defined in the `SYSSMANAGER:LIB$DT_STARTUP.COM` command procedure that is executed by the system manager before using these routines.

The following actions occur when any translation of a logical name fails:

- If the translation of `SYSSLANGUAGE` or any logical name relating to text fails, then English is used and a status of `LIB$_ENGLUSED` is returned.
- If the translation of `LIB$DT_FORMAT`, `LIB$DT_INPUT_FORMAT`, or any logical name relating to format fails, the operating system standard (`SYSSASCTIM`) representation of the date and time is used, that is, *dd-`MMM-yyy` hh:mm:ss.cc*, and a status of `LIB$_DEFFORUSE` is returned.

Since English is the default language and must therefore always be available, English spellings are not taken from logical name translations, but rather are looked up in an internal table.

27.6.2.3 Specifying Input Formats at Run Time

Using the logical name `LIB$DT_INPUT_FORMAT`, you can define your own input format at run time using the mnemonics listed in Table 27–6. Once an input format is defined, any dates or times that are input to the application are parsed against this format. For example:

```
$ DEFINE LIB$DT_INPUT_FORMAT -
_ $ "!MAU !DD, !Y4 !H02:!M0:!S0:!C2 !MIU"
```

A valid input date string would be as follows:

```
JUNE 15, 1993 08:45:06:50 PM
```

If the user has selected a language other than English, then the translation of `SYSSLANGUAGE` is used by the parser to recognize alphabetic months and meridiem indicators in the selected language.

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27.6 Date/Time Formatting Routines

Input Format String

The input format string used to define the input date/time format must contain at least the first seven of the following eight fields:

- Month (either alphabetic or numeric)
- Day of the month (numeric)
- Year (from 1 to 4 digits)
- Hour (12- or 24-hour clock)
- Minute of the hour
- Second of the minute
- Fractional seconds
- Meridiem indicator (required for 12-hour clock; illegal for 24-hour clock)

If the input format string specifies a 24-hour clock, the string contains only the first seven fields in the preceding list. If a 12-hour clock is specified, the eighth field (the meridiem indicator) is required.

The format string fields must appear in two groups: one for date and one for time (date and time fields cannot be intermixed within a group). For the input format, alphabetic case distinctions and abbreviation-specific codes have no significance. For example, the following format string specifies that the month name will be uppercase and spelled out in full:

```
!MAU !DD, !Y4 !H02:!M0:!S0:!C2 !MIU
```

If the input string corresponding to this format string contains a month name that is abbreviated and lowercase, the parse of the input string still works correctly. For example:

```
feb 25, 1988 04:39:02:55 am
```

If this input string is entered, the parse still recognizes “feb” as the month name and “am” as the meridiem indicator, even though the format string specified both of these fields as uppercase, and the month name as unabbreviated.

Punctuation in the Format and Input Strings

One important aspect to consider when formatting date/time input strings is punctuation. The punctuation referred to here is the characters that separate the various date/time fields or the date and time groups. Punctuation in these strings is important because it is used as an outline for the parser, allowing the parser to synchronize the input fields to the format fields.

There are three distinct classes of punctuation:

- None
Although it is common for no punctuation to begin or end an input format string, you can specify a date/time format that also has no punctuation between the fields or groups of the format string. If this is the case, the corresponding input string must not have any punctuation between the respective fields or groups, although white space (see the next item in this list) may appear at the beginning or end of the input string.

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- **White space**
White space includes any combination of spaces and tabs. In the interpretation of the format string, any white space is condensed to a single space. When parsing an input string, white space is generally noted as synchronizing punctuation and is skipped; however, white space is significant in some situations, such as with blank-filled numbers.
- **Explicit**
Explicit punctuation refers to any string of one or more characters that is used as punctuation and is not solely comprised of white space. Any white space appearing within an explicit punctuation string is interpreted literally; in other words, the white space is not compressed. In the format string, you can use explicit punctuation to denote a particular format and to guide the parser in parsing the input string. In the input string, you can use explicit punctuation to synchronize the parse of the input string against the format string. The explicit punctuation used should not be a subset of the valid input of any field that it precedes or follows it.

Punctuation is especially important in providing guidelines for the parser to translate the input date/time string properly.

Default Date/Time Fields

Punctuation in a date/time string is also useful for specifying which fields you want to omit in order to accept the default values. That is, you can control the parsing of the input string by supplying punctuation without the appropriate field values. If only the punctuation is supplied and a user-supplied default is not specified, the value of the omitted field defaults according to the following rules:

- For the date group, the default is the current date.
- For the time group, the default is 00:00:00.00.

Table 27–7 gives some examples of input strings (using punctuation to indicate defaulted fields) and their full translations (assuming a current date of 25-FEB-1993 and using the default input format).

Table 27–7 Input String Punctuation and Defaults

Input	Full Date/Time Input String
31	31-FEB-1993 00:00:00.00
-MAR	25-MAR-1993 00:00:00.00
-SEPTEMBER	25-SEP-1993 00:00:00.00
-1993	25-FEB-1993 00:00:00.00
23:	25-FEB-1993 23:00:00.00
:45:	25-FEB-1993 00:45:00.00
::23	25-FEB-1993 00:00:23.00
.01	25-FEB-1993 00:00:00.01

Note on the Changing Century

Because the default is the current date for the date group, if you specify a value of 00 with the !Y2 format, the year is interpreted as 1900. After January 1, 2000, the value 00 will be interpreted as 2000.

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For example, 02/29/00 is interpreted as 29-FEB-1900, which results in LIB\$INVTIME because 1900 is not a leap year. After the turn of the century (the year 2000), 02/29/00 will be 29-FEB-2000, which is a valid date because 2000 is a leap year.

27.6.2.4 Specifying Output Formats at Run Time

If the logical name method is used to specify an output format at run time, the translations of the logical names SYSSLANGUAGE and LIB\$DT_FORMAT specify one or more executive mode logical names which in turn must be translated to determine the actual format string. These additional logical names supply such things as the names of the days of the week and the months in the selected language (as determined by SYSSLANGUAGE). All of these logicals are predefined, so that a nonprivileged user can select any one of these languages and formats. In addition, a user can create his or her own languages and formats; however, the CMEXEC, SYSNAM and SYSPRV privileges are required.

To select a particular format for a date or time, or both, you must define the LIB\$DT_FORMAT logical name using the following:

- LIB\$DATE_FORMAT_ *nnn*, where *nnn* ranges from 001 to 040
- LIB\$TIME_FORMAT_ *nnn*, where *nnn* ranges from 001 to 020

The order in which these logical names appear in the definition of LIB\$DT_FORMAT determines the order in which they are output. A single space is inserted into the output string between the two elements, if the definition specifies that both are output. For example:

```
$ DEFINE LIB$DT_FORMAT LIB$DATE_FORMAT_006, LIB$TIME_FORMAT_012
```

This definition causes the date to be output in the specified format, followed by a space and the time in the specified format, as follows:

```
13 JAN 93 9:13 AM
```

Table 27–8 lists all predefined date format logical names, their formats, and examples of the output generated using those formats. (The mnemonics used to specify the formats are listed in Table 27–6.)

Table 27–8 Predefined Output Date Formats

Date Format Logical Name	Format	Example
LIB\$DATE_FORMAT_001	!DB-!MAAU-!Y4	13-JAN-1993
LIB\$DATE_FORMAT_002	!DB !MAU !Y4	13 JANUARY 1993
LIB\$DATE_FORMAT_003	!DB.!MAU !Y4	13.JANUARY 1993
LIB\$DATE_FORMAT_004	!DB.!MAU.!Y4	13.JANUARY.1993
LIB\$DATE_FORMAT_005	!DB !MAU !Y2	13 JANUARY 93
LIB\$DATE_FORMAT_006	!DB !MAAU !Y2	13 JAN 93
LIB\$DATE_FORMAT_007	!DB.!MAAU !Y2	13.JAN 93
LIB\$DATE_FORMAT_008	!DB.!MAAU.!Y2	13.JAN.93
LIB\$DATE_FORMAT_009	!DB !MAAU !Y4	13 JAN 1993
LIB\$DATE_FORMAT_010	!DB.!MAAU !Y4	13.JAN 1993

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Table 27–8 (Cont.) Predefined Output Date Formats

Date Format Logical Name	Format	Example
LIB\$DATE_FORMAT_011	!DB.!MAAU.!Y4	13.JAN.1993
LIB\$DATE_FORMAT_012	!MAU !DD, !Y4	JANUARY 13, 1993
LIB\$DATE_FORMAT_013	!MN0!/D0!/Y2	01/13/93
LIB\$DATE_FORMAT_014	!MN0-!D0-!Y2	01-13-93
LIB\$DATE_FORMAT_015	!MN0.!D0.!Y2	01.13.93
LIB\$DATE_FORMAT_016	!MN0 !D0 !Y2	01 13 93
LIB\$DATE_FORMAT_017	!D0!/MN0!/Y2	13/01/93
LIB\$DATE_FORMAT_018	!D0!/MN0-!Y2	13/01-93
LIB\$DATE_FORMAT_019	!D0-!MN0-!Y2	13-01-93
LIB\$DATE_FORMAT_020	!D0.!MN0.!Y2	13.01.93
LIB\$DATE_FORMAT_021	!D0 !MN0 !Y2	13 01 93
LIB\$DATE_FORMAT_022	!Y2!/MN0!/D0	93/01/13
LIB\$DATE_FORMAT_023	!Y2-!MN0-!D0	93-01-13
LIB\$DATE_FORMAT_024	!Y2.!MN0.!D0	93.01.13
LIB\$DATE_FORMAT_025	!Y2 !MN0 !D0	93 01 13
LIB\$DATE_FORMAT_026	!Y2!MN0!D0	930113
LIB\$DATE_FORMAT_027	/!Y2.!MN0.!D0	/93.01.13
LIB\$DATE_FORMAT_028	!MN0!/D0!/Y4	01/13/1993
LIB\$DATE_FORMAT_029	!MN0-!D0-!Y4	01-13-1993
LIB\$DATE_FORMAT_030	!MN0.!D0.!Y4	01.13.1993
LIB\$DATE_FORMAT_031	!MN0 !D0 !Y4	01 13 1993
LIB\$DATE_FORMAT_032	!D0!/MN0!/Y4	13/01/1993
LIB\$DATE_FORMAT_033	!D0-!MN0-!Y4	13-01-1993
LIB\$DATE_FORMAT_034	!D0.!MN0.!Y4	13.01.1993
LIB\$DATE_FORMAT_035	!D0 !MN0 !Y4	13 01 1993
LIB\$DATE_FORMAT_036	!Y4!/MN0!/D0	1993/01/13
LIB\$DATE_FORMAT_037	!Y4-!MN0-!D0	1993-01-13
LIB\$DATE_FORMAT_038	!Y4.!MN0.!D0	1993.01.13
LIB\$DATE_FORMAT_039	!Y4 !MN0 !D0	1993 01 13
LIB\$DATE_FORMAT_040	!Y4!MN0!D0	19930113

Table 27–9 lists all predefined time format logical names, their formats, and examples of the output generated using those formats.

Table 27–9 Predefined Output Time Formats

Time Format Logical	Format	Example
LIB\$TIME_FORMAT_001	!H04:!M0:!S0.!C2	09:13:25.14
LIB\$TIME_FORMAT_002	!H04:!M0:!S0	09:13:25

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27.6 Date/Time Formatting Routines

Table 27–9 (Cont.) Predefined Output Time Formats

Time Format Logical	Format	Example
LIB\$TIME_FORMAT_003	!H04.!M0.!S0	09.13.25
LIB\$TIME_FORMAT_004	!H04 !M0 !S0	09 13 25
LIB\$TIME_FORMAT_005	!H04:!M0	09:13
LIB\$TIME_FORMAT_006	!H04.!M0	09.13
LIB\$TIME_FORMAT_007	!H04 !M0	09 13
LIB\$TIME_FORMAT_008	!HH4:!M0	9:13
LIB\$TIME_FORMAT_009	!HH4.!M0	9.13
LIB\$TIME_FORMAT_010	!HH4 !M0	9 13
LIB\$TIME_FORMAT_011	!H02:!M0 !MIU	09:13 AM
LIB\$TIME_FORMAT_012	!HH2:!M0 !MIU	9:13 AM
LIB\$TIME_FORMAT_013	!H04!M0	0913
LIB\$TIME_FORMAT_014	!H04H!M0m	09H13m
LIB\$TIME_FORMAT_015	kl !H04.!M0	kl 09.13
LIB\$TIME_FORMAT_016	!H04H!M0'	09H13'
LIB\$TIME_FORMAT_017	!H04.!M0 h	09.13 h
LIB\$TIME_FORMAT_018	h !H04.!M0	h 09.13
LIB\$TIME_FORMAT_019	!HH4 h !MM	9 h 13
LIB\$TIME_FORMAT_020	!HH4 h !MM min !SS s	9 h 13 min 25 s

27.6.2.5 Specifying Formats at Compile Time

If an application reads text from internal storage or formats text for internal storage or transmission, you should specify the language and format at compile time. The routine LIB\$INIT_DATE_TIME_CONTEXT allows the user to specify the language and format at compile time by initializing the context area used by LIB\$FORMAT_DATE_TIME for output or LIB\$CONVERT_DATE_STRING for input with specific strings, instead of through logical name translations. Note that when the text will be parsed by another program, LIB\$INIT_DATE_TIME_CONTEXT expects all required context information (including spellings) to be specified. For applications where the context specifies a user's preferred format style, the spellings can be looked up from the logical name tables.

Only one context component can be initialized per call to LIB\$INIT_DATE_TIME_CONTEXT. Table 27–10 lists the available components and their number of elements. (_ABB indicates an abbreviated version of the month and weekday names.)

Table 27–10 Available Components for Specifying Formats at Compile Time

Available Component	Number of Elements
LIB\$K_MONTH_NAME	12
LIB\$K_MONTH_NAME_ABB	12
LIB\$K_FORMAT_MNEMONICS	9

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Table 27–10 (Cont.) Available Components for Specifying Formats at Compile Time

Available Component	Number of Elements
LIBSK_WEEKDAY_NAME	7
LIBSK_WEEKDAY_NAME_ABB	7
LIBSK_RELATIVE_DAY_NAME	3
LIBSK_MERIDIEM_INDICATOR	2
LIBSK_OUTPUT_FORMAT	2
LIBSK_INPUT_FORMAT	1
LIBSK_LANGUAGE	1

To specify the actual values for these elements, you must use an initialization string in the following format:

```
"[delim][string-1][delim][string-2][delim]...[delim][string-n][delim]"
```

In this format, [-] is a delimiting character that is not in any of the strings, and [*string-n*] is the spelling of the *n*th instance of the component.

For example, a string passed to this routine to specify the English spellings of the abbreviated month names might be as follows:

```
" |JAN|FEB|MAR|APR|MAY|JUN|
  |JUL|AUG|SEP|OCT|NOV|DEC| "
```

The string must contain the exact number of elements for the associated component; otherwise the error LIBS_NUMELEMENTS is returned. Note that the string begins and ends with a delimiter. Thus, there is one more delimiter than the number of string elements in the initialization string.

27.6.2.6 Specifying Input Format Mnemonics at Compile Time

To specify the input format mnemonics at compile time, the user must initialize the component LIBSK_FORMAT_MNEMONICS with the appropriate values. Table 27–11 lists the nine fields that must be initialized, in the appropriate order, along with their default (English) values.

Table 27–11 Legible Format Mnemonics

Order	Format Field	Legible Mnemonic (Default)
1	Year	YYYY
2	Numeric month	MM
3	Numeric day	DD
4	Hours (12- or 24-hour)	HH
5	Minutes	MM
6	Seconds	SS
7	Fractional seconds	CC
8	Meridiem indicator	AM/PM
9	Alphabetic month	MONTH

For example, the following is a valid definition of the component LIBSK_FORMAT_MNEMONICS, using English as the natural language:

```
|YYYY|MM|DD|HH|MM|SS|CC|AM/PM|MONTH|
```

If the user were entering the same string using Austrian as the natural language, the definition of the component LIB\$K_FORMAT_MNEMONICS would be as follows:

```
|JJJJ|MM|TT|SS|MM|SS|HH| |MONAT|
```

27.6.2.7 Specifying Output Formats at Compile Time

To specify an output format at compile time, the user must preinitialize the component LIB\$K_OUTPUT_FORMAT. Two elements are associated with this output format string. One describes the date format fields, the other the time format fields. The order in which they appear in the string determines the order in which they are output. A single space is inserted into the output stream between the two elements, if the call to LIB\$FORMAT_DATE_TIME specifies that both be output. For example:

```
" |!DB!MAAU!Y4 |!H04!M0!S0!C2 |"
```

(These mnemonics are listed in Table 27–6.) This format string represents the format used by the \$ASCTIM system service for outputting times. Note that the middle delimiter is replaced by a space in the resultant output.

```
13-JAN-1993 14:54:09:24
```

27.6.3 Converting with the LIB\$CONVERT_DATE_STRING Routine

The LIB\$CONVERT_DATE_STRING routine converts an absolute date/time string into an operating system internal format date/time quadword. You can optionally specify which fields of the input string can be defaulted (using the **input-flags** argument), and what the default values should be (using the **defaults** argument). By default, the time fields can be defaulted but the date fields cannot. Table 27–7 gives some examples of these default values.

You can use the optional **defaulted-fields** argument to LIB\$CONVERT_DATE_STRING to determine which input fields were defaulted. That is, the **defaulted-fields** argument is a bit mask in which each set bit indicates that the corresponding field was defaulted in the input date/time string.

If you want to use LIB\$CONVERT_DATE_STRING to return the current time as well as the current date, you can call the \$NUMTIM system service and pass the **timbuf** argument, which contains the current date and time, to LIB\$CONVERT_DATE_STRING as the **defaults** argument. This tells the LIB\$CONVERT_DATE_STRING routine to take the default values for the date and time fields from the 7-word array returned by \$NUMTIM.

LIB\$CONVERT_DATE_STRING specifies 2-digit years from input by selecting the current century as the default for the century portion of the date. This is true when the !Y2 format is used. This selection may not be desirable for you since 00 would be interpreted as 1900 (and as 2000 on 1/1/2000).

A new format has been added so that you can select a new behavior for LIB\$CONVERT_DATE_STRING. You can use the Z format in every place the Y format is used to represent years. The Z format acts exactly like the Y format except for !Z2. Using !Z2 causes LIB\$CONVERT_DATE_STRING to interpret a 2-digit year of 99 as 1999 and a 2-digit year of 01 as 2001. The transition year is on a sliding scale determined by the current year minus 43. So if the current year is 1999, the transition year is 56. A 2-digit year greater or equal to this has a century of 1900 and a 2-digit year less than this has a century of 2000. Thus, the year 60 would be 1960 and the year 50 would be 2050. You can use the

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!Z2 format either in the logical LIB\$DT_INPUT_FORMAT, or in the **init-string** parameter for a call to LIB\$INIT_DATE_TIME_CONTEXT to establish the input format for LIB\$CONVERT_DATE_STRING. Below is a list of the new Z formats:

Date	Explanation
!Z4	Year; 4 digits
!Z3	Year; 3 digits
!Z2	Year; 2 digits (New behavior for the LIB\$CONVERT_DATE_STRING routine)
!Z1	Year; 1 digit

27.6.4 Retrieving with LIB\$GET_DATE_FORMAT Routine

The LIB\$GET_DATE_FORMAT routine enables you to retrieve information about the currently selected input format. The string returned by LIB\$GET_DATE_FORMAT parallels the currently defined input format string, consisting of the format punctuation (with most white space compressed) and legible mnemonics representing the various format fields.

Based on the currently defined input date/time format, LIB\$GET_DATE_FORMAT returns a string comprised of the mnemonics that represent the current format. These mnemonics are listed in Table 27–11.

Table 27–12 gives some examples of input format strings and their resultant mnemonic strings (using English as the default language).

Table 27–12 Sample Input Format Strings

Sample Format String	LIB\$GET_DATE_FORMAT Value
!MAU !DD, !Y4 !H04:!M0:!S0:!C2	MONTH DD, YYYY4 HH:MM:SS:CC2
!MN0-!D0-!Y2 !H04:!M0:!S0.!C2	MM-DD-YYYY2 HH:MM:SS.CC2
!MN0/!D0/!Y2 !H02:!M0:!S0.!C2 !MIU	MM/DD/YYYY2 HH:MM:SS.CC2 AM/PM

27.6.4.1 Using User-Defined Output Formats

In addition to the 40 date output formats and 20 time output formats, users can define their own date and time output formats using the logical names LIB\$DATE_FORMAT_*nnn* and LIB\$TIME_FORMAT_*nnn*, where *nnn* ranges from 501 to 999. (That is, values of *nnn* from 001 to 500 are reserved for use by Compaq Computer Corporation.) The mnemonics used to define output formats are listed in Table 27–6.

User-defined output formats must be defined as executive-mode logicals, and they must be defined in the table LNM\$DT_FORMAT_TABLE. These formats are normally defined from the site-specific startup command procedure. The following example illustrates the steps the system manager must use to create a particular output format using French as the language:

```
$ DEFINE/EXEC/TABLE=LNM$DT_FORMAT_TABLE LIB$DATE_FORMAT_501 -
_$ "!WL, le !DD !MAL !Y4"
$ DEFINE/EXEC/TABLE=LNM$DT_FORMAT_TABLE LIB$TIME_FORMAT_501 -
_$ "!H04 heures et !M0 minutes"
```


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After the system manager defines the desired formats, the user can access them by using the following commands:

```
$ DEFINE SYS$LANGUAGE FRENCH
$ DEFINE LIB$DT_FORMAT LIB$DATE_FORMAT_501, LIB$TIME_FORMAT_501
```

After completing these steps, a program outputting the date and time provides the following results:

```
mardi, le 20 janvier 1993 13 heures et 50 minutes
```

In addition to creating their own date and time formats, users can also define their own language tables (provided they have the SYSNAM, SYSPRV and CMEXEC privileges). To create a language table, a user must define all the logical names required.

The following example defines a portion of the Dutch language table. This table is included in its entirety in the set of predefined languages provided with the international date/time formatting routines.

```
$ CREATE/NAME/PARENT=LNMSYSTEM_DIRECTORY/EXEC/PROT=(S:RWED,G:R,W:R) -
_$ LNM$LANGUAGE_DUTCH
$ DEFINE/EXEC/TABLE=LNMSLANGUAGE_DUTCH LIB$WEEKDAYS_L -
_$ "maandag", "dinsdag", "woensdag", "donderdag", "vrijdag", -
_$ "zaterdag", "zondag"
$ DEFINE/EXEC/TABLE=LNMSLANGUAGE_DUTCH LIB$WEEKDAY_ABBREVIATIONS_L -
_$ "maa", "din", "woe", "don", "vri", "zat", "zon"
$ DEFINE/EXEC/TABLE=LNMSLANGUAGE_DUTCH LIB$MONTHS_L "januari", -
_$ "februari", "maart", "april", "mei", "juni", "juli", "augustus", -
_$ "september", "oktober", "november", "december"
$ DEFINE/EXEC/TABLE=LNMSLANGUAGE_DUTCH LIB$MONTH_ABBREVIATIONS_L -
_$ "jan", "feb", "mrt", "apr", "mei", "jun", "jul", "aug", "sep", -
_$ "okt", "nov", "dec"
$ DEFINE/EXEC/TABLE=LNMSLANGUAGE_AUSTRIAN LIB$RELATIVE_DAYS_L -
_$ "gisteren", "vandaag", "morgen"
```

All logical names that are used to build a language are as follows:

LIB\$WEEKDAYS_[U|L|C]

These logical names supply the names of the weekdays, spelled out in full (uppercase, lowercase, or mixed case). Weekdays must be defined in order, starting with Monday.

LIB\$WEEKDAY_ABBREVIATIONS_[U|L|C]

These logical names supply the abbreviated names of the weekdays (uppercase, lowercase, or mixed case). Weekday abbreviations must be defined in order, starting with Monday.

LIB\$MONTHS_[U|L|C]

These logical names supply the names of the months, spelled out in full (uppercase, lowercase, or mixed case). Months must be defined in order, starting with January.

LIB\$MONTH_ABBREVIATIONS_[U|L|C]

These logical names supply the abbreviated names of the months (uppercase, lowercase, or mixed case). Month abbreviations must be defined in order, starting with January.

System Time Operations

27.6 Date/Time Formatting Routines

LIB\$MI_[U|L|C]

These logical names supply the spellings for the meridiem indicators (uppercase, lowercase, or mixed case). Meridiem indicators must be defined in order; the first indicator represents the hours 0:00:0.0 to 11:59:59.99, and the second indicator represents the hours 12:00:00.00 to 23:59:59.99.

LIB\$RELATIVE_DAYS_[U|L|C]

These logical names supply the spellings for the relative days (uppercase, lowercase, or mixed case). Relative days must be defined in order: yesterday, today, and tomorrow, respectively.

LIB\$FORMAT_MNEMONICS

This logical name supplies the abbreviations for the appropriate format mnemonics. That is, the information supplied in this logical name is used to specify a desired input format in the user-defined language. The format mnemonics, along with their English values, are listed in the order in which they must be defined.

1. Year (YYYY)
2. Numeric month (MM)
3. Day of the month (DD)
4. Hour of the day (HH)
5. Minutes of the hour (MM)
6. Seconds of the minute (SS)
7. Parts of the second (CC)
8. Meridiem indicator (AM/PM)
9. Alphabetic month (MONTH)

The English definition of LIB\$FORMAT_MNEMONIC is therefore as follows:

```
$ DEFINE/EXEC/TABLE=LNMS$LANGUAGE_ENGLISH LIB$FORMAT_MNEMONICS -  
_$_$ "YYYY", "MM", "DD", "HH", "MM", "SS", "CC", "AM/PM ", "MONTH"
```

27.7 Coordinated Universal Time Format

This section provides information about VAX systems that supply system base date and time format other than the Smithsonian base date and time system. The other base date and time format system is the Coordinated Universal Time (UTC) system. UTC time is determined by a network of atomic clocks that are maintained by standard bodies in several countries. Formerly, applications that spanned time zones often used Greenwich Mean Time (GMT) as a time reference.

UTC binary timestamps are opaque octawords of 128-bits that contain several fields. Important fields of the UTC format are an absolute time value, a time differential factor (TDF) that contains the offset of the host node's clock from UTC, and an inaccuracy, or tolerance, that can be applied to the absolute time value. Unlike UTC, the operating system binary date and timestamps in the Smithsonian base date and time format represent only the local time of the host node; they do not contain TDF values or inaccuracy values.

System Time Operations

27.7 Coordinated Universal Time Format

The UTC system services allow applications to gain the benefits of a Coordinated Universal Time reference. The UTC system services enable applications to reference a common time standard independent of the host's location and local date and time value.

By calling the UTC system services, applications can perform the following functions:

- Obtain binary representations of UTC in the binary UTC format
- Convert the binary operating system format date and time to binary UTC-format date and time
- Convert binary UTC-format date and time to the binary operating system date and time
- Convert ASCII-format date and time to binary UTC-format date and time
- Convert binary UTC-format date and time to ASCII-format date and time

System services that implement the UTC-format date and time are:

- SYS\$ASCUTC—Convert UTC to ASCII
- SYS\$BINUTC—Convert ASCII String to UTC Binary Time
- SYS\$GETUTC—Get UTC Time
- SYS\$NUMUTC—Convert UTC Time to Numeric Components
- SYS\$TIMCON—Time Converter

For specific implementation information about the UTC system services, see the *OpenVMS System Services Reference Manual*.

File Operations

This chapter describes file operations that support file input/output (I/O) and file I/O instructions of the operating system's high-level languages. This chapter contains the following sections:

Section 28.1 describes file attributes.

Section 28.2 describes strategies to access files.

Section 28.3 describes protection and access of files.

Section 28.4 describes file mapping.

Section 28.5 describes how to open and update a sequential file.

Section 28.6 describes using the Fortran user-open routines.

I/O statements transfer data between records in files and variables in your program. The I/O statement determines the operation to be performed; the I/O control list specifies the file, record, and format attributes; and the I/O list contains the variables to be acted upon.

Note

Some confusion might arise between records in a file and record variables. Where this chapter refers to a record variable, the term *record variable* is used; otherwise, *record* refers to a record in a file.

28.1 File Attributes

Before writing a program that accesses a data file, you must know the attributes of the file and the order of the data. To determine this information, see your language-specific programming manual.

File attributes (organization, record structure, and so on) determine how data is stored and accessed. Typically, the attributes are specified by keywords when you open the data file.

Ordering of the data within a file is not important mechanically. However, if you attempt to read data without knowing how it is ordered within the file, you are likely to read the wrong data; if you attempt to write data without knowing how it is ordered within the file, you are likely to corrupt existing data.

File Operations

28.1 File Attributes

28.1.1 Specifying File Attributes

You can specify large sets of attributes using the File Definition Language utility (FDL). You can specify all of the file attributes using OpenVMS RMS in a user-open routine (see Section 28.6). Typically, you need only programming language file specifiers. Use FDL only when language specifiers are unavailable.

Refer to the appropriate programming language reference manual for information about the use of language specifiers.

For complete information about how to use FDL, see the *OpenVMS Record Management Utilities Reference Manual*.

28.1.2 Using Extended File Specifications (Alpha Only)

On Alpha systems running OpenVMS V7.2, extended file specifications support disk file specifications of greater length, a larger character set, and deeper directories than was supported on previous versions of Alpha OpenVMS. For information about extended file specifications, see the *OpenVMS Guide to Extended File Specifications* and the *Guide to OpenVMS File Applications* for a description of these features.

28.2 File Access Strategies

When determining the file attributes and order of your data file, consider how you plan to access that data. File access strategies fall into the following categories:

- Complete access

If your program processes all or most of the data in the file and especially if many references are made to the data, you should read the entire file into memory. Put each record in its own variable or set of variables.

If your program is larger than the amount of virtual memory available (including the additional memory you get by using memory allocation routines), you must declare fewer variables and process your file in pieces. To determine the size of your program, add the number of bytes in each program section. The DCL command LINK/MAP produces a listing that includes the length of each program section (PSECT).

- Record-by-record access

If your program accesses records one after another, or if you cannot fit the entire file into memory, you should read one record into memory at a time.

- Discrete records access

If your program processes only a selection of the file's records, you should read only the necessary records into memory.

- Sequential and indexed file access

If your program demands speed and needs to conserve disk space, use an unformatted sequential file. Use indexed files either to process selected sets of records or to access records directly. Use either a sequential file with fixed-length records, a relative file, or an indexed file to access records directly.

28.3 File Protection and Access

Files are owned by the process that creates them and receive the default protection of the creating process. To create a file with ownership and protection other than the default, use the File Definition Language (FDL) attributes OWNER and PROTECTION in the file.

28.3.1 Read-Only Access

By default, the user of your program must have write access to a file in order for your program to open that file. However, if you specify use of the Fortran READONLY specifier when opening the file, the user needs only read access to the file to open it. The READONLY specifier does not set the protection on a file. The user cannot write to a file opened with the READONLY specifier.

28.3.2 Shared Access

The Fortran specifier READONLY and the SHARED specifier allow multiple processes to open the same file simultaneously, provided that each process uses one of these specifiers when opening the file. The READONLY specifier allows the process read access to the file; the SHARED specifier allows other processes read and write access to the file. If a process opens the file without specifying READONLY or SHARED, no other process can open that file even by specifying READONLY or SHARED.

In the following Fortran segment, if the read operation indicates that the record is locked, the read operation is repeated. You should not attempt to read a locked record without providing a delay (in this example, the call to ERRSNS) to allow the other process time to complete its operation and unlock the record.

```

! Status variables and values
INTEGER STATUS,
2      IOSTAT,
2      IO_OK
PARAMETER (IO_OK = 0)
INCLUDE '($FORDEF)'
! Logical unit number
INTEGER LUN /1/
! Record variables
INTEGER LEN
CHARACTER*80 RECORD
.
.
.
READ (UNIT = LUN,
2     FMT = '(Q,A)'
2     IOSTAT = IOSTAT) LEN, RECORD (1:LEN)
IF (IOSTAT .NE. IO_OK) THEN
  CALL ERRSNS (,,,STATUS)
  IF (STATUS .EQ. FOR$_SPERECLOC) THEN
    DO WHILE (STATUS .EQ. FOR$_SPERECLOC)
      READ (UNIT = LUN,
2         FMT = '(Q,A)'
2         IOSTAT = IOSTAT) LEN, RECORD(1:LEN)
      IF (IOSTAT .NE. IO_OK) THEN
        CALL ERRSNS (,,,STATUS)
        IF (STATUS .NE. FOR$_SPERECLOC) THEN
          CALL LIB$SIGNAL(%VAL(STATUS))
        END IF
      END IF
    END DO
  ELSE
    CALL LIB$SIGNAL (%VAL(STATUS))
  
```

File Operations

28.3 File Protection and Access

```
END IF
END IF
.
.
.
```

In Fortran, each time you access a record in a shared file, that record is automatically locked either until you perform another I/O operation on the same logical unit, or until you explicitly unlock the record using the UNLOCK statement. If you plan to modify a record, you should do so before unlocking it; otherwise, you should unlock the record as soon as possible.

28.4 File Access and Mapping

To copy an entire data file from the disk to program variables and back again, either use language I/O statements to read and write the data or use the Create and Map Section (SYS\$CRMPSC) system service to map the data. Often times, mapping the file is faster than reading it. However, a mapped file usually uses more virtual memory than one that is read using language I/O statements. Using I/O statements, you have to store only the data that you have entered. Using SYS\$CRMPSC, you have to initialize the database and store the entire structure in virtual memory including the parts that do not yet contain data.

28.4.1 Using SYS\$CRMPSC

Mapping a file means associating each byte of the file with a byte of program storage. You access data in a mapped file by referencing the program storage; your program does not use I/O statements.

Note

Files created using OpenVMS RMS typically contain control information. Unless you are familiar with the structure of these files, do not attempt to map one. The best practice is to map only those files that have been created as the result of mapping.

To map a file, perform the following operations:

1. Place the program variables for the data in a common block. Page align the common block at link time by specifying an options file containing the following link option for VAX and Alpha systems:

For VAX systems, specify the following:

```
PSECT_ATTR = name, PAGE
```

For Alpha systems, specify the following:

```
PSECT_ATTR = name, solitary
```

The variable *name* is the name of the common block.

Within the common block, you should specify the data in order from most complex to least complex (high to low rank), with character data last. This naturally aligns the data, thus preventing troublesome page breaks in virtual memory.

2. Open the data file using a user-open routine. The user-open routine must open the file for user I/O (as opposed to OpenVMS RMS I/O) and return the channel number on which the file is opened.
3. Map the data file to the common block.
4. Process the records using the program variables in the common block.
5. Free the memory used by the common block, forcing modified data to be written back to the disk file.

Do not initialize variables in a common block that you plan to map; the initial values will be lost when SYSSCRMPSC maps the common block.

28.4.1.1 Mapping a File

The format for SYSSCRMPSC is as follows:

```
SYS$CRMPSC [inadr],[retadr],[acmode],[flags],[gsdnam],[ident],[relpag],  
           [chan],[pagent],[vbn],[prot],[pfc]
```

For a complete description of the SYSSCRMPSC system service, see the *OpenVMS System Services Reference Manual*.

Starting and Ending Addresses of the Mapped Section

On VAX systems, specify the location of the first variable in the common block as the value of the first array element of the array passed by the **inadr** argument. Specify the location of the last variable in the common block as the value of the second array element.

On Alpha systems, specify the location of the first variable in the common block as the value of the first array element of the array passed by the **inadr** argument; the second array element must be the address of the last variable in the common block, which is derived by performing a logical OR with the value of the size of a memory page minus 1. The size of the memory page can be retrieved by a call to the SYSSGETSYI system service.

If the first variable in the common block is an array or string, the first variable in the common block is the first element of that array or string. If the last variable in the common block is an array or string, the last variable in the common block is the last element in that array or string.

Returning the Location of the Mapped Section

On VAX systems, SYSSCRMPSC returns the location of the first and last elements mapped in the **retadr** argument. The value returned as the starting virtual address should be the same as the starting address passed to the **inadr** argument. The value returned as the ending virtual address should be equal to or slightly more than (within 512 bytes, or 1 block) the value of the ending virtual address passed to the **inadr** argument.

On Alpha systems, SYSSCRMPSC returns the location of the first and last elements mapped in the **retadr** argument. The value returned as the starting virtual address should be the same as the starting address passed to the **inadr** argument. The value returned as the ending virtual address should be equal to or slightly less than (within a single page size) the value of the ending virtual address passed to the **inadr** argument.

If the first element is in error, you probably forgot to page-align the common block containing the mapped data.

If the second element is in error, you were probably creating a new data file and forgot to specify the size of the file in your program (see Section 28.4.1.3).

File Operations

28.4 File Access and Mapping

Using Private Sections

Specify `SECSM_WRT` for the **flags** to indicate that the section is writable. If the file is new, also specify `SECSM_DZRO` to indicate that the section should be initialized to zero.

Obtaining the Channel Number

You must use a user-open routine to get the channel number (see Section 28.4.1.2). Pass the channel number to the **chan** argument.

On VAX systems, Example 28–1 maps a data file consisting of one longword and three real arrays to the `INC_DATA` common block. The options file `INCOME.OPT` page-aligns the `INC_DATA` common block.

If `SYSSCRMPSC` returns a status of `SS$IVSECFLG` and you have correctly specified the flags in the mask argument, check to see if you are passing a channel number of 0.

Example 28–1 Mapping a Data File to the Common Block on a VAX System

```
!INCOME.OPT
PSECT_ATTR = INC_DATA, PAGE

INCOME.FOR

! Declare variables to hold statistics
REAL PERSONS_HOUSE (2048),
2  ADULTS_HOUSE (2048),
2  INCOME_HOUSE (2048)
INTEGER TOTAL_HOUSES
! Declare section information
! Data area
COMMON /INC_DATA/ PERSONS_HOUSE,
2  ADULTS_HOUSE,
2  INCOME_HOUSE,
2  TOTAL_HOUSES
! Addresses
INTEGER ADDR(2),
2  RET_ADDR(2)
! Section length
INTEGER SEC_LEN
! Channel
INTEGER*2 CHAN,
2  GARBAGE
COMMON /CHANNEL/ CHAN,
2  GARBAGE
! Mask values
INTEGER MASK
INCLUDE '($SECDEF)'
! User-open routines
INTEGER UFO_OPEN,
2  UFO_CREATE
EXTERNAL UFO_OPEN,
2  UFO_CREATE
! Declare logical unit number
INTEGER STATS_LUN
! Declare status variables and values
INTEGER STATUS,
2  IOSTAT,
2  IO_OK
PARAMETER (IO_OK = 0)
INCLUDE '($FORDEF)'
EXTERNAL INCOME_BADMAP
! Declare logical for INQUIRE statement
LOGICAL EXIST
```

(continued on next page)

Example 28–1 (Cont.) Mapping a Data File to the Common Block on a VAX System

```

! Declare subprograms invoked as functions
INTEGER LIB$GET_LUN,
2     SYS$CRMPSC,
2     SYS$DELTVA,
2     SYS$DASSGN
! Get logical unit number for STATS.SAV
STATUS = LIB$GET_LUN (STATS_LUN)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
INQUIRE (FILE = 'STATS.SAV',
2     EXIST = EXIST)
IF (EXIST) THEN
    OPEN (UNIT=STATS_LUN,
2     FILE='STATS.SAV',
2     STATUS='OLD',
2     USEROPEN = UFO_OPEN)
    MASK = SEC$M_WRT
ELSE
    ! If STATS.SAV does not exist, create new database
    MASK = SEC$M_WRT .OR. SEC$M_DZRO
    SEC_LEN =
! (address of last - address of first + size of last + 511)/512
2 ( (%LOC(TOTAL_HOUSES) - %LOC(PERSONS_HOUSE(1)) + 4 + 511)/512 )
    OPEN (UNIT=STATS_LUN,
2     FILE='STATS.SAV',
2     STATUS='NEW',
2     INITIALSIZE = SEC_LEN,
2     USEROPEN = UFO_CREATE)
END IF
! Free logical unit number and map section
CLOSE (STATS_LUN)
! *****
! MAP DATA
! *****
! Specify first and last address of section
ADDR(1) = %LOC(PERSONS_HOUSE(1))
ADDR(2) = %LOC(TOTAL_HOUSES)
! Map the section
STATUS = SYS$CRMPSC (ADDR,
2     RET_ADDR,
2     ,
2     %VAL(MASK),
2     ,
2     %VAL(CHAN),
2     ,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
! Check for correct mapping
IF (ADDR(1) .NE. RET_ADDR (1))
2 CALL LIB$SIGNAL (%VAL (%LOC(INCOME_BADMAP)))
.
.
.
! Reference data using the
! data structures listed
! in the common block
.
.
.
! Close and update STATS.SAV
STATUS = SYS$DELTVA (RET_ADDR,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
STATUS = SYS$DASSGN (%VAL(CHAN))
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
END

```

(continued on next page)

File Operations

28.4 File Access and Mapping

Example 28–1 (Cont.) Mapping a Data File to the Common Block on a VAX System

Example 28–2 shows the code for performing the same functions as Example 28–1 but in an Alpha system's environment.

Example 28–2 Mapping a Data File to the Common Block on an Alpha System

```
!INCOME.OPT
PSECT_ATTR = INC_DATA, SOLITARY, SHR, WRT

INCOME.FOR

! Declare variables to hold statistics
REAL PERSONS_HOUSE (2048),
2  ADULTS_HOUSE (2048),
2  INCOME_HOUSE (2048)
INTEGER TOTAL_HOUSES, STATUS
! Declare section information
! Data area
COMMON /INC_DATA/ PERSONS_HOUSE,
2  ADULTS_HOUSE,
2  INCOME_HOUSE,
2  TOTAL_HOUSES
! Addresses
INTEGER ADDR(2),
2  RET_ADDR(2)
! Section length
INTEGER SEC_LEN
! Channel
INTEGER*2 CHAN,
2  GARBAGE
COMMON /CHANNEL/ CHAN,
2  GARBAGE
! Mask values
INTEGER MASK
INCLUDE '($SECDEF)'
! User-open routines
INTEGER UFO_OPEN,
2  UFO_CREATE
EXTERNAL UFO_OPEN,
2  UFO_CREATE
! Declare logical unit number
INTEGER STATS_LUN
! Declare status variables and values
INTEGER STATUS,
2  IOSTAT,
2  IO_OK
PARAMETER (IO_OK = 0)
INCLUDE '($FORDEF)'
EXTERNAL INCOME_BADMAP
! Declare logical for INQUIRE statement
LOGICAL EXIST
! Declare subprograms invoked as functions
INTEGER LIB$GET_LUN,
2  SYS$CRMPSC,
2  SYS$DELTVA,
2  SYS$DASSGN
! Get logical unit number for STATS.SAV
STATUS = LIB$GET_LUN (STATS_LUN)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
```

(continued on next page)

Example 28–2 (Cont.) Mapping a Data File to the Common Block on an Alpha System

```

INQUIRE (FILE = 'STATS.SAV',
2       EXIST = EXIST)
IF (EXIST) THEN
  OPEN (UNIT=STATS_LUN,
2       FILE='STATS.SAV',
2       STATUS='OLD',
2       USEROPEN = UFO_OPEN)
  MASK = SEC$M_WRT
ELSE
  ! If STATS.SAV does not exist, create new database
  MASK = SEC$M_WRT .OR. SEC$M_DZRO
  SEC_LEN =
  ! (address of last - address of first + size of last + 511)/512
2  ( (%LOC(TOTAL_HOUSES) - %LOC(PERSONS_HOUSE(1)) + 4 + 511)/512 )
  OPEN (UNIT=STATS_LUN,
2       FILE='STATS.SAV',
2       STATUS='NEW',
2       INITIALSIZE = SEC_LEN,
2       USEROPEN = UFO_CREATE)
END IF
! Free logical unit number and map section
CLOSE (STATS_LUN)
! *****
! MAP DATA
! *****
STATUS = LIB$GETSYI(SYI$PAGE_SIZE, PAGE_MAX,,,)
IF (.NOT. STATUS) CALL LIB$STOP (%VAL (STATUS))
! Specify first and last address of section
ADDR(1) = %LOC(PERSONS_HOUSE(1))
! Section will always be smaller than page_max bytes
ADDR(2) = ADDR(1) + PAGE_MAX -1
! Map the section
STATUS = SYS$CRMPSC (ADDR,
2                   RET_ADDR,
2                   ,
2                   %VAL(MASK),
2                   ,
2                   %VAL(CHAN),
2                   ,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
! Check for correct mapping
IF (ADDR(1) .NE. RET_ADDR (1))

2 CALL LIB$SIGNAL (%VAL (%LOC(INCOME_BADMAP)))
.
.
.
! Reference data using the
! data structures listed
! in the common block
.
.
! Close and update STATS.SAV
STATUS = SYS$DELTVA (RET_ADDR,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
STATUS = SYS$DASSGN (%VAL(CHAN))
IF (.NOT. STATUS) CALL LIB$SIGNAL(%VAL(STATUS))
END

```

File Operations

28.4 File Access and Mapping

28.4.1.2 Using the User-Open Routine

When you open a file for mapping in Fortran, for example, you must specify a user-open routine (Section 28.6 discusses user-open routines) to perform the following operations:

1. Set the user-file open bit (FAB\$V_UFO) in the file access block (FAB) options mask.
2. Open the file using SYSSOPEN for an existing file or SYSSCREATE for a new file. (Do not invoke SYSSCONNECT if you have set the user-file open bit.)
3. Return the channel number to the program unit that started the OPEN operation. The channel number is in the additional status longword of the FAB (FAB\$L_STV) and must be returned in a common block.
4. Return the status of the open operation (SYSSOPEN or SYSSCREATE) as the value of the user-open routine.

After setting the user-file open bit in the FAB options mask, you cannot use language I/O statements to access data in that file. Therefore, you should free the logical unit number associated with the file. The file is still open. You access the file with the channel number.

Example 28–3 shows a user-open routine invoked by the sample program in Section 28.4.1.1 if the file STATS.SAV exists. (If STATS.SAV does not exist, the user-open routine must invoke SYSSCREATE rather than SYSSOPEN.)

Example 28–3 Using a User-Open Routine

```
!UFO_OPEN.FOR

INTEGER FUNCTION UFO_OPEN (FAB,
2                      RAB,
2                      LUN)

! Include Open VMS RMS definitions
INCLUDE '($FABDEF)'
INCLUDE '($RABDEF)'
! Declare dummy arguments
RECORD /FABDEF/ FAB
RECORD /RABDEF/ RAB
INTEGER LUN
! Declare channel
INTEGER*4 CHAN
COMMON /CHANNEL/ CHAN
! Declare status variable
INTEGER STATUS
! Declare system procedures
INTEGER SYSSOPEN
! Set useropen bit in the FAB options longword
FAB.FAB$L_FOP = FAB.FAB$L_FOP .OR. FAB$M_UFO
! Open file
STATUS = SYSSOPEN (FAB)
! Read channel from FAB status word
CHAN = FAB.FAB$L_STV

! Return status of open operation
UFO_OPEN = STATUS

END
```

28.4.1.3 Initializing a Mapped Database

The first time you map a file you must perform the following operations in addition to those listed at the beginning of Section 28.4.1:

1. Specify the size of the file—SYSSCRMPSC maps data based on the size of the file. Therefore, when creating a file that is to be mapped, you must specify in your program a file large enough to contain all of the expected data. Figure the size of your database as follows:
 - Find the size of the common block (in bytes)—Subtract the location of the first variable in the common block from the location of the last variable in the common block and then add the size of the last element.
 - Find the number of blocks in the common block—Add 511 to the size and divide the result by 512 (512 bytes = 1 block).
2. Initialize the file when you map it—The blocks allocated to a file might not be initialized and therefore contain random data. When you first map the file, you should initialize the mapped area to zeros by setting the SECSV_DZRO bit in the mask argument of SYSSCRMPSC.

The user-open routine for creating a file is the same as the user-open routine for opening a file except that SYSSOPEN is replaced by SYSSCREATE.

28.4.1.4 Saving a Mapped File

To close a data file that was opened for user I/O, you must deassign the I/O channel assigned to that file. Before you can deassign a channel assigned to a mapped file, you must delete the virtual memory associated with the file (the memory used by the common block). When you delete the virtual memory used by a mapped file, any changes made while the file was mapped are written back to the disk file. Use the Delete Virtual Address Space (SYSSDELTV) system service to delete the virtual memory used by a mapped file. Use the Deassign I/O Channel (SYSSDASSGN) system service to deassign the I/O channel assigned to a file.

The program segment shown in Example 28–4 closes a mapped file, automatically writing any modifications back to the disk. To ensure that the proper locations are deleted, pass SYSSDELTV the addresses returned to your program by SYSSCRMPSC rather than the addresses you passed to SYSSCRMPSC. If you want to save modifications made to the mapped section without closing the file, use the Update Section File on Disk (SYSSUPDSEC) system service. To ensure that the proper locations are updated, pass SYSSUPDSEC the addresses returned to your program by SYSSCRMPSC rather than the addresses you passed to SYSSCRMPSC. Typically, you want to wait until the update operation completes before continuing program execution. Therefore, use the **efn** argument of SYSSUPDSEC to specify an event flag to be set when the update is complete, and wait for the system service to complete before continuing. For a complete description of the SYSSDELTV, SYSSDASSGN, and SYSSUPDSEC system services, see the *OpenVMS System Services Reference Manual*.

File Operations

28.4 File Access and Mapping

Example 28–4 Closing a Mapped File

```
! Section address
INTEGER*4 ADDR(2),
2      RET_ADDR(2)
! Event flag
INTEGER*4 FLAG
! Status block
STRUCTURE /IO_BLOCK/
  INTEGER*2 IOSTAT,
2      HARDWARE
  INTEGER*4 BAD_PAGE
END STRUCTURE
RECORD /IO_BLOCK/ IOSTATUS
.
.
.
! Get an event flag
STATUS = LIB$GET_EF (FLAG)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
! Update the section
STATUS = SYS$UPDSEC (RET_ADDR,
2      ' ',
2      %VAL(FLAG)
2      ' ',
2      IOSTATUS,,)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
! Wait for section to be updated
STATUS = SYS$SYNCH (%VAL(FLAG),
2      IOSTATUS)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
.
.
.
```

28.5 Opening and Updating a Sequential File

This section provides an example, written in Compaq Fortran, of how to open and update a sequential file on a VAX system. A sequential file consists of records arranged one after the other in the order in which they are written to the file. Records can only be added to the end of the file. Typically, sequential files are accessed sequentially.

Creating a Sequential File

To create a sequential file, use the OPEN statement and specify the following keywords and keyword values:

- STATUS = 'NEW'
- ACCESS = 'SEQUENTIAL'
- ORGANIZATION = 'SEQUENTIAL'

The file structure keyword ORGANIZATION also accepts the value 'INDEXED' or 'RELATIVE'.

File Operations

28.5 Opening and Updating a Sequential File

Example 28–5 creates a sequential file of fixed-length records.

Example 28–5 Creating a Sequential File of Fixed-Length Records

```
.
.
.
INTEGER STATUS,
2     LUN,
2     LIB$GET_INPUT,
2     LIB$GET_LUN,
2     STR$UPCASE
INTEGER*2  FN_SIZE,
2         REC_SIZE
CHARACTER*256 FILENAME
CHARACTER*80 RECORD
! Get file name
STATUS = LIB$GET_INPUT (FILENAME,
2                       'File name: ',
2                       FN_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Get free unit number
STATUS = LIB$GET_LUN (LUN)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Open the file
OPEN (UNIT = LUN,
2     FILE = FILENAME (1:FN_SIZE),
2     ORGANIZATION = 'SEQUENTIAL',
2     ACCESS = 'SEQUENTIAL',
2     RECORDTYPE = 'FIXED',
2     FORM = 'UNFORMATTED',
2     RECL = 20,
2     STATUS = 'NEW')
! Get the record input
STATUS = LIB$GET_INPUT (RECORD,
2                       'Input: ',
2                       REC_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
DO WHILE (REC_SIZE .NE. 0)

    ! Convert to uppercase
    STATUS = STR$UPCASE (RECORD,RECORD)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))

    WRITE (UNIT=LUN) RECORD(1:REC_SIZE)
    ! Get more record input
    STATUS = LIB$GET_INPUT (RECORD,
2                           'Input: ',
2                           REC_SIZE)
    IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
END DO
END
```

Updating a Sequential File

To update a sequential file, read each record from the file, update it, and write it to a new sequential file. Updated records cannot be written back as replacement records for the same sequential file from which they were read.

Example 28–6 updates a sequential file, giving the user the option of modifying a record before writing it to the new file. The same file name is used for both files; because the new update file was opened after the old file, the new file has a higher version number.

File Operations

28.5 Opening and Updating a Sequential File

Example 28–6 Updating a Sequential File

```

      .
      .
      .
INTEGER STATUS,
2     LUN1,
2     LUN2,
2     IOSTAT
INTEGER*2 FN_SIZE
CHARACTER*256 FILENAME
CHARACTER*80 RECORD
CHARACTER*80 NEW_RECORD
INCLUDE '($FORDEF)'
INTEGER*4 LIB$GET_INPUT,
2     LIB$GET_LUN,
2     STR$UPCASE
! Get file name
STATUS = LIB$GET_INPUT (FILENAME,
2                       'File name: ',
2                       FN_SIZE)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Get free unit number
STATUS = LIB$GET_LUN (LUN1)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Open the old file
OPEN (UNIT=LUN1,
2     FILE=FILENAME (1:FN_SIZE),
2     ORGANIZATION='SEQUENTIAL',
2     ACCESS='SEQUENTIAL',
2     RECORDTYPE='FIXED',
2     FORM='UNFORMATTED',
2     RECL=20,
2     STATUS='OLD')
! Get free unit number
STATUS = LIB$GET_LUN (LUN2)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Open the new file
OPEN (UNIT=LUN2,
2     FILE=FILENAME (1:FN_SIZE),
2     ORGANIZATION='SEQUENTIAL',
2     ACCESS='SEQUENTIAL',
2     RECORDTYPE='FIXED',
2     FORM='UNFORMATTED',
2     RECL=20,
2     STATUS='NEW')
! Read a record from the old file
READ (UNIT=LUN1,
2     IOSTAT=IOSTAT) RECORD
IF (IOSTAT .NE. IOSTAT_OK) THEN
  CALL ERRSNS (,,,STATUS)
  IF (STATUS .NE. FOR$_ENDDURREA) THEN
    CALL LIB$SIGNAL (%VAL(STATUS))
  END IF
END IF
DO WHILE (STATUS .NE. FOR$_ENDDURREA)
  TYPE *, RECORD
```

(continued on next page)

Example 28–6 (Cont.) Updating a Sequential File

```
! Get record update
STATUS = LIB$GET_INPUT (NEW_RECORD,
2      'Update: ')
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))
! Convert to uppercase
STATUS = STR$UPCASE (NEW_RECORD,
2      NEW_RECORD)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL (STATUS))

! Write unchanged record or updated record
IF (NEW_RECORD .EQ. ' ') THEN
  WRITE (UNIT=LUN2) RECORD
ELSE
  WRITE (UNIT=LUN2) NEW_RECORD
END IF

! Read the next record
READ (UNIT=LUN1,
2      IOSTAT=IOSTAT) RECORD
IF (IOSTAT .NE. IOSTAT_OK) THEN
  CALL ERRSNS (,,,STATUS)
  IF (STATUS .NE. FOR$_ENDDURREA) THEN
    CALL LIB$SIGNAL (%VAL(STATUS))
  END IF
END IF
END DO
END
```

28.6 User-Open Routines

A user-open routine in Fortran, for example, gives you direct access to the file access block (FAB) and record access block (RAB) (the OpenVMS RMS structures that define file characteristics). Use a user-open routine to specify file characteristics that are otherwise unavailable from your programming language.

When you specify a user-open routine, you open the file rather than allow the program to open the file for you. Before passing the FAB and RAB to your user-open routine, any default file characteristics and characteristics that can be specified by keywords in the programming language are set. Your user-open routine should not set or modify such file characteristics because the language might not be aware that you have set the characteristics and might not perform as expected.

28.6.1 Opening a File

Section 28.4.1.2 provides guidelines on opening a file with a user-open routine. This section provides an example of a Fortran user-open routine.

28.6.1.1 Specifying USEROPEN

To open a file with a user-open routine, include the USEROPEN specifier in the Fortran OPEN statement. The value of the USEROPEN specifier is the name of the routine (not a character string containing the name). Declare the user-open routine as an INTEGER*4 function. Because the user-open routine name is specified as an argument, it must be declared in an EXTERNAL statement.

File Operations

28.6 User-Open Routines

The following statement instructs Fortran to open SECTION.DAT using the routine UFO_OPEN:

```
! Logical unit number
INTEGER LUN

! Declare user-open routine
INTEGER UFO_OPEN
EXTERNAL UFO_OPEN
.
.
.
OPEN (UNIT = LUN,
2     FILE = 'SECTION.DAT',
2     STATUS = 'OLD',
2     USEROPEN = UFO_OPEN)
.
.
.
```

28.6.1.2 Writing the User-Open Routine

Write a user-open routine as an INTEGER function that accepts three dummy arguments:

- FAB address—Declare this argument as a RECORD variable. Use the record structure FABDEF defined in the \$FABDEF module of SYS\$LIBRARY:FORSYSDEF.TLB.
- RAB address—Declare this argument as a RECORD variable. Use the record structure RABDEF defined in the \$RABDEF module of SYS\$LIBRARY:FORSYSDEF.TLB.
- Logical unit number—Declare this argument as an INTEGER.

A user-open routine must perform at least the following operations. In addition, before opening the file, a user-open routine usually adjusts one or more fields in the FAB or the RAB or in both.

- Opens the file—To open the file, invoke the SYSSOPEN system service if the file already exists, or the SYSSCREATE system service if the file is being created.
- Connects the file—Invoke the SYSSCONNECT system service to establish a record stream for I/O.
- Returns the status—To return the status, equate the return status of the SYSSOPEN or SYSSCREATE system service to the function value of the user-open routine.

The following user-open routine opens an existing file. The file to be opened is specified in the OPEN statement of the invoking program unit.

UFO_OPEN.FOR

```
INTEGER FUNCTION UFO_OPEN (FAB,
2                          RAB,
2                          LUN)

! Include Open VMS RMS definitions
INCLUDE '($FABDEF)'
INCLUDE '($RABDEF)'
! Declare dummy arguments
RECORD /FABDEF/ FAB
RECORD /RABDEF/ RAB
INTEGER LUN
```

```

! Declare status variable
INTEGER STATUS
! Declare system routines
INTEGER SYS$CREATE,
2     SYS$OPEN,
2     SYS$CONNECT
! Optional FAB and/or RAB modifications
.
.
.
! Open file
STATUS = SYS$OPEN (FAB)
IF (STATUS)
2  STATUS = SYS$CONNECT (RAB)

! Return status of $OPEN or $CONNECT
UFO_OPEN = STATUS

END

```

28.6.1.3 Setting FAB and RAB Fields

Each field in the FAB and RAB is identified by a symbolic name, such as FABSL_FOP. Where separate bits in a field represent different attributes, each bit offset is identified by a similar symbolic name, such as FAB\$V_CTG. The first three letters identify the structure containing the field. The letter following the dollar sign indicates either the length of the field (B for byte, W for word, or L for longword) or that the name is a bit offset (V for bit) rather than a field. The letters following the underscore identify the attribute associated with the field or bit. The symbol FABSL_FOP identifies the FAB options field, which is a longword in length; the symbol FAB\$V_CTG identifies the contiguity bit within the options field.

The STRUCTURE definitions for the FAB and RAB are in the \$FABDEF and \$RABDEF modules of the library SYSS\$LIBRARY:FORSYSDEF.TLB. To use these definitions, do the following:

1. Include the modules in your program unit.
2. Declare RECORD variables for the FAB and the RAB.
3. Reference the various fields of the FAB and RAB using the symbolic name of the field.

The following user-open routine specifies that the blocks allocated for the file must be contiguous. To specify contiguity, you clear the best-try-contiguous bit (FAB\$V_CBT) of the FABSL_FOP field and set the contiguous bit (FAB\$V_CTG) of the same field.

UFO_CONTIG.FOR

```

INTEGER FUNCTION UFO_CONTIG (FAB,
2     RAB,
2     LUN)

! Include Open VMS RMS definitions
INCLUDE '($FABDEF)'
INCLUDE '($RABDEF)'
! Declare dummy arguments
RECORD /FABDEF/ FAB
RECORD /RABDEF/ RAB
INTEGER LUN
! Declare status variable
INTEGER STATUS

```

File Operations

28.6 User-Open Routines

```
! Declare system procedures
INTEGER SYS$CREATE,
2     SYS$CONNECT
! Clear contiguous-best-try bit and
! set contiguous bit in FAB options
FAB.FAB$L_FOP = IBCLR (FAB.FAB$L_FOP, FAB$V_CBT)
FAB.FAB$L_FOP = IBSET (FAB.FAB$L_FOP, FAB$V_CTG)
! Open file
STATUS = SYS$CREATE (FAB)
IF (STATUS) STATUS = SYS$CONNECT (RAB)

! Return status of open or connect
UFO_CONFIG = STATUS

END
```

Using the Distributed Transaction Manager

This chapter describes how to use the distributed transaction manager. It shows you how to use DECdtm services to bind together operations on several databases or files into a single transaction. To use DECdtm services, the resource managers taking part in the transaction must support DECdtm. DEC Rdb for OpenVMS Alpha, DEC Rdb for OpenVMS VAX, DEC DBMS for OpenVMS Alpha, DEC DBMS for OpenVMS VAX, and OpenVMS RMS Journaling support DECdtm.

This chapter is divided into the following sections:

Section 29.1 gives an introduction to DECdtm services.

Section 29.2 discusses how to call DECdtm services.

Section 29.3 gives an example that shows how to use DECdtm services.

29.1 Introduction to DECdtm Services

A transaction performs operations on resources. Examples of resources are databases and files. A transaction often needs to use more than one resource on one or more nodes. This type of transaction is called a **distributed transaction**.

Maintaining the integrity and consistency of the resources used by a distributed transaction can be complex. To help with this, DECdtm manages distributed transactions and reduces the amount of coding required in your applications.

DECdtm uses an optimized version of the standard two-phase commit protocol. This ensures that transactions are **atomic**. If a transaction is atomic, either all the transaction operations take effect (the transaction is **committed**), or none of the operations take effect (the transaction is **aborted**).

The two-phase commit protocol makes sure that *all* the operations can take effect before the transaction is committed. If any operation cannot take effect, for example if a network link is lost, then the transaction is aborted, and none of the operations take effect.

29.1.1 Sample Atomic Transaction

Edward Jessup, an employee of a computer company in Italy, is transferring to a subsidiary of the company in Japan. An application must remove his personal information from an Italian DBMS database and add them to a Japanese Rdb database. Both of these operations must happen, otherwise Edward may either end up “in limbo” (the application might remove him from the Italian database but then lose a network link while trying to add him to the Japanese database), or find that he is in both databases at the same time. Either way, the two databases would be out of step.

If the application used DECdtm to execute both operations as an atomic transaction, then this error could never happen; DECdtm would automatically detect the network link failure and abort the transaction. Neither of the databases would be updated, and the application could then try again.

Using the Distributed Transaction Manager

29.1 Introduction to DECdtm Services

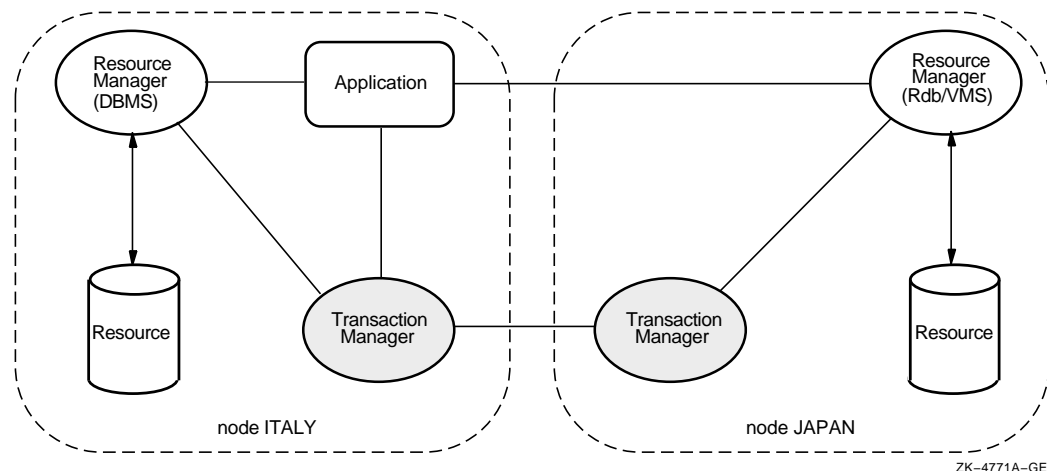
29.1.2 Transaction Participants

A DECdtm transaction involves the following participants:

- **Application:** Defines the operations that the transaction will perform.
- **Resource manager:** Performs the operations on the resources. A resource manager must support DECdtm. Examples of those that do are Rdb, DBMS, and OpenVMS RMS Journaling.
- **Transaction manager:** Coordinates the actions of the resource managers on its node. Transaction managers are provided by DECdtm.

Figure 29–1 shows the participants in the distributed transaction discussed in Section 29.1.1. The application is on node ITALY.

Figure 29–1 Participants in a Distributed Transaction



29.1.3 DECdtm System Services

The DECdtm system services are:

- **SYSSSTART_TRANSW:** Starts a new transaction and returns the transaction identifier
- **SYSSEND_TRANSW:** Ends a transaction by attempting to commit it; returns the outcome of the transaction (either commit or abort)
- **SYSSABORT_TRANSW:** Aborts a transaction

These are all synchronous system service calls. There are also asynchronous versions (SYSSSTART_TRANS, SYSSEND_TRANS, and SYSSABORT_TRANS). For a full description of all the DECdtm system services, see the *OpenVMS System Services Reference Manual*.

29.1.4 Default Transactions

Some resource managers (such as OpenVMS RMS Journaling) support the concept of **default transactions**. This means that the application does not need to specify the transaction identifier when executing transaction operations. The resource manager checks whether the calling process has a default transaction; if it has, the resource manager assumes that the operation is part of the default transaction.

29.2 Calling DECdtm System Services

An application using the DECdtm system services follows these steps:

1. Calls `SYSS$START_TRANSW`. This starts a new transaction and returns the transaction identifier.
2. Instructs the resource managers to perform the required operations on their resources.
3. Ends the transaction in one of two ways:
 - **Commit:** To attempt to perform, or commit, the transaction, the application calls `SYSS$END_TRANSW`. This checks whether all the participants can commit their operations. If any participant cannot commit an operation, the transaction is aborted.

When `SYSS$END_TRANSW` returns, the application finds out the outcome of the transaction by reading the completion status in the I/O status block.

- **Abort:** To abort the transaction, the application calls `SYSS$ABORT_TRANSW`. Typically, an application aborts a transaction if a resource manager returns an error or if the user enters invalid information during the transaction.

29.3 Using DECdtm Services: An Example

The following is a sample Fortran application that uses DECdtm system services. It can be found in `SYSS$EXAMPLES:DECDTM$EXAMPLE1`.

The application opens two files, sets a counter, then enters a loop to perform the following steps:

- Increments the counter by 1
- Calls `SYSS$START_TRANSW` to start a new transaction
- Writes the counter value to the two files
- Either calls `SYSS$END_TRANSW` to attempt to commit the transaction, or calls `SYSS$ABORT_TRANSW` to abort the transaction

The application repeats these steps until either an error occurs or the user requests an interrupt. Because DECdtm services are used, the two files will always be in step with each other. If DECdtm services were not used, one file could have been updated while the other was not. This would result in the files' being out of step.

Using the Distributed Transaction Manager

29.3 Using DECdtm Services: An Example

This example contains numbered callouts, which are explained after the program listing.

```
C
C This program assumes that the files DECDTM$EXAMPLE1.FILE_1 and
C DECDTM$EXAMPLE1.FILE_2 are created and marked for recovery unit
C journaling using the command file SYS$EXAMPLES:DECDTM$EXAMPLE1.COM
C
C To run this example, enter the following:
C $ FORTRAN SYS$EXAMPLES:DECDTM$EXAMPLE1
C $ LINK DECDTM$EXAMPLE1
C $ @SYS$EXAMPLES:DECDTM$EXAMPLE1
C $ RUN DECDTM$EXAMPLE1
C
C SYS$EXAMPLES also contains an example C application, DECDTM$EXAMPLE2.C
C The C application performs the same operations as this Fortran example.
C
      IMPLICIT      NONE
      INCLUDE      '($SDEF)'
      INCLUDE      '($FORIOSDEF)'
      CHARACTER*12 STRING
      INTEGER*2    IOSB(4)
      INTEGER*4    STATUS,COUNT,TID(4)
      INTEGER*4    SYS$START_TRANSW,SYS$END_TRANSW,SYS$ABORT_TRANSW
      EXTERNAL    SYS$START_TRANSW,SYS$END_TRANSW,SYS$ABORT_TRANSW
      EXTERNAL    JOURNAL_OPEN
C
C Open the two files
C
1      OPEN (UNIT = 10, FILE = 'DECDTM$EXAMPLE1.FILE_1', STATUS = 'OLD',
      1      ACCESS = 'DIRECT', RECL = 3, USEROPEN = JOURNAL_OPEN)
      OPEN (UNIT = 11, FILE = 'DECDTM$EXAMPLE1.FILE_2', STATUS = 'OLD',
      1      ACCESS = 'DIRECT', RECL = 3, USEROPEN = JOURNAL_OPEN)
      COUNT = 0
      TYPE *, 'Running DECdtm example program'
      TYPE *, 'Press CTRL-Y to interrupt'
C
C Loop forever, updating both files under transaction control
C
      DO WHILE (.TRUE.)
C
C Update the count and convert it to ASCII
C
2      COUNT = COUNT + 1
      ENCODE (12,8000,STRING) COUNT
8000      FORMAT (I12)
C
C Start the transaction
C
3      STATUS = SYS$START_TRANSW (%VAL(1),,IOSB,,TID)
      IF (STATUS .NE. SS$_NORMAL .OR. IOSB(1) .NE. SS$_NORMAL) GO TO 9040
C
C Update the record in each file
C
4      WRITE (UNIT = 10, REC = 1, ERR = 9000, IOSTAT = STATUS) STRING
      WRITE (UNIT = 11, REC = 1, ERR = 9010, IOSTAT = STATUS) STRING
C
C Attempt to commit the transaction
C
5      STATUS = SYS$END_TRANSW (%VAL(1),,IOSB,,TID)
      IF (STATUS .NE. SS$_NORMAL .OR. IOSB(1) .NE. SS$_NORMAL) GO TO 9050
```

Using the Distributed Transaction Manager

29.3 Using DECdtm Services: An Example

```

        END DO
C
C Errors that should cause the transaction to abort
C
6
9000   TYPE *, 'Failed to update DECDTM$EXAMPLE1.FILE_1'
        GO TO 9020

9010   TYPE *, 'Failed to update DECDTM$EXAMPLE1.FILE_2'
9020   STATUS = SYS$ABORT_TRANSW (%VAL(1),,IOSB,,,TID)
        IF (STATUS .NE. SS$_NORMAL .OR. IOSB(1) .NE. SS$_NORMAL) GO TO 9060
        STOP

C
C Errors from DECdtm system services
C
9040   TYPE *, 'Unable to start a transaction'
        GO TO 9070
9050   TYPE *, 'Failed to commit the transaction'
        GO TO 9070
9060   TYPE *, 'Failed to abort the transaction'
9070   TYPE *, 'Status = ', STATUS, ' IOSB = ', IOSB(1)
        END

C
C Switch off TRUNCATE access and PUT with truncate on OPEN for RU Journaling
C
        INTEGER FUNCTION JOURNAL_OPEN (FAB, RAB, LUN)

        INCLUDE '($FABDEF)'
        INCLUDE '($RABDEF)'
        INCLUDE '($SYSSRVNAM)'

        RECORD /FABDEF/ FAB, /RABDEF/ RAB

        FAB.FAB$B_FAC = FAB.FAB$B_FAC .AND. .NOT. FAB$M_TRN
        RAB.RAB$L_ROP = RAB.RAB$L_ROP .AND. .NOT. RAB$M_TPT

        JOURNAL_OPEN = SYS$OPEN (FAB)
        IF (.NOT. JOURNAL_OPEN) RETURN
        JOURNAL_OPEN = SYS$CONNECT (RAB)

        RETURN
        END

```

- 1** The application opens DECDTM\$EXAMPLE1.FILE1 and DECDTM\$EXAMPLE1.FILE2 for writing. It then zeroes the variable COUNT and enters an infinite loop.
- 2** The application increments the count by one and converts it to an ASCII string.
- 3** The application calls SYS\$START_TRANSW to start a transaction. The application checks the immediate return status and service completion status to see whether they signify an error.
- 4** The application attempts to write the string to the two files. If it cannot, the application aborts the transaction. Because the files are OpenVMS RMS journaled files, the default transaction is assumed.
- 5** The application calls SYS\$END_TRANSW to attempt to commit the transaction. It checks the immediate return status and service completion status to see whether they signify an error. If they do, the application reports the error and exits. If there are no errors, the transaction is committed and the application continues with the loop.

Using the Distributed Transaction Manager

29.3 Using DECdtm Services: An Example

- ⑥ If either of the two files could not be updated, the application calls `SYSS$ABORT_TRANSW` to abort the transaction. It checks the immediate return status and service completion status to see whether they signify an error. If they do, the application reports the error and exits.

Creating User-Written System Services

This chapter describes how to create user-written system services. It contains the following sections:

Section 30.1 describes privileged routines and privileged shareable images.

Section 30.2 describes how to write a privileged routine.

Section 30.3 describes how to create a privileged shareable image on VAX systems.

Section 30.4 describes how to create a privileged shareable image on Alpha systems.

30.1 Overview

Your application may contain certain routines that perform privileged functions, called **user-written system services**. To create these routines, put them in a privileged shareable image. User-mode routines in other modules can call the routines in the privileged shareable image to perform functions in a more privileged mode.

You create a privileged shareable image as you would any other shareable image, using the `/SHAREABLE` qualifier with the linker. (For more information about how to create a shareable image, see the *OpenVMS Linker Utility Manual*.) However, because a call to a routine in a more privileged mode must be vectored through the system service dispatch routine, you must perform some additional steps. The following steps outline the basic procedure. Section 30.3 provides more detail about requirements specific to VAX systems. Section 30.4 describes the necessary steps for Alpha systems.

1. Create the source file. The source file for a privileged shareable image contains the routines that perform privileged functions. In addition, because user-written system services are called using the system service dispatcher, you must include a privileged library vector (PLV) in your shareable image. A PLV is an operating-system-defined data structure that communicates the location of the privileged routines to the operating system.

On VAX systems, the PLV contains the addresses of dispatch routines for each access mode used in the image. You must write these dispatch routines and include them in your shareable image. Section 30.3.1 provides more information.

On Alpha systems, you list the names of the privileged routines in the PLV, sorted by access mode. You do not need to create dispatch routines; the image activator creates them for you automatically.

Section 30.2 provides guidelines for creating privileged routines.

2. Compile or assemble the source file.

Creating User-Written System Services

30.1 Overview

3. Create the shareable image. You create a privileged shareable image as you would any other shareable image: by specifying the `/SHAREABLE` qualifier to the `LINK` command. Note, however, that creating privileged shareable images has some additional requirements. The following list summarizes these requirements. See the *OpenVMS Linker Utility Manual* for additional information about linker qualifiers and options.
 - Declare the privileged routine entry points as universal symbols. Privileged shareable images use the same mechanisms to declare universal symbols as other shareable images: transfer vectors on VAX and symbol vectors on Alpha systems. However, because calls to user-written system services must be vectored through the system service dispatcher, you must use extensions to these mechanisms for privileged shareable images. Section 30.3.3 describes how to declare a universal symbol in a VAX privileged shareable image. Section 30.4.2 describes how to declare a universal symbol in an Alpha system privileged shareable image.
 - Prevent the linker from processing the system default shareable image library, `SYSS$LIBRARY:IMAGELIB.OLB`, by specifying the `/NOSYSSHR` linker qualifier. Otherwise, the linker processes this library by default.
 - Protect the shareable image from user-mode access by specifying the `/PROTECT` linker qualifier. If you want to protect only certain portions of the shareable image, instead of the entire image, use the `PROTECT=linker` option.
 - Set the `VEC` attribute of the program section containing the PLV by using the `PSECT_ATTR=` linker option. Modules written in MACRO can specify this attribute in the `.PSECT` directive. The PLV must appear in a program section with the `VEC` attribute set.
 - Set the shareable image identification numbers using the `GSMATCH=` option.

If your privileged application requires that you link against the system executive, see the *OpenVMS Linker Utility Manual* for more information.

4. Install the privileged shareable image as a protected permanent global section. Privileged shareable images must be installed to be available to nonprivileged programs. The following procedure is recommended:
 - a. Move the privileged shareable image to a protected directory, such as `SYSS$SHARE`.
 - b. Invoke the Install utility, specifying the `/PROTECT`, `/OPEN`, and `/SHARED` qualifiers. You can also specify the `/HEADER_RESIDENT` qualifier. The following entry could be used to install a user-written system service whose image name is `MY_PRIV_SHARE`:

```
$ INSTALL
INSTALL> ADD SYSS$SHARE:MY_PRIV_SHARE/PROTECT/OPEN/SHARED/HEADER_RES
```

To use a privileged shareable image, you include it in a link operation as you would any other shareable image: specifying the shareable image in a linker options file with the `/SHAREABLE` qualifier appended to the file specification to identify it as a shareable image.

30.2 Writing a Privileged Routine (User-Written System Service)

On both VAX systems and Alpha systems, the routines that implement user-written system services must enable any privileges they need that the nonprivileged user of the user-written system service lacks. The user-written system service must also disable any such privileges before the nonprivileged user receives control again. To enable or disable a set of privileges, use the Set Privileges (\$SETPRV) system service. The following example shows the operator (OPER) and physical I/O (PHY_IO) privileges being enabled. (Any code executing in executive or kernel mode is granted an implicit SETPRV privilege so it can enable any privileges it needs.)

```
PRVMSK: .LONG <1@PRV$V_OPER>!<1@PRV$V_PHY_IO> ;OPER and PHY_IO
        .LONG 0 ;quadword mask required. No bits set in
        ;high-order longword for these privileges.
        .
        .
        .
        $SETPRV_S ENBFLG=#1,- ;1=enable, 0=disable
        PRVADR=PRVMSK ;Identifies the privileges
```

When you design your system service, you must carefully define the boundaries between the protected subsystem and the user who calls the service. A protected image has privileges to perform tasks on its own behalf. When your image performs tasks on behalf of users, you must ensure that your image performs only those tasks the users could not have done on their own. Always keep the following coding principles in mind:

- Keep privileges off, and turn them on only when necessary.
- Make sure privileges are off on all exit paths. When you perform a task for the user, operate in user mode whenever possible and operate at all times with the user's privileges, identity, and so on. Make sure that operating in an inner mode does not give you any special privileges with respect to the operation being performed. Resume a privileged state only when you are about to resume operation on your own behalf.
- If user input can affect an operation executed with privilege, you have to carefully validate the input. Never pass user parameters directly to an operation executed in an inner mode or with privilege. When designing your program, keep in mind that the inner modes implicitly provide a user with the system privileges SETPRV, CMKRNL, SYSNAM, and SYSLCK. (See the *OpenVMS Guide to System Security* for descriptions.)
- As a protected image, your program does not have the entire operating system programming environment at its disposal. Unless a module has the prefix SYS\$ or EXE\$, you must avoid calling it from an inner mode. In particular, do not call LIB\$GET_VM or LIB\$RET_VM from an inner mode. You can call OpenVMS RMS routines from executive mode but not from kernel mode.
On VAX systems, Version 5.4 or later of the operating system, any OpenVMS RMS files that were opened with privilege from an inner mode can be left open during user execution; however, this is not acceptable on earlier versions of the operating system.
- Never make subroutine calls to other shareable images from kernel or executive mode.

Creating User-Written System Services

30.2 Writing a Privileged Routine (User-Written System Service)

- When a protected subsystem opens a file on its own behalf, it should specify executive-mode logical names only by naming executive mode explicitly in the FAB\$V_LNM_MODE subfield of the file access block (FAB). This prevents a user's logical name from redirecting a file specification.

On VAX systems, refer to SYS\$EXAMPLES:USSDISP.MAR and USSTEST.MAR for listings of modules in a user-written system service and of a module that calls the user-written system service.

On Alpha systems, for C examples refer to SYS\$EXAMPLES:UWSS.C and SYS\$EXAMPLES:UWSS_TEST.C.

30.3 Creating a Privileged Shareable Image (VAX Only)

On VAX systems, you must create dispatch routines that transfer control to the privileged routines in your shareable image. You then put the addresses of these dispatch routines in a privileged library vector (PLV). Section 30.3.1 describes how to create a dispatch routine. Section 30.3.2 describes how to create a PLV.

30.3.1 Creating User-Written Dispatch Routines on VAX Systems

On VAX systems, you must create kernel-mode and executive-mode dispatching routines that transfer control to the routine entry points. You must supply one dispatch routine for all your kernel mode routines and a separate routine for all the executive mode routines. The dispatcher is usually written using the CASE construct, with each routine identified by a code number. Make sure that the identification code you use in the dispatch routine and the code specified in the transfer vector identify the same routine.

The image activator, when it activates a privileged shareable image, obtains the addresses of the dispatch routines from the PLV and stores these addresses at a location known to the system service dispatcher. When a call to a privileged routine is initiated by a CHME or CHMK instruction, the system service dispatcher attempts to match the code number with a system service code. If there is no match, it transfers control to the location where the image activator has stored the address of your dispatch routines.

A dispatch routine must validate the CHMK or CHME operand identification code number, handling any invalid operands. In addition, the dispatching routine must transfer control to the appropriate routine for each identification code if the user-written system service contains functionally separate coding segments. The CASE instruction in VAX MACRO or a computed GOTO-type statement in a high-level language provides a convenient mechanism for determining where to transfer control.

Creating User-Written System Services

30.3 Creating a Privileged Shareable Image (VAX Only)

Note

Users of your privileged shareable image must specify the same code number to identify a privileged routine as you used to identify it in the dispatch routine. Users specify the code number in their CHMK or CHME instruction. See Section 30.3.3 for information about transfer vectors.

In your source file, a dispatch routine must precede the routines that implement the user-written system service.

Example 30–1 illustrates a sample dispatching routine, taken from the sample privileged shareable image in SYS\$EXAMPLES named USSDISP.MAR.

Example 30–1 Sample Dispatching Routine

```
KERNEL_DISPATCH::                ; Entry to dispatcher
    MOVAB    W^-KCODE_BASE(R0),R1 ; Normalize dispatch code value
    BLSS    KNOTME                 ; Branch if code value too low
    CMPW    R1,#KERNEL_COUNTER    ; Check high limit
    BGEQU   KNOTME                 ; Branch if out of range
;
; The dispatch code has now been verified as being handled by this dispatcher,
; now the argument list will be probed and the required number of arguments
; verified.
;
    MOVZBL  W^KERNEL_NARG[R1],R1  ; Get required argument count
    MOVAL   @#4[R1],R1            ; Compute byte count including argcount
    IFNORD  R1,(AP),KACCVIO       ; Branch if arglist not readable
    CMPB    (AP),W^<KERNEL_NARG-KCODE_BASE>[R0] ; Check for required number
    BLSSU   KINSFARG              ; of arguments
    MOVL    FP,SP                 ; Reset stack for service routine
    CASEW   R0,-                  ; Case on change mode
    .
    .
    .
```

30.3.2 Creating a PLV on VAX Systems

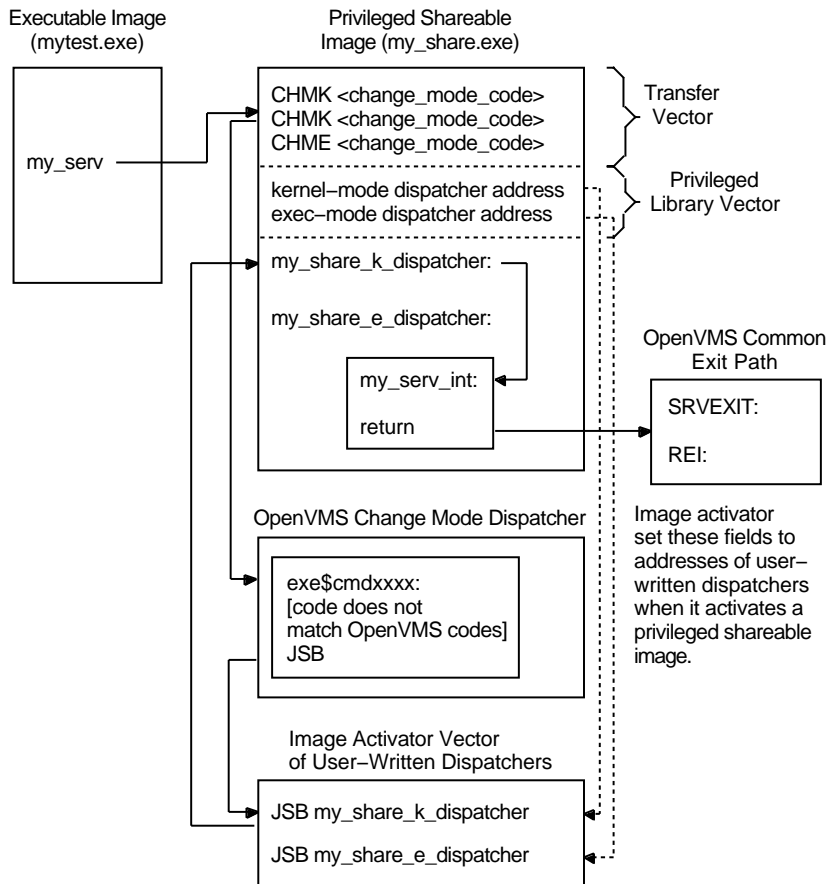
On VAX systems, a call to a privileged routine goes to the transfer vector that executes a change mode instruction (CHMx) specifying the identification code of the privileged routine as the operand to the instruction. The operating system routes the change mode instruction to the system service dispatch routine, which attempts to locate the system service with the code specified. Because the code is a negative number, the system service dispatcher drops through its list of known services and transfers control to a user-written dispatch routine, if any have been specified.

Creating User-Written System Services

30.3 Creating a Privileged Shareable Image (VAX Only)

The image activator has already placed at this location the address of whatever user-written dispatch routines it found in the privileged shareable image's PLV when it activated the PLV. The dispatch routine transfers control to the routine in the shareable image identified by the code. (You must ensure that the code used in the transfer vector and the code specified in the dispatch routine both identify the same routine.) Figure 30-1 illustrates this flow of control.

Figure 30-1 Flow of Control Accessing a Privileged Routine on VAX Systems



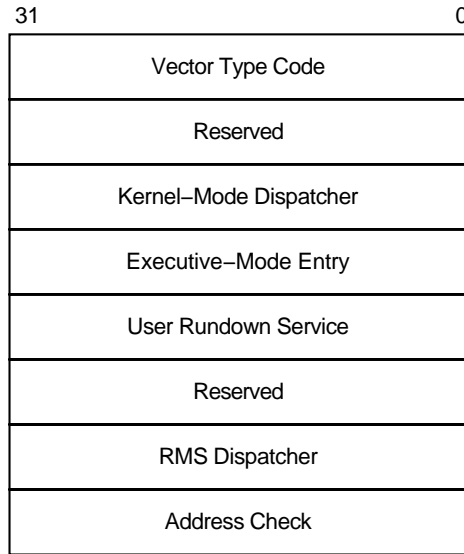
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Creating User-Written System Services

30.3 Creating a Privileged Shareable Image (VAX Only)

Figure 30–2 shows the components of the PLV in VAX shareable images.

Figure 30–2 Components of the Privileged Library Vector on VAX Systems



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Table 30–1 describes each field in the PLV on a VAX processor, including the symbolic names the operating system defines to access each field. These names are defined by the \$PLVDEF macro in SYSS\$LIBRARY:STARLET.MLB.

Table 30–1 Components of the VAX Privileged Library Vector

Component	Symbol	Description
Vector type code	PLV\$ <u>L</u> _TYPE	Identifies the type of vector. For PLVs, you must specify the symbolic constant defined by the operating system, PLV\$C_TYP_CMOD, which identifies a privileged library vector.
Kernel-mode dispatcher	PLV\$ <u>L</u> _KERNEL	Contains the address of the user-supplied kernel-mode dispatching routine if your privileged library contains routines that run in kernel mode. The address is expressed as an offset relative to the start of the data structure (self-relative pointer). A value of 0 indicates that a kernel-mode dispatcher does not exist.
Executive-mode dispatcher	PLV\$ <u>L</u> _EXEC	Contains the address of the user-supplied executive-mode dispatching routine if your privileged library contains routines that run in executive mode. The address is expressed as an offset relative to the start of the data structure (self-relative pointer). A value of 0 indicates that a kernel-mode dispatcher does not exist.

(continued on next page)

Creating User-Written System Services

30.3 Creating a Privileged Shareable Image (VAX Only)

Table 30–1 (Cont.) Components of the VAX Privileged Library Vector

Component	Symbol	Description
User-supplied rundown routine	PLV\$\$_USRUNDWN	Contains the address of a user-supplied rundown routine that performs image-specific cleanup and resource deallocation if your privileged library contains such a routine. When the image linked against the user-written system service is run down by the system, this run-time routine is invoked. Unlike exit handlers, the routine is always called when a process or image exits. (The image rundown code calls this routine with a JSB instruction; it returns with an RSB instruction called in kernel mode at IPL 0.)
RMS dispatcher	PLV\$\$_RMS	Contains the address of a user-supplied dispatcher for OpenVMS RMS services. A value of 0 indicates that a user-supplied OpenVMS RMS dispatcher does not exist. Only one user-written system service should specify the OpenVMS RMS vector, because only the last value is used. This field is intended for use only by Compaq.
Address check	PLV\$\$_CHECK	Contains a value to verify that a user-written system service that is not position independent is located at the proper virtual address. If the image is position independent, this field should contain a zero. If the image is not position independent, this field should contain its own address.

Example 30–2 illustrates how the sample privileged shareable image in SYS\$EXAMPLES assigns values to the PLV.

Example 30–2 Assigning Values to a PLV on a VAX System

```

.PAGE
$PLVDEF                                ; Define PLV fields
.SBTTL Change Mode Dispatcher Vector Block
❶ .PSECT USER_SERVICES,PAGE,VEC,PIC,NOWRT,EXE

❷ .LONG  PLV$$_C_TYP_CM0D                ; Set type of vector to change mode
.LONG    0                               ; Reserved
.LONG    KERNEL_DISPATCH-.               ; Offset to kernel mode dispatcher
.LONG    EXEC_DISPATCH-.                 ; Offset to executive mode dispatcher
.LONG    USER_RUNDOWN-.                  ; Offset to user rundown service
.LONG    0                               ; Reserved.
.LONG    0                               ; No RMS dispatcher
.LONG    0                               ; Address check - PIC image

```

- ❶ The sample program sets the VEC attribute of the program section containing the PLV.
- ❷ Values are assigned to each field of the PLV.

Creating User-Written System Services

30.3 Creating a Privileged Shareable Image (VAX Only)

30.3.3 Declaring Privileged Routines as Universal Symbols Using Transfer Vectors on VAX Systems

On VAX systems, you use the transfer vector mechanism to declare universal symbols (described in the *OpenVMS Linker Utility Manual*). However, for privileged shareable images, the transfer vector must also contain a CHMx instruction because the target routine operates in a more privileged mode. You identify the privileged routine by its identification code, supplied as the only operand to the CHMx instruction. Note that the code number used must match the code used to identify the routine in the dispatch routine. The following example illustrates a typical transfer vector for a privileged routine:

```
.TRANSFER my_serv
.MASK      my_serv
CHMK      <code_number>
RET
```

Because the OpenVMS system services codes are all positive numbers and because the call to a privileged routine is initially handled by the system service dispatcher, you should assign negative code numbers to identify your privileged routines so they do not conflict with system services identification codes.

30.4 Creating a User-Written System Service (Alpha Only)

On Alpha systems, in addition to the routines that perform privileged functions, you must also include a PLV in your source file. However, on Alpha systems, you list the privileged routines by name in the PLV. You do not need to create a dispatch routine that transfers control to the routine; the routine is identified by a special code.

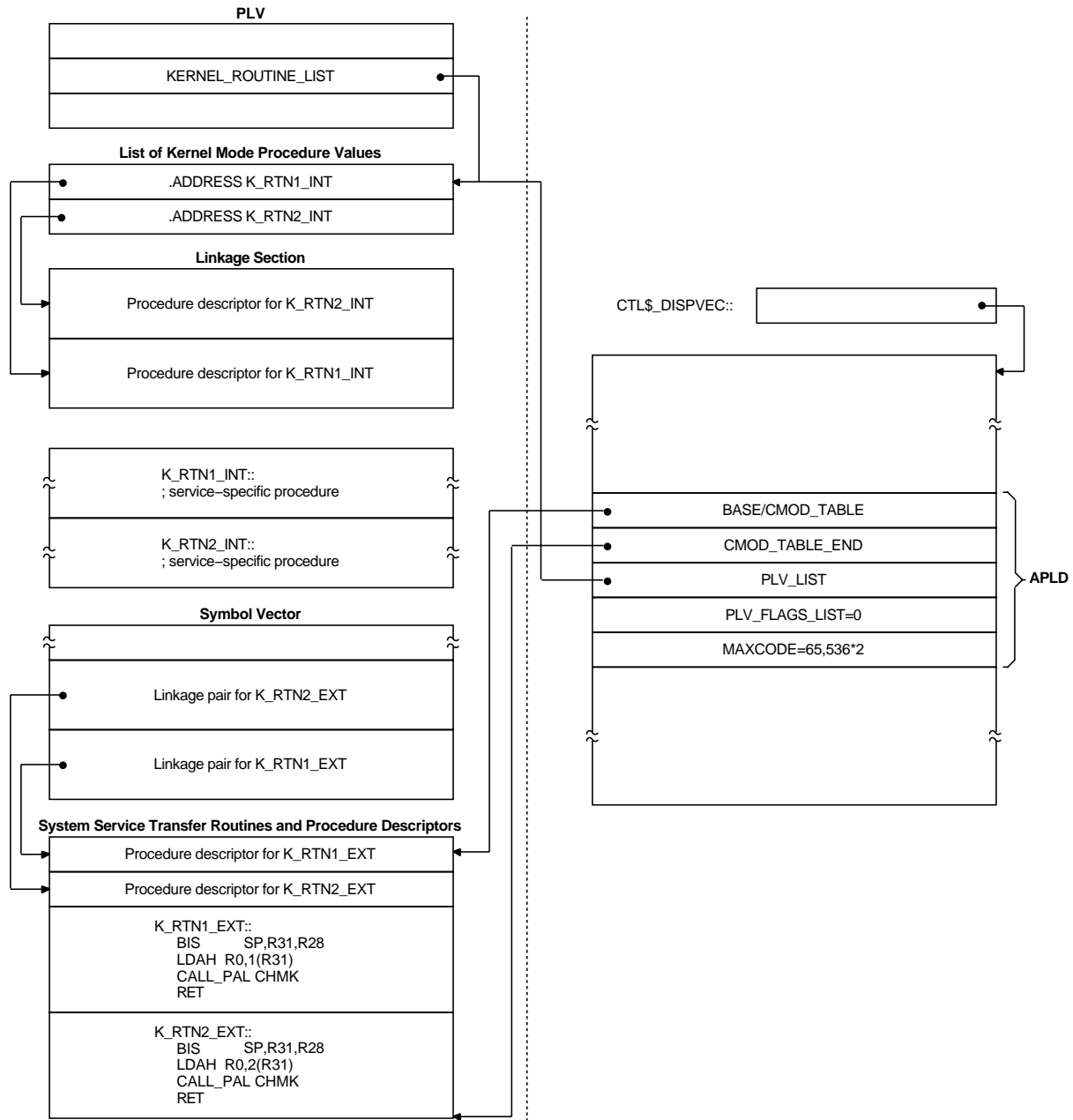
30.4.1 Creating a PLV on Alpha Systems

On Alpha systems, the PLV contains a list of the actual addresses of the privileged routines. The image activator creates the dispatch routines. Figure 30–3 illustrates the linkage for a privileged routine on Alpha systems.

Creating User-Written System Services

30.4 Creating a User-Written System Service (Alpha Only)

Figure 30–3 Linkage for a Privileged Routine After Image Activation



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Table 30–2 describes the components of the privileged library vector on Alpha systems.

Creating User-Written System Services

30.4 Creating a User-Written System Service (Alpha Only)

Table 30–2 Components of the Alpha Privileged Library Vector

Component	Symbol	Description
Vector type code	PLV\$SL_TYPE	Identifies the type of vector. You must specify the symbolic constant, PLV\$SC_TYP_CM0D, to identify a privileged library vector.
System version number	PLV\$SL_VERSION	Specifies the system version number (unused).
Kernel-mode routine count	PLV\$SL_KERNEL_ROUTINE_COUNT	Specifies the number of user-supplied kernel-mode routines listed in the kernel-mode routine list. The address of this list is specified in PLV\$SPS_KERNEL_ROUTINE_LIST.
Executive-mode routine count	PLV\$SL_EXEC_ROUTINE_COUNT	Specifies the number of user-supplied executive-mode routines listed in the executive-mode routine list. The address of this list is specified in PLV\$SPS_EXEC_ROUTINE_LIST.
Kernel-mode routine list	PLV\$SPS_KERNEL_ROUTINE_LIST	Specifies the address of a list of user-supplied kernel-mode routines.
Executive-mode routine list	PLV\$SPS_EXEC_ROUTINE_LIST	Specifies the address of a list of user-supplied executive-mode routines.
User-supplied rundown routine	PLV\$SPS_KERNEL_RUNDOWN_HANDLER	May contain the address of a user-supplied rundown routine that performs image-specific cleanup and resource deallocation. When the image linked against the user-written system service is run down by the system, this run-time routine is invoked. Unlike exit handlers, the routine is always called when a process or image exits. (Image rundown code calls this routine with a JSB instruction; it returns with an RSB instruction called in kernel mode at IPL 0.)
Thread-safe system service	PLV\$SM_THREAD_SAFE	Flags the system service dispatcher that the service requires no explicit synchronization. It is assumed by the dispatcher that the service provides its own internal data synchronization and that multiple kernel threads can safely execute the service in parallel.
RMS dispatcher	PLV\$SPS_RMS_DISPATCHER	Specifies the address of an alternative RMS dispatching routine.
Kernel Routine Flags Vector	PLV\$SPS_KERNEL_ROUTINE_FLAGS	Contains either the address of an array of quadwords that contains the defined flags associated with each kernel system service, or a zero. If a flag is set, the kernel mode service may return the status SSS_WAIT_CALLERS_MODE.
Executive Routine Flags Vector	PLV\$SPS_EXEC_ROUTINE_FLAGS	Contains a zero value, because there are no defined flags for executive mode.

Example 30–3 illustrates how to create a PLV on Alpha systems.

Creating User-Written System Services

30.4 Creating a User-Written System Service (Alpha Only)

Example 30-3 Creating a PLV on Alpha Systems

! What follows is the definition of the PLV. The PLV lives
! in its own PSECT, which must have the VEC attribute. The
! VEC attribute is forced in the linker. The PLV looks like
! this:

```
!
! +-----+
! | Vector Type Code | PLV$L_TYPE
! | (PLV$C_TYP_CMOD) |
! +-----+
! | System Version Number | PLV$L_VERSION
! | (unused) |
! +-----+
! | Count of Kernel Mode Services | PLV$L_KERNEL_ROUTINE_COUNT
! +-----+
! | Count of Exec Mode Services | PLV$L_EXEC_ROUTINE_COUNT
! +-----+
! | Address of a List of Entry Points | PLV$PS_KERNEL_ROUTINE_LIST
! | for Kernel Mode Services |
! +-----+
! | Address of a List of Entry Points | PLV$PS_EXEC_ROUTINE_LIST
! | for Exec Mode Services |
! +-----+
! | Address of Kernel Mode | PLV$PS_KERNEL_RUNDOWN_HANDLER
! | Rundown Routine |
! +-----+
! | | PLV$M_THREAD_SAFE
! +-----+
! | Address of Alternative RMS | PLV$PS_RMS_DISPATCHER
! | Dispatching Routine |
! +-----+
! | Kernel Routine Flags Vector | PLV$PS_KERNEL_ROUTINE_FLAGS
! +-----+
! | Exec Routine Flags Vector | PLV$PS_EXEC_ROUTINE_FLAGS
! +-----+
!
PSECT OWN = USER_SERVICES (NOWRITE, NOEXECUTE);
OWN PLV_STRUCT : $BBLOCK[PLV$C_LENGTH] INITIAL (LONG (PLV$C_TYP_CMOD,! Type
! of vector
0, ! System version number
(KERNEL_TABLE_END - KERNEL_TABLE_START) / %UPVAL, ! Number of kernel mode
! services
(EXEC_TABLE_END - EXEC_TABLE_START) / %UPVAL, ! Number of exec mode
! services
KERNEL_TABLE_START, ! Address of list of kernel mode service routine
EXEC_TABLE_START, ! Address of list of exec mode service routine
RUNDOWN_HANDLER, ! Address of list of kernel mode rundown routine
0, ! Reserved longword
0, ! Address of alternate RMS dispatcher
0, ! reserved
0)); ! reserved
PSECT OWN = $OWN$;
```


Creating User-Written System Services

30.4 Creating a User-Written System Service (Alpha Only)

30.4.2 Declaring Privileged Routines as Universal Symbols Using Symbol Vectors on Alpha Systems

On Alpha systems, you declare a user-written system service to be a universal symbol by using the symbol vector mechanism. (See the *OpenVMS Linker Utility Manual* for more information about creating symbol vectors.) However, because user-written system services must be accessed by using the privileged library vector (PLV), you must specify an alias for the user-written system service. Use the following syntax for the SYMBOL_VECTOR= option to specify an alias that can be universal:

```
SYMBOL_VECTOR = ([universal_alias_name/]internal_name = {PROCEDURE ||  
                DATA})
```

In a privileged shareable image, calls from within the image that use the alias name result in a fixup and subsequent vectoring through the PLV, which results in a mode change. Calls from within the shareable image that use the internal name are made in the caller's mode. (Calls from external images always result in a fixup.)

The linker command procedures and options file shown in Example 30-4 illustrate how to declare universal symbols in an Alpha system privileged shareable image.

Example 30-4 Declaring Universal Symbols for Privileged Shareable Image on an Alpha System

```
$ !  
$ ! Link the protected shareable image containing  
$ ! the user-written system services  
$ !  
$ LINK /SHARE=UWSS -  
      /PROTECT -  
      /MAP=UWSS -  
      /SYSEXEC -  
      /FULL/CROSS/NOTRACE -  
      UWSS, -  
      SYS$INPUT:/OPTIONS  
  
!  
! Set the GSMATCH options  
!  
GSMATCH=LEQUAL,1,1  
  
!  
! Define transfer vectors for protected shareable image  
!  
SYMBOL_VECTOR = ( -  
                FIRST_SERVICE = PROCEDURE, -  
                SECOND_SERVICE = PROCEDURE, -  
                THIRD_SERVICE = PROCEDURE, -  
                FOURTH_SERVICE = PROCEDURE -  
                )  
  
!  
! Need to add the VEC attribute to the PLV psect  
!  
PSECT=USER_SERVICES,VEC
```

System Security Services

This chapter describes the security system services that provide various mechanisms to enhance the security of operating systems. It contains the following sections:

Section 31.1 provides an overview of the protection scheme.

Section 31.2 describes identifiers and how they are used in security.

Section 31.3 describes the rights database.

Section 31.4 describes the persona and per-thread security features.

Section 31.5 describes how to create, translate, and maintain access control entries (ACEs).

Section 31.6 describes protected subsystems.

Section 31.7 describes security auditing.

Section 31.8 describes how to determine a user's access to an object.

Section 31.9 describes `SYSS$CHECK_PRIVILEGE` system service.

Section 31.10 describes how to implement site-specific security policies.

31.1 Overview of the Operating System's Protection Scheme

The basis of the security scheme is an **identifier**, which is a 32-bit binary value that represents a set of users to the system. An identifier can represent an individual user, a group of users, or some aspect of the environment in which a user is operating. A process is a **holder** of an identifier when that identifier can represent that process to the system. The protection scheme also includes the user identification code (UIC), the authorization database, and access control lists.

Authorization Database

The authorization database consists of the system authorization file (`SYSUAF.DAT`), the network proxy database, and the rights list database (`RIGHTSLISTS.DAT`). Note that the network proxy database is called `NETPROXY.DAT` on Alpha systems and `NET$PROXY.DAT` on VAX systems. (The file `NETPROXY.DAT` on VAX systems is maintained for platform compatibility, translation of DECnet Phase IV node names, and layered product support.) The system **rights database** is an indexed file consisting of identifier and holder records. These records define the identifiers and the holders of those identifiers on a system. When a user logs in to the system, a process is created and `LOGINOUT` creates a rights list for the process from the applicable entries in the rights database. The **process rights list** contains all the identifiers that the process holds. A process can be the holder of a number of identifiers. These identifiers determine the access rights of the list holder. The process rights list becomes part of the process and is propagated to any created subprocesses.

System Security Services

31.1 Overview of the Operating System's Protection Scheme

Access Protection

When a process without special privileges attempts to access an object (protected by an ACL) in the system, the operating system uses the rights list when performing a protection check. The system compares the identifiers in the rights list to the protection attributes of the object and grants or denies access to the object based on the comparison. In other words, the entries in the rights list do not specifically grant access; instead, the system uses them to perform a protection check when the process attempts to access an object.

Access Control Lists

The protection scheme provides security with the mechanism of the access control list (ACL). An ACL consists of access control entries (ACEs) that specify the type of access an identifier has to an object like a file, device, or queue. When a process attempts to access an object with an associated ACL, the system grants or denies access based on whether an exact match for the identifier in the ACL exists in the process rights list.

The following sections describe each of the components of the security scheme—identifiers, rights database, process and system rights lists, protection codes, and ACLs—and the system services affecting those components.

31.2 Identifiers

The basic component of the protection scheme is an identifier. An **identifier** represents various types of agents using the system. The types of agents represented include individual users, groups of users, and environments in which a process is operating. Identifiers and their attributes apply to both processes and objects. An **identifier name** consists of 1 to 31 alphanumeric characters with no embedded blanks and must contain at least one nonnumeric character. It can include the uppercase letters A through Z, dollar signs (\$), and underscores (_), as well as the numbers 0 through 9. Any lowercase letters are automatically converted to uppercase.

31.2.1 Identifier Format

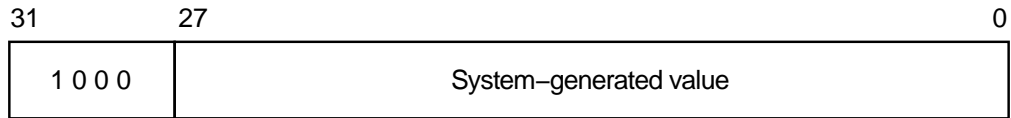
Each of the three types of identifier has an internal format in the rights database: user identification code (UIC) format, identification (ID) format, and facility-specific format. The high-order bits <31:28> of the identifier value specify the format of the identifier.

31.2.2 General Identifiers

You can define general identifiers to meet the specific needs of your site. You grant these identifiers to users by establishing holder records in the rights database. General identifiers can identify a single user, a single UIC group, a group of users, or a number of groups.

Bit <31>, which is set to 1, specifies ID format used by general identifiers as shown in Figure 31-1. Bits <30:28> are reserved by Compaq. The remaining bits specify the identifier value.

Figure 31–1 ID Format



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You define identifiers and their holders in the rights database with the Authorize utility or with the appropriate system services. Each user can hold multiple identifiers. This allows you to create a different kind of group designation from the one used with the user's UIC.

The alternative grouping described here permits each user to be a member of multiple overlapping groups. Access control lists (ACLs) define the access to protected objects based on the identifiers the user holds rather than on the user's UIC. See Section 31.5.3.1 for information on creating ACLs.

You can also define identifiers to represent particular terminals, times of day, or other site-specific environmental attributes. These identifiers are not given holder records in the rights database but may be granted to users by customer-written privileged software. This feature of the security system allows each site flexibility and, because the identifiers can be specific to the site, enhanced security. For a programming example demonstrating this technique, see Section 31.3.2.4. For more information, also see the *OpenVMS Guide to System Security*.

31.2.3 System-Defined Identifiers

System-defined identifiers, or **environmental** identifiers, are general identifiers that are automatically defined when the rights database is initialized. The following system-defined identifiers correspond directly with the login classes and relate to the environment in which the process operates:

BATCH	All attempts at access made by batch jobs
NETWORK	All attempts at access made across the network
INTERACTIVE	All attempts at access made by interactive processes
LOCAL	All attempts at access made by users logged in at local terminals
DIALUP	All attempts at access made by users logged in at dialup terminals
REMOTE	All attempts at access made by users logged in on a network

Depending on the environment in which the process is operating, the system includes one or more of these identifiers when creating the process rights list.

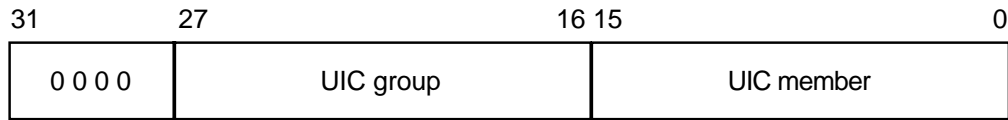
31.2.4 UIC Identifiers

Each UIC identifier is unique and represents a system user. By default, when an account is created, its UIC is associated with the account's user name generating an identifier value. When the high-order bit <31> of the identifier value is zero, the value identifies a UIC format identifier as shown in Figure 31–2.

System Security Services

31.2 Identifiers

Figure 31–2 UIC Identifier Format



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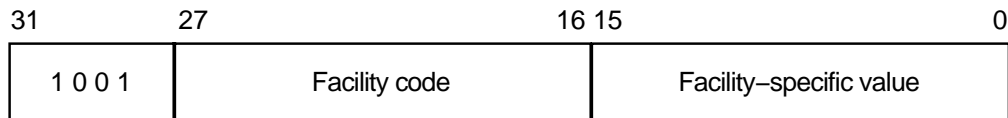
Bits <27:16> and <15:0> designate a group field and member field. Group numbers range from 1 through 16,382; member numbers range from 0 through 65,534.

31.2.5 Facility Identifiers

Facility-specific rights identifiers allow a range of unique binary identifier values to be reserved for a particular software product or application. Compare the format of facility-specific identifiers with the format of general identifiers and UIC identifiers, as shown in Section 31.2.1. The system normally determines the binary values of general identifiers when the system manager creates them; the system manager determines the binary values of UIC identifiers.

Figure 31–3 shows the facility-specific identifiers.

Figure 31–3 Facility-Specific Identifiers



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The binary value of a facility-specific identifier is determined at the time the application is designed. The facility number of the identifier must match the facility number the application has chosen for its condition and message codes. The remaining 16-bit facility-specific value may be assigned at will by the application designer. By reserving specific binary identifier values, the application designer may code fixed identifier values into an application's calls to \$CHECK_PRIVILEGE, \$GRANT_ID, and so forth. It avoids the added complexity of first having to translate an identifier name to binary with \$ASCTOID.

An application can choose to register the identifiers in the rights database or not, depending on its needs. If the identifiers are registered, they are visible to the system manager who may grant them to users. In any case, they will be displayed properly if they appear on access control lists. If they are not registered, they will remain invisible to the system manager. Unregistered identifiers that appear on access control lists are displayed as a hexadecimal value.

To register its identifiers, the installation procedure of the application must run a program that enters the identifiers into the rights database using the \$ADD_IDENT service. You cannot specify facility-specific identifier values to AUTHORIZE with the ADD/IDENTIFIER command.

Typically, facility-specific identifiers serve to extend the OpenVMS privilege mechanism for an application. For example, consider a database manager that includes a function to allow appropriately privileged users to modify a schema. Access to this function could be controlled through a facility-specific identifier named, for example, DBM\$MOD_SCHEMA. The system manager grants the identifier to authorized persons using the AUTHORIZE command GRANT/ID. The database services that modify schemas use the \$CHECK_PRIVILEGE service to check that the caller holds the identifier.

In another example, a privileged program run by users when they log in uses \$GRANT_ID to grant the user certain facility-specific identifiers, depending on conditions determined by the program; for example, time of day or access port name. These identifiers can be placed on the ACLs of files to control file access, or they might be checked by other software with \$CHECK_PRIVILEGE.

31.2.6 Identifier Attributes

An identifier has attributes associated with it in the rights database. The process rights list includes the attributes of any identifiers that the process holds.

The use of rights identifiers can be extended with the following identifier attribute keywords:

DYNAMIC	Allows unprivileged holders of an identifier to add or remove the identifier from the process rights list using the DCL SET RIGHTS command. Conversely, an unprivileged user who does not have the attribute cannot modify the identifier.
HOLDER_HIDDEN	Prevents someone from using the SYSS\$FIND HOLDER system service to get a list of users who hold an identifier, unless that person holds the identifier.
NAME_HIDDEN	Allows only the holders of an identifier to have it translated, either from binary to ASCII or from ASCII to binary.
NO_ACCESS	Specifies that the identifier does not affect the access rights of the user holding the identifier.
RESOURCE	Allows the holder of an identifier to charge resources, such as disk blocks, to an identifier.
SUBSYSTEM	Allows holders of the identifier to create and maintain protected subsystems.

Using the Resource Attribute

The following example demonstrates the advantages of defining an identifier and holders for a project.

The Physics department of a school has a common library with an associated disk quota on the system. In order to use the Resource attribute, you must enable disk quotas and establish a quota file entry using the SYSMAN utility. You want to allow the faculty members to charge disk quota that they use in conjunction with the library to the identifier PHYSICS associated with the common library and to prevent the students from charging resources to that identifier.

- Define an identifier PHYSICS with the Resource attribute in the rights database using the SYSS\$ADD_IDENT service.
- Enable disk quotas using SYSMAN as shown in the example.

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31.2 Identifiers

```
$ MCR SYSMAN
SYSMAN> DISKQUOTA CREATE/DEVICE=DKB0:
SYSMAN> DISKQUOTA MODIFY/DEVICE=DKB0: PHYSICS /PERMQUOTA=150000 -
SYSMAN> /OVERDRAFT=5000
SYSMAN> EXIT
```

- Create the common library and assign the identifier PHYSICS using the run-time library routine LIB\$CREATE_DIR.
- Grant the identifier PHYSICS to holders FRED, a faculty member, and GEORGE, a student, using the SYSS\$ADD_HOLDER service.

If you specify the Resource attribute for identifier FRED, he can charge disk resources to the PHYSICS identifier; if you do not specify the Resource attribute for identifier GEORGE, he will not inherit the Resource attribute associated with the identifier PHYSICS and cannot charge disk resources to the PHYSICS identifier. The following input file, USERLIST.DAT, contains valid UIC identifiers of students and faculty members:

```
FRED NORESOURCE
GEORGE RESOURCE
NANCY NORESOURCE
HAROLD RESOURCE
SUSAN RESOURCE
CHERYL NORESOURCE
MARVIN NORESOURCE
```

The following program reads USERLIST.DAT and associates the UIC identifiers with the identifier PHYSICS:

```
#include <stdio.h>
#include <descrip.h>
#include <ssdef.h>
#include <lib$routines.h>
#include <kgbdef.h>
#include <nam.h>
#include <string.h>
#include <stdlib.h>

#define IDENT_LEN 31
#define NO_ATTR 0

#define RESOURCE 1
#define NORESOURCE 0

unsigned int sys$asctoid(),
            sys$add_ident(),
            sys$add_holder(),
            sys$idtoasc(),
            convert_id( struct dsc$descriptor_s, unsigned int );

void add_holder( unsigned int, unsigned int, unsigned int);

struct {
    unsigned int uic;
    unsigned int terminator;
}holder;

static char ascii_ident[IDENT_LEN],
            abuffer[IDENT_LEN],
            dirbuf[NAM$C_MAXRSS],
            targbuf[IDENT_LEN];

$DESCRIPTOR(target,targbuf);

unsigned int status;

main() {
```



```

FILE *ptr;
char attr[11];
unsigned int owner_uic, attrib, resid, bin_id;
$DESCRIPTOR(dirspec,dirbuf);
$DESCRIPTOR(aident, abuffer);

printf("\nEnter directory spec: ");
gets(dirbuf);
dirspec.dsc$w_length = strlen(dirbuf);

printf("\nEnter its owner identifier: ");
gets(targbuf);
target.dsc$w_length = strlen(targbuf);

/* Add target identifier WITH resource attribute to the rights database */
attrib = KGB$M_RESOURCE;
status = sys$add_ident( &target, 0, attrib, &resid);
if((status & 1) != SS$NORMAL)
    lib$signal( status );
else
    printf("\nAdding identifier %s to rights database...\n",
        target.dsc$a_pointer);

/* Create the common directory with the target id as owner */
owner_uic = resid;
status = lib$create_dir( &dirspec, &owner_uic, 0, 0);
if((status & 1) != SS$NORMAL)
    lib$signal( status );
else
    printf("Creating the directory %s...\n",dirspec.dsc$a_pointer);

/* Open an input file of UIC identifiers and attribute types */
if((ptr = fopen("USERLIST.DAT","r")) == NULL) {
    perror("OPEN");
    exit(EXIT_FAILURE);
}

/* Read the input file of UIC identifiers */
while((fscanf(ptr,"%s %s\n",abuffer,attr)) != EOF) {
    aident.dsc$w_length = strlen(abuffer);
    attrib = (strcmp(attr,"RESOURCE")) == 0 ? KGB$M_RESOURCE : NO_ATTR;
    bin_id = convert_id( aident, attrib);
    add_holder( bin_id, resid, attrib );
}

/* Close the input file */
fclose(ptr);
}

unsigned int convert_id( struct dsc$descriptor_s uic_id,
    unsigned int attr ) {

    unsigned int bin_id;

    status = sys$asctoid(&uic_id, &bin_id, &attr);
    if((status & 1) != SS$NORMAL)
        lib$signal( status );
    else {
        printf("Converting identifier %s to binary format...\n",
            uic_id.dsc$a_pointer);
        return bin_id;
    }
}

void add_holder( unsigned int bin_id, unsigned int resid,
    unsigned int attrib ) {

```

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31.2 Identifiers

```

int i;
$DESCRIPTOR(nambuf,  ascii_ident);

holder.uic = bin_id;
holder.terminator = 0;

status = sys$add_holder( resid, &holder, attrib);
if((status & 1) != SS$NORMAL)
    lib$signal( status );
else {
    status = sys$idtoasc(bin_id, 0, &nambuf, 0, 0, 0);
    if((status & 1) != SS$NORMAL)
        lib$signal( status );
/* Remove padding */
    nambuf.dsc$w_length = strlen(ascii_ident);
    for(i=0;i < nambuf.dsc$w_length + 1; i++)
        if (ascii_ident[i] == 0x20)
            ascii_ident[i] = '\0';
    printf("\nAdding holder %s to target identifier %s...\n", \
            nambuf.dsc$a_pointer, target.dsc$a_pointer);
}
}

```

31.3 Rights Database

The rights database is an indexed file containing two types of records that define all identifiers: identifier records and holder records.

One identifier record appears in the rights database for each identifier. The identifier record associates the identifier name with its 32-bit binary value and specifies the attributes of the identifier. Figure 31–4 depicts the format of the identifier record.

Figure 31–4 Format of the Identifier Record

Identifier Value
Attributes
0
0
Identifier Name
Identifier Name
Identifier Name
Identifier Name

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One holder record exists in the rights database for each holder of each identifier. The holder record associates the holder with the identifier, specifies the attributes of the holder, and identifies the UIC identifier of the holder. Figure 31–5 depicts the format of the holder record.

Figure 31–5 Format of the Holder Record

Identifier Value
Attributes
UIC Identifier of Holder
(Reserved)
(Reserved)
(Reserved)
(Reserved)

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The rights database is an indexed file with three keys. The primary key is the identifier value, the secondary key is the holder ID, and the tertiary key is the identifier name. Through the use of the secondary key of the holder ID, all the identifiers held by a process can be retrieved quickly when the system creates the process's rights list.

31.3.1 Initializing a Rights Database

You initialize the rights database in one of the following ways:

- When a system is installed
- With the Authorize utility
- With the SYS\$CREATE_RDB system service

When you call SYS\$CREATE_RDB, you can use the **sysid** argument to pass the system identification value associated with the rights database. If you omit **sysid**, the system uses the current system time in 64-bit format. If the rights database already exists, SYS\$CREATE_RDB fails with the error code RMS\$_FEX. To create a new rights database when one already exists, you must explicitly delete or rename the old one.

You can specify the location and name of the rights database by defining the logical name RIGHTSLIST as a system logical name in executive mode; its equivalence string must contain the device, directory, and file name of the rights database.

The file RIGHTSLIST.DAT has the protection of (S:RWED,O:RWED,G:R,W).

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31.3 Rights Database

In order to use SYSS\$CREATE_RDB, write access to the database is necessary. If the database is in SYSS\$SYSTEM, which is the default, you need the SYSPRV privilege to grant write access to the directory.

When SYSS\$CREATE_RDB initializes a rights database, system-defined identifiers, which describe the environment in which a process can operate, are automatically created.

To add any other identifiers to the rights database, you must define them with the Authorize utility or with the appropriate system service.

31.3.2 Using System Services to Affect a Rights Database

The identifier and holder records in the rights database contain the following elements:

- Identifier binary value
- Identifier name
- Holders of each identifier
- Attribute of each identifier and each holder of each identifier

You can use the Authorize utility or one of the system services described in Table 31–1 to add, delete, display, modify, or translate the various elements of the rights database.

Table 31–1 Using System Services to Manipulate Elements of the Rights Database

Action	Element	Service Used
Translate	Identifier name to identifier binary value	SYSS\$ASCTOID
	Identifier binary value to identifier name	SYSS\$IDTOASC
Add	Identifier holder record	SYSS\$ADD_HOLDER
	New identifier record	SYSS\$ADD_IDENT
Find	Identifier value held by holder	SYSS\$FIND_HELD
	Holders of an identifier	SYSS\$FIND_HOLDER
	All identifiers	SYSS\$IDTOASC
Modify	Attribute in holder record	SYSS\$MOD_HOLDER
	Attribute in identifier record	SYSS\$MOD_IDENT
Delete	Holder from identifier record	SYSS\$REM_HOLDER
	Identifier and all its holders	SYSS\$REM_IDENT

The following table shows what access you need for which services:

Service	Required Access
SYSS\$ADD_HOLDER	Write
SYSS\$ADD_IDENT	Write
SYSS\$ASCTOID	Read ¹

¹On VAX systems, read access is required when certain restrictions are present (for example, if the identifiers have the name hidden or holder hidden attributes).

Service	Required Access
SYSS\$CREATE_RDB	Write ²
SYSS\$FIND_HELD	Read ¹
SYSS\$FIND HOLDER	Read ¹
SYSS\$FINISH_RDB	Read ¹
SYSS\$IDTOASC	Read ¹
SYSS\$MOD HOLDER	Write
SYSS\$MOD_IDENT	Write
SYSS\$REM HOLDER	Write
SYSS\$REM_IDENT	Write

¹On VAX systems, read access is required when certain restrictions are present (for example, if the identifiers have the name hidden or holder hidden attributes).

²File creation access.

31.3.2.1 Translating Identifier Values and Identifier Names

To the system, an identifier is a 32-bit binary value; however, to make identifiers easy to use, each binary value has an associated identifier name. The identifier value and the ASCII identifier name string are associated in the rights database. You can use the SYSS\$ASCTOID and SYSS\$IDTOASC system services to translate from one format to another. When you pass to SYSS\$ASCTOID the address of a string descriptor pointing to an identifier name, the corresponding identifier binary value is returned. Conversely, you use the SYSS\$IDTOASC service to translate a binary identifier value to an ASCII identifier name string.

Preventing a Translation

You can prevent a translation operation by unauthorized users by specifying the KGBSV_NAME_HIDDEN within an attributes mask.

Listing Identifiers in the Rights Database

You can also use the SYSS\$IDTOASC service to list the identifier names of all of the identifiers in the rights database. Specify the **id** argument as -1, initialize the **context** argument to 0, and repeatedly call SYSS\$IDTOASC until the status code SSS_NOSUCHID is returned. The SYSS\$IDTOASC service returns the identifier names in alphabetical order. When SSS_NOSUCHID is returned, SYSS\$IDTOASC clears the context longword and deallocates the record stream. If you complete your calls to SYSS\$IDTOASC before SSS_NOSUCHID is returned, use SYSS\$FINISH_RDB to clear the context longword and to deallocate the record stream.

The following programming example uses SYSS\$IDTOASC to identify all identifiers in a rights database:

```

Program ID_LIST
*
* Produce a list of all the identifiers
*
integer SYSS$IDTOASC
external SSS_NORMAL, SSS_NOSUCHID
character*31 NAME
integer IDENTIFIER, ATTRIBUTES
integer ID/-1/, LENGTH, CONTEXT/0/
integer NAME_DSC(2)/31, 0/

```

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```
integer STATUS
*
* Initialization
*
NAME_DSC(2) = %loc(NAME)
STATUS = %loc(SS$NORMAL)
*
* Scan through the entire RDB ...
*
do while (STATUS .and. (STATUS .ne. %loc(SS$NOSUCHID)))
STATUS = SYS$IDTOASC(%val(ID), LENGTH, NAME_DSC,
+ IDENTIFIER, ATTRIBUTES, CONTEXT)
if (STATUS .and. (STATUS .ne. %loc(SS$NOSUCHID))) then
NAME(LENGTH+1:LENGTH+1) = ', '
print 1, NAME, IDENTIFIER, ATTRIBUTES
1 format(1X, 'Name: ', A31, ' Id: ', Z8, ', Attributes: ', Z8)
end if
end do
*
* Do we need to finish the RDB ???
*
if (STATUS .ne. %loc(SS$NOSUCHID)) then
call SYS$FINISH_RDB(CONTEXT)
end if
end
```

31.3.2.2 Adding Identifiers and Holders to the Rights Database

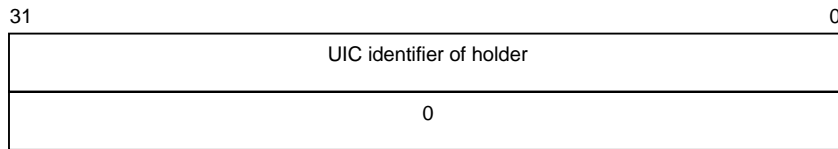
To add identifiers to the rights database, use the `SYSSADD_IDENT` service in a program. When you call `SYSSADD_IDENT`, use the **name** argument to pass the identifier name you want to add. You can specify an identifier value with the **id** argument; however, if you do not specify a value, the system selects an identifier value from the general identifier space.

In addition to defining the identifier value and identifier name, you use `SYSSADD_IDENT` to specify attributes in the identifier record. Attributes are enabled for a holder of an identifier *only* when they are set in both the identifier record and the holder record. The **attrib** argument is a longword containing a bit mask specifying the attributes. The symbol `KGB$V_RESOURCE`, defined in the system macro library `$KGBDEF`, sets the Resource bit in the attribute longword, and the symbol `KGB$V_DYNAMIC` sets the Dynamic bit. (You can use the prefix `KGB$M` rather than `KGB$V`.) See the description of `SYSSADD_IDENT` in the *OpenVMS System Services Reference Manual* for a complete list of symbols.

When `SYSSADD_IDENT` successfully completes execution, a new identifier record containing the identifier value, the identifier name, and the attributes of the identifier exists in the rights database.

When the identifier record exists in the rights database, you define the holders of that identifier with the `SYSSADD HOLDER` system service. You pass the binary identifier value with the **id** argument and you specify the holder with the **holder** argument, which is the address of a quadword data structure in the following format. Figure 31–6 shows the format of the **holder** argument.

Figure 31–6 Format of the Holder Argument



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In the rights database, the holder identifier is in UIC format. You specify the attributes of the holder with the **attrib** argument in the same manner as with SYSSADD_IDENT.

After SYSSADD_HOLDER completes execution, a new holder record containing the binary value of the identifier that the holder holds, the attributes of the holder, and the UIC of the holder exists in the rights database.

31.3.2.3 Determining Holders of Identifiers

To determine the holders of a particular identifier, use the SYSSFIND_HOLDER service in a program. When you call SYSSFIND_HOLDER, use the **id** argument to pass the binary value of the identifier whose holder you want to determine. On successful execution, SYSSFIND_HOLDER returns the holder identifier with the **holder** argument and the attributes of the holder with the **attrib** argument.

You can identify all of the identifier's holders by initializing the **context** argument to 0 and repeatedly calling SYSSFIND_HOLDER, as detailed in Section 31.3.3. Because SYSSFIND_HOLDER identifies the records by the same key (holder ID), it returns the records in the order in which they were written.

31.3.2.4 Determining Identifiers Held by a Holder

To determine the identifiers held by a holder, use the SYSSFIND_HELD service in a program. When you call SYSSFIND_HELD, use the **holder** argument to specify the holder whose identifier is to be found.

On successful execution, SYSSFIND_HELD returns the identifier's binary identifier value and attributes.

You can identify all the identifiers held by the specified holder by initializing the **context** argument to 0 and repeatedly calling SYSSFIND_HELD, as detailed in Section 31.3.3. Because SYSSFIND_HELD identifies the records by the same key (identifier), it returns the records in the order in which they were written.

31.3.2.5 Modifying the Identifier Record

To modify an identifier record by changing the identifier's name, value, or attributes, or all three in the rights database, use the SYSSMOD_IDENT service in a program. Use the **id** argument to pass the binary value of the identifier whose record you want to modify. To enable attributes, use the **set_attrib** argument, which is a longword containing a bit mask specifying the attributes. The symbol KGB\$V_RESOURCE, defined in the system macro library \$KGBDEF, sets the Resource bit in the attribute longword. The symbol KGB\$V_DYNAMIC sets the Dynamic bit. (You can use the prefix KGB\$M rather than KGB\$V.) See the description of SYSSMOD_IDENT in the *OpenVMS System Services Reference Manual* for a complete list of symbols.

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If you want to disable the attributes for the identifier, use the **clr_attrib** argument, which is a longword containing a bit mask specifying the attributes. If the same attribute is specified in **set_attrib** and **clr_attrib**, the attribute is enabled.

You can also change the identifier name, value, or both with the **new_name** and **new_value** arguments. The **new_name** argument is the address of a descriptor pointing to the identifier name string; **new_value** is a longword containing the binary identifier value. If you change the value of an identifier that is the holder of other identifiers (a UIC, for example), SYSSMOD_IDENT updates all the corresponding holder records with the new holder identifier value.

When SYSSMOD_IDENT successfully completes execution, a new identifier record containing the identifier value, the identifier name, and the attributes of the identifier exists in the rights database.

31.3.2.6 Modifying a Holder Record

To modify a holder record, use the SYSSMOD_HOLDER service in a program. When you call SYSSMOD_HOLDER, use the **id** argument and the **holder** argument to pass the binary identifier value and the UIC holder identifier whose holder record you want to modify.

Use the SYSSMOD_HOLDER service to enable or disable the attributes of an identifier in the same way as with SYSSMOD_HOLDER.

When SYSSMOD_HOLDER completes execution, a new holder record containing the identifier value, the identifier name, and the attributes of the identifier exists in the rights database.

The following programming example uses SYSSMOD_HOLDER to modify holder records in the rights database:

```
Program MOD_HOLDER
*
* Modify the attributes of all the holders of identifiers to reflect
* the current attribute setting of the identifiers themselves.
*
external SS$NOSUCHID
parameter KGB$M_RESOURCE = 1, KGB$M_DYNAMIC = 2
integer SYS$IDTOASC, SYS$FIND_HELD, SYSSMOD_HOLDER
*
* Store information about the holder here.
*
integer HOLDER(2)/2*0/
equivalence (HOLDER(1), HOLDER_ID)
integer HOLDER_NAME(2)/31, 0/
integer HOLDER_ID, HOLDER_CTX/0/
character*31 HOLDER_STRING
*
* Store attributes here.
*
integer OLD_ATTR, NEW_ATTR, ID_ATTR, CONTEXT
*
* Store information about the identifier here.
*
integer IDENTIFIER, ID_NAME(2)/31, 0/
character*31 ID_STRING
```


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```
integer STATUS
*
* Initialize the descriptors.
*
    HOLDER_NAME(2) = %loc(HOLDER_STRING)
    ID_NAME(2) = %loc(ID_STRING)
*
* Scan through all the identifiers.
*
    do while
+   (SYS$IDTOASC(%val(-1)),, HOLDER_NAME, HOLDER_ID,, HOLDER_CTX)
+   .ne. %loc(SS$_NOSUCHID)
*
* Test all the identifiers held by this identifier (our HOLDER).
*
    if (HOLDER_ID .le. 0) go to 2
    CONTEXT = 0
    do while
+   (SYS$FIND_HELD(HOLDER, IDENTIFIER, OLD_ATTR, CONTEXT)
+   .ne. %loc(SS$_NOSUCHID))
*
* Get name and attributes of held identifier.
*
        STATUS = SYS$IDTOASC(%val(IDENTIFIER),, ID_NAME,, ID_ATTR,)
*
* Modify the holder record to reflect the state of the identifier itself.
*
    if ((ID_ATTR .and. KGB$M_RESOURCE) .ne. 0) then
        STATUS = SYS$MOD_HOLDER
+       (%val(IDENTIFIER), HOLDER, %val(KGB$M_RESOURCE),)
        NEW_ATTR = OLD_ATTR .or. KGB$M_RESOURCE
    else
        STATUS = SYS$MOD_HOLDER
+       (%val(IDENTIFIER), HOLDER,, %val(KGB$M_RESOURCE))
        NEW_ATTR = OLD_ATTR .and. (.not. KGB$M_RESOURCE)
    end if
    if ((ID_ATTR .and. KGB$M_DYNAMIC) .ne. 0) then
        STATUS = SYS$MOD_HOLDER
+       (%val(IDENTIFIER), HOLDER, %val(KGB$M_DYNAMIC),)
        NEW_ATTR = OLD_ATTR .or. KGB$M_DYNAMIC
    else
        STATUS = SYS$MOD_HOLDER
+       (%val(IDENTIFIER), HOLDER,, %val(KGB$M_DYNAMIC))
        NEW_ATTR = OLD_ATTR .and. (.not. KGB$M_DYNAMIC)
    end if
*
* Was it successful?
*
    if (.not. STATUS) then
        NEW_ATTR = OLD_ATTR
        call LIB$SIGNAL(%val(STATUS))
    end if
*
* Report it all.
*
```

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```
        print 1, HOLDER_STRING, ID_STRING,
+         OLD_ATTR, ID_ATTR, NEW_ATTR
1      format(1X, 'Holder: ', A31, ' Id: ', A31,
+         ' Old: ', Z8, ' Id: ', Z8, ' New: ', Z8)

        end do
2      continue

    end do
end
```

31.3.2.7 Removing Identifiers and Holders from the Rights Database

To remove an identifier and all of its holders, use the SYSSREM_IDENT service in a program. When you call SYSSREM_IDENT, use the **id** argument to pass the binary value of the identifier you want to remove. When SYSSREM_IDENT completes execution, the identifier and all of its associated holder records are removed from the rights database.

To remove a holder from the list of an identifier's holders, use the SYSSREM_HOLDER service in a program. When you call SYSSREM_HOLDER, use the **id** argument and the **holder** argument to pass the binary ID value and the UIC identifier of the holder whose holder record you want to delete.

On successful execution, SYSSREM_HOLDER removes the holder from the list of the identifier's holders.

31.3.3 Search Operations

You can search the entire rights database when you use the SYSSIDTOASC, SYSSFIND_HELD, and SYSSFIND_HOLDER services. You initialize the context longword to 0 and repeatedly call one of the three services until the status code SSS_NOSUCHID is returned. When SSS_NOSUCHID is returned, the service clears the context longword and deallocates the record stream. If you complete your calls to one of these services before SSS_NOSUCHID is returned, you must use SYSSFINISH_RDB to clear the context longword and to deallocate the record stream.

The structure of the rights database affects the order in which each of these services returns the records when you search the rights database. The rights database is an indexed file with three keys. The primary key is the identifier binary value, the secondary key is the holder UIC identifier, and the tertiary key is the identifier name.

During a searching operation, the service obtains the first record with an indexed OpenVMS RMS GET operation. The key used for the GET operation depends on the service. The SYSSFIND_HOLDER service uses the identifier binary value; SYSSFIND_HELD uses the holder UIC identifier. After the indexed GET, the service returns the records with sequential RMS GET operations. Consequently, the file organization, the key used for the first GET operation, and the order in which the records were originally written in the database determine the order of records returned.

Table 31–2 summarizes how records are returned by the SYSSIDTOASC, SYSSFIND_HELD, and SYSSFIND_HOLDER services when used in a searching operation.

Table 31–2 Returned Records of SYS\$IDTOASC, SYS\$FIND_HELD, and SYS\$FIND HOLDER

Service	Record Order
SYS\$IDTOASC	Identifier name order.
SYS\$FIND_HELD	First GET operation—holder key. Subsequent records are returned in the order in which they were written.
SYS\$FIND HOLDER	First GET operation—identifier key. Subsequent records are returned in the order in which they were written.

The following programming example uses SYS\$IDTOASC, SYS\$FINISH_RDB, and SYS\$FIND HOLDER to search the entire rights database for identifiers with holders and produces a list of those identifiers and their holders:

```

Module ID HOLDER
(  main = MAIN,
  addressing_mode(external=GENERAL) ) =
begin
!
!   Produce a list of all the identifiers, that have holders,
!   with their respective holders.
!
!
!   Declarations:
!
  library
    'SYS$LIBRARY:LIB';
  forward routine
    MAIN;
  external routine
    LIB$PUT_OUTPUT,
    SYS$FAO,
    SYS$IDTOASC,
    SYS$FINISH_RDB,
    SYS$FIND HOLDER;
!
!   To create static descriptors
!
  macro S_DESCRIPTOR[NAME, SIZE] =
    own
      %name(NAME, '_BUFFER'): block[%number(SIZE), byte],
      %name(NAME): block[DSC$K_S_BLN, byte]
      preset( [DSC$B_CLASS] = DSC$K_CLASS_S,
              [DSC$W_LENGTH] = %number(SIZE),
              [DSC$A_POINTER] = %name(NAME, '_BUFFER') ); %;
!
!   Descriptors for ID, holder NAME, and output LINE
!
  S_DESCRIPTOR('ID_NAME', 31);
  S_DESCRIPTOR('NAME', 31);
  S_DESCRIPTOR('LINE', 76);
own
  STATUS,

```

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```

ID,
ID_LENGTH,
ID_CONTEXT: initial(0),

HOLDER,
LENGTH,
CONTEXT: initial(0),

ATTRIBS,
VALUE,
LINE_: block[DSC$K_S_BLN, byte]
        preset( [DSC$B_CLASS] = DSC$K_CLASS_S,
                [DSC$A_POINTER] = LINE_BUFFER );

!
!   To check for existence of an ID or HOLDER
!

macro CHECK(EXPRESSION) =
    (STATUS = %remove(EXPRESSION)) and (.STATUS neq SS$_NOSUCHID) %;

!
!   List all the identifiers, which have holders, with their holders.
!

routine MAIN =
begin

!
!   Examine all IDs (-1).
!

while
    CHECK(<SYS$IDTOASC(-1, ID_LENGTH, ID_NAME, ID, ATTRIBS, ID_CONTEXT)>)
do
    begin
        CONTEXT = 0;

!
!   Find all holders of ID.
!

        while CHECK(<SYS$FIND_HOLDER(.ID, HOLDER, ATTRIBS, CONTEXT)>) do
            begin

!
!   Translate the HOLDER to find its NAME.
!

                SYS$IDTOASC(.HOLDER, LENGTH, NAME, VALUE, ATTRIBS, 0);

!
!   Print a message reporting ID and HOLDER.
!

                SYS$FAO( %ascid'Id: !AD, Holder: !AD',
                        LINE_[DSC$W_LENGTH], LINE,
                        .ID_LENGTH, .ID_NAME[DSC$A_POINTER],
                        .LENGTH, .NAME[DSC$A_POINTER] );

                LIB$PUT_OUTPUT(LINE_);

            end;

        end;

    return SS$_NORMAL;

end;

end
eludom

```

31.3.4 Modifying a Rights List

When a process is created, LOGINOUT builds a rights list for the process consisting of the identifiers the user holds and any appropriate environmental identifiers. A **system rights list** is the default rights list used in addition to any process rights list. Modifications to the system rights list effectively become modifications to the rights of each process.

A privileged user can alter the process or system rights list with the SYS\$GRANTID or SYS\$REVOKID services. These services are not intended for the general system user. Use of these services requires CMKRNL privilege. The SYS\$GRANTID service adds an identifier to a rights list or, if the identifier is already part of the rights list, the SYS\$GRANTID service modifies the attributes of the identifier. The SYS\$REVOKID service removes an identifier from a rights list.

The SYS\$GRANTID and SYS\$REVOKID services treat the **pidadr** and **prcnam** arguments the same way all other process control services treat these arguments. For more details, see the *OpenVMS Guide to System Security*.

You can also modify the process or system rights list with the DCL command SET RIGHTS_LIST. Additionally, you can use SET RIGHTS_LIST to modify the attributes of the identifier if the identifier is already part of the rights list. Note that you cannot use the SET RIGHTS_LIST command to modify the rights database from which the rights list was created. For more information about using the SET RIGHTS_LIST command, see the *OpenVMS DCL Dictionary*.

31.4 Persona (Alpha Only¹)

A **persona** contains a user's security profile. The persona contains all identity and credential information about the process, including the username, UIC, privileges masks, and rights identifiers. Every process in the system has at least one persona, the **natural persona** of the process. The natural persona is created during process creation. OpenVMS stores a persona in a single data structure, the Persona Security Block (PSB).

The persona block (PSB) contains the following:

- UIC
- Persona and system rights chains
- Permanent, authorized, and working privileges
- Account name
- User name
- Auditing flags and counters

¹ Earlier versions of OpenVMS contained base support for the persona. The base support was provided by the SYS\$PERSONA_CREATE, SYS\$PERSONA_ASSUME, and SYS\$PERSON_DELETE system services. VAX support is limited to these base services.

System Security Services

31.4 Persona (Alpha Only¹)

31.4.1 Impersonation Services (Alpha Only)

For client/server applications, the server processes requests on behalf of the client. With OpenVMS, the server application developer can use impersonation services for client requests. This mechanism allows the operating system to perform object access checking (and auditing) for the server.

The impersonation system services allow a privileged OpenVMS process to create and use personae. A process, for example a server, can acquire more Persona System Blocks and switch between them using impersonation system services, such as `SYSSPERSONA_CREATE`, `SYSSPERSONA_ASSUME`, and `SYSSPERSONA_CLONE`. Each process has a persona array which is used to store the addresses of all PSBs allocated to the process. Other impersonation services support PSB lookup and attribute retrieval and modification, such as `SYSSPERSONA_FIND`, `SYSSPERSONA_QUERY`, and `SYSSPERSONA_MODIFY`, respectively.

31.4.1.1 Using Impersonation System Services

The following discussion assumes there is a running server that has the ability to impersonate clients and is able to perform work requests for clients. This could be a file server, for example.

When the client connects to the server, the server creates a user profile using the `SYSSPERSONA_CREATE` service with the username argument. The server can do the following to process a client's requests:

- Switch the server's execution context to the client's profile, which has been previously created, by having the server call `SYSSPERSONA_ASSUME`, specifying the client's persona.
- Make copies of the created profile and then execute client requests under thread control with a multithreaded server. That is, the server calls the `SYSSPERSONA_CLONE` service, specifying the client's persona as input, resulting in a copy. The server can now handle multiple requests from the client, using an available copy of the client's persona as input to `SYSSPERSONA_ASSUME`.
- Check to determine if a given client's profile already exists by calling `SYSSPERSONA_FIND`. The `SYSSPERSONA_FIND` service enables the caller to find the personae, within a process, that have certain attributes or settings. For example, the service could specify the `USERNAME` item as an attribute.
- Check the client's profile, since some client requests may require certain privileges or rights, by calling `SYSSPERSONA_QUERY`, specifying the persona to check and the items to retrieve. If required and allowable, the server can update the person's working privileges or rights by calling `SYSSPERSONA_MODIFY`, specifying the client's persona and the attributes to change.
- Remove a client's profiles with a client disconnects. The server again could use `SYSSPERSONA_FIND` to locate personae that match the client's `USERNAME` attribute. The server invokes `SYSSPERSONA_DELETE` to remove the specified persona from the server's process.

For more information about the persona system services, see the *OpenVMS System Services Reference Manual: GETUTC-Z*.

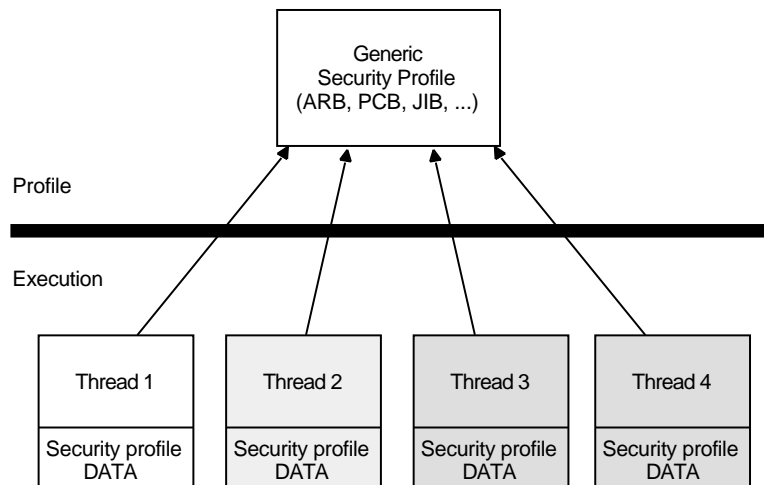
31.4.2 Per-Thread Security (Alpha Only)

OpenVMS provides per-thread security capabilities. With per-thread security, a multithreaded process allows each thread of execution to have an individual security profile. That is, a PSB is bound to a thread of execution. Each process has at least one kernel thread. The kernel thread block (KTB) points to the PSB for the currently active thread. Individual user threads can point to different PSBs, which give each user thread a separate identity. Per-thread security profiles are supported by impersonation system services and changes to the underlying system framework.

31.4.2.1 Previous Security Model

Prior to OpenVMS V7.2, the information that constitutes a user's security profile was bound at the process level, common to all threads of execution within a process. Figure 31-7 shows this relationship.

Figure 31-7 Previous Per-Thread Security Model



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Modifications that are made to the security profile by one thread are potentially visible to other threads, depending on two key factors:

- Whether multiple threads can truly execute simultaneously
- How the threads perform profile management among themselves

31.4.2.2 Per-Thread Security Model

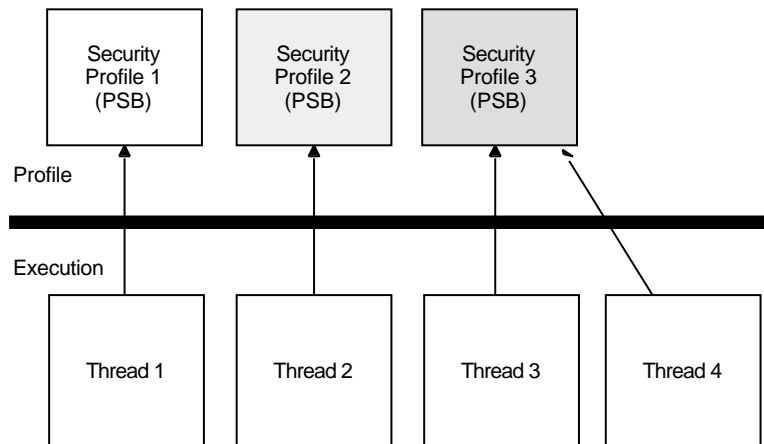
With OpenVMS Version 7.2, the users' security profile (that is, their privileges, rights, and identifier information) is shifted from the process level to the user thread level. The security information previously stored in several structures, including the Access Rights Block (ARB), the Process Control Block (PCB), the Process Header Descriptor (PHD), the Job Information Block (JIB), and the Control (CTL) region fields, has moved to the new Persona Security Block (PSB) data structure.

System Security Services

31.4 Persona (Alpha Only¹)

Each thread of execution can share a security profile with other threads or have a thread-specific security profile. Figure 31–8 shows these relationships.

Figure 31–8 Per-Thread Security Profile Model



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As is the case with the previous model, modifications to a shared profile are potentially visible to all threads that share the profile. However, modifications made to a thread-specific profile are only applicable to the particular thread.

For more information about per-thread security, see the *OpenVMS Guide to System Security*.

31.4.3 Persona Extensions (Alpha Only)

A **persona extension** is a mechanism to attach support for additional security credentials into the already existing persona support. This mechanism consists of extension-specific execlet-based code and an extension-specific data structure (PXB) attached to an existing persona block (PSB).

To extend these capabilities, **persona extension blocks (PXBs)** that represent identity and credential information of a security agent *other than OpenVMS* can be attached to a PSB. The process can therefore have multiple identities: for example, one for OpenVMS and one for NT.

An extension is more than just a data structure attached to a PSB. Routines provided by the extension are called to process the extension data structure. This leaves the layout of the PXB completely up to the author of the extension support routines. A new credential/security extension can be added to a system by simply creating the new extension routines that describe a PXB. This capability will be added in a future release of OpenVMS.

The new and existing SYSSPERSONA system services invoke extension-specific support routines on behalf of the registered extensions. The services also handle new item codes that describe values stored in the PXB. Besides operating on items for individually named extension-specific data, the services use other item codes to establish a current PXB on which subsequent items operate. Before using an extension-specific item code, that extension must be switched to by using the SWITCH_EXTENSION item code. A generic set of item codes pointing to

generally useful PXB values (for example, principal name and domain) can be used to fetch these values without concern for the extension-specific name.

31.5 Managing Object Protection

An ACL is a list of entries defining the type of access allowed to an object in the system such as a file, device, or mailbox. An access control entry (ACE) consists of an identifier and one or more access types.

```
( IDENTIFIER=GREEN ,ACCESS=WRITE+READ+CONTROL )
( IDENTIFIER=YELLOW ,ACCESS=READ )
( IDENTIFIER=RED ,ACCESS=NOACCESS )
```

Managing object protection involves using system services to manipulate protection codes, UICs, and ACEs; that is, creating, translating, and maintaining ACEs, establishing object ownership, and manipulating the protection codes of protected objects.

31.5.1 Protected Objects

A **protected object** is an entity that can contain or receive information. When such information is not considered shareable, access to those objects can be restricted. The system recognizes eleven classes of protected objects as shown in the following table:

Class Name	Description
Capability ¹	A resource to which the system controls access; currently, the only defined capability is the vector processor.
Common event flag cluster	A set of 32 event flags that enable cooperating processes to post event notifications to each other.
Device	A class of peripherals connected to a processor that are capable of receiving, storing, or transmitting data.
File	Files—11 On-Disk Structure Level 2 (ODS-2) files and directories.
Group global section	A shareable memory section potentially available to all processes in the same group.
Logical name table	A shareable table of logical names and their equivalence names for the system or a particular group.
Queue	A set of jobs to be processed in a batch, terminal, server, or print job queue.
Resource domain	A namespace controlling access to the lock manager's resources.
Security class	A data structure containing the elements and management routines for all members of the security class.
System global section	A shareable memory section potentially available to all processes in the system.
Volume	A mass storage medium, such as a disk or tape, that is in ODS-2 format. Volumes contain files and may be mounted on devices.

¹Exists only on systems with vector processors

System Security Services

31.5 Managing Object Protection

31.5.2 Object Security Profile

The security profile summarizes the various types of protection mechanisms applied to a protected object. The security profile associates a protected object with an owner, a protection code, and optionally an ACL. When a user or process requests access to a protected object, the system compares the user's privileges and identifiers in the system authorization database with appropriate elements in the object's security profile.

31.5.2.1 Displaying the Security Profile

You can display an object's security profile by using the SYSSGET_SECURITY system service. On your first call to SYSSGET_SECURITY, be sure to initialize the context variable to 0. Use the OSSM_RELCTX flag to release any locks on the context structure when the routine completes execution. The following example illustrates the type of information contained in the security profile of a logical name table:

```
LNM$GROUP object of class LOGICAL_NAME_TABLE
  Owner: [ACCOUNTING]
  Protection: (System: RWCD, Owner: RWCD, Group: R, World: R)
  Access Control List:
    (IDENTIFIER=[USER,CHEHKOV],ACCESS=CONTROL)
    (IDENTIFIER=[USER,VANNEST],ACCESS=READ+WRITE)
```

After you have returned owner and protection code information, you can call SYSSGET_SECURITY iteratively to return each ACE in the ACL (if it exists) or you can read the entire ACL. In addition, you can perform iterative searches to retrieve objects and their templates.

31.5.2.2 Modifying the Security Profile

You can modify all the security characteristics listed in a protected object's profile by using the SYSSSET_SECURITY system service. You can add or delete ACEs in the ACL selectively or you can delete the entire ACL. You have the option of modifying a local copy of the profile without altering the master copy using the OSSM_LOCAL flags or you can modify the master copy directly. Also, use the context to release the context structure after the service completes execution.

31.5.3 Types of Access Control Entries

There are seven types of security-related ACEs as described in the following table:

ACE	Description
Alarm	Sets an alarm
Application	Contains application-dependent information
Audit	Sets a security audit
Creator	Controls access to an object based on creators
Default Protection	Specifies the default protection for all files and subdirectories created in the directory
Identifier	Controls the type of access allowed based on identifiers
Subsystem	Maintains protected subsystems

For information about the structure of specific types of ACEs, see the SYSSFORMAT_ACL system service in *OpenVMS System Services Reference Manual*.

You use SYSS\$FORMAT_ACL and SYSS\$PARSE_ACL to translate ACEs from one format to another in the same way that SYSS\$IDTOASC and SYSS\$ASCTOID translate identifiers from binary to text format and text to binary format.

To create and manipulate ACLs, use the ACL editor, the DCL command SET ACL, or the SYSS\$GET_SECURITY and SYSS\$SET_SECURITY system services in a program. The following table lists services that manipulate ACEs:

Service	Description
SYSS\$FORMAT_ACL	Converts an ACE from binary format to ASCII text
SYSS\$GET_SECURITY	Retrieves the security characteristics of an object
SYSS\$PARSE_ACL	Converts an ACE from ASCII text to binary format
SYSS\$SET_SECURITY	Modifies the security characteristics of a protected object

31.5.3.1 Design Considerations

Before you attempt to manipulate ACLs, you should understand the meaning and relationship among existing identifiers. If you are populating a previously empty ACL, you need to plan the access types and position of each ACE within the ACL.

The position of the ACE within the ACL is an important consideration when creating an ACE. By default, ACEs are added to the top of an ACL. The ACL management services accept options allowing you to control the placement of ACEs. The system compares the identifiers granted to the process requesting access with those associated with the object starting with the top ACE in the object's ACL. Once a matching identifier name is found in the object's ACL, the search stops.

31.5.3.2 Translating ACEs

To translate ACEs from binary format to a text string, use the SYSS\$FORMAT_ACL service. The **aclent** argument is the address of a descriptor pointing to a buffer containing the description of the ACE. The first byte of the buffer contains the length of the ACE and the second byte contains the type, which in turn defines the format of the ACE.

The **acllen** argument specifies the length of the text string written to the buffer pointed to by **aclstr**. You use the **width**, **trmdsc**, and **indent** arguments to specify a particular width, termination character, and number of blank characters for an ACE. The **accnam** argument contains the address of an array of 32 quadword descriptors called an **access name table**. The access name table defines the names of the bits in the access mask of the ACE. The access mask defines the access types associated with a protected object. Use run-time library (RTL) routine LIB\$GET_ACCNAM described in the *OpenVMS RTL Library (LIB\$) Manual* to obtain the address of the access name table. If **accnam** is omitted, the following names are used:

System Security Services

31.5 Managing Object Protection

```

Bit <0>   READ
Bit <1>   WRITE
Bit <2>   EXECUTE
Bit <3>   DELETE
Bit <4>   CONTROL
Bit <5>   BIT_5
Bit <6>   BIT_6
.
.
.
Bit <31>  BIT_31

```

The SYSSPARSE_ACL service translates an ACE from text string format to binary format. The **aclstr** argument is the address of a string descriptor pointing to the ACE text string. As with SYSSFORMAT_ACL, the **acilent** argument is the address of a descriptor pointing to a buffer containing the description of the ACE. The first byte of the buffer contains the length of the ACE and the second byte contains the type, which in turn defines the format of the ACE. If SYSSPARSE_ACL fails, the **errpos** argument points to the failing point in the string. The **accnam** argument contains the address of an array of 32 quadword descriptors that define the names of the bits in the access mask of the ACE. If **accnam** is omitted, the names specified in the description of SYSSFORMAT_ACL are used.

31.5.3.3 Creating and Maintaining ACEs

The SYSSGET_SECURITY and SYSSSET_SECURITY system services replace the SYSSCHANGE_ACL system service. The *OpenVMS System Services Reference Manual: A-GETUAI* and the *OpenVMS System Services Reference Manual: GETUTC-Z* describe these system services.

To create or modify an ACL associated with a protected object, you use the SYSSSET_SECURITY service. You specify the object whose ACL is to be modified with either the **objhan** argument, which specifies the I/O channel associated with the object, or the **objnam** argument, which specifies the object name. If you specify **objnam**, **objhan** must be omitted or specified as 0. The **clsnam** argument specifies the type of object.

Use the **acmode** argument to specify the access mode used when checking file access protection. By default, kernel mode is used, but the system compares **acmode** against the caller's access mode and uses the least privileged mode. Compaq recommends that this argument be omitted (passed as zero).

The item code specifies the change to be made to the ACL. Table 31–3 describes the symbols for the item codes that are defined in the system macro library (\$ACLDEF). Note that without the **itmlst** argument, you can manipulate only the security profile locks or release **contxt** resources.

Table 31–3 Item Code Symbols and Meanings

Item Code	Description
OSS\$_ACL_ADD_ENTRY	Adds an access control entry (ACE)
OSS\$_ACL_DELETE	Deletes all unprotected ACEs from an ACL
OSS\$_ACL_DELETE_ALL	Deletes the ACL, including protected ACEs
OSS\$_ACL_DELETE_ENTRY	Deletes an ACE

(continued on next page)

Table 31–3 (Cont.) Item Code Symbols and Meanings

Item Code	Description
OSS\$_ACL_FIND_ENTRY	Locates an ACE
OSS\$_ACL_FIND_NEXT	Moves the current position to the next ACE in the ACL
OSS\$_ACL_FIND_TYPE	Locates an ACE of the specified type
OSS\$_ACL_MODIFY_ENTRY	Replaces an ACE at the current position
OSS\$_ACL_POSITION_BOTTOM	Sets a marker that points to the end of the ACL
OSS\$_ACL_POSITION_TOP	Sets a marker that points to the beginning of the ACL
OSS\$_OWNER	Sets the UIC or general identifier of the object's owner
OSS\$_PROTECTION	Sets the protection code of the object

31.6 Protected Subsystems

A protected subsystem is a set of application programs that allows controlled access to objects. It has under its control one or more protected objects and a gatekeeper application. Users cannot access the objects within the subsystem unless they execute the gatekeeper application. Once users have successfully executed the application, their process rights list acquires the identifiers necessary to access objects owned by the subsystem. The identifiers allow processes to use the resources of the subsystem. When the application completes execution or the user exits, the identifiers are removed from the user's process rights list. Protected subsystems are an alternative to creating privileged images and protected shareable images (user-written system services), and help prevent the overuse of privileges.

Roles and Responsibilities

You should think of a protected subsystem as an isolated security domain where the system manager creates and grants SUBSYSTEM identifiers using the Authorize utility as shown in the following example:

```
UAF> ADD/IDENTIFIER FOO/ATTRIBUTES=SUBSYSTEM
UAF> GRANT/IDENTIFIER FOO FRANK /ATTRIBUTES=SUBSYSTEM
```

The system manager can delegate responsibility for the maintenance of the subsystem to subsystem managers who can associate existing identifiers with the subsystem executable and its data. In the following example, the manager of a protected subsystem creates an ACE in a subsystem's image and data files:

```
$ SET SECURITY BLOP.EXE -
_$_ /ACL=(SUBSYSTEM, IDENTIFIER=FOO) -
$ SET SECURITY BLOP.DAT -
_$_ /ACL=(IDENTIFIER=FOO, ACCESS=READ+WRITE) -
$ SET SECURITY BLOP.EXE -
_$_ /ACL=(IDENTIFIER=HARRY, ACCESS=EXECUTE) -
```

Finally, a user uses the protected subsystem to access data available only through the subsystem.

System Security Services

31.6 Protected Subsystems

Subsystem Security

During the execution of a protected subsystem, \$IMGACT adds subsystem identifiers to the image rights list. What happens if the user presses the Ctrl/Y key sequence during execution? Will the user retain whatever privileges were granted by the subsystem? If the user presses Ctrl/Y, image identifiers are removed from the process. Also, subprocesses do not inherit image identifiers by default. However, SYSSCREPRC and LIBSSPAWN do contain flags PRC\$M_SUBSYSTEM and SUBSYSTEM, respectively, that allow subprocesses to inherit image identifiers.

31.7 Security Auditing

Auditing is the recording of security-relevant activity as it occurs on a system. See the *OpenVMS Guide to System Security* for a list of all types of security-relevant activity or classes of **events** that are audited. The following table describes the security services that provide security auditing:

Service	Description
SYSSAUDIT_EVENT	Appends an event message to the system audit log file or sends an alarm to a security operator terminal
SYSSCHECK_PRIVILEGE	Determines whether the caller has the specified privileges or identifiers

The system service SYSSAUDIT_EVENT is used to report security events to the auditing system. It examines the settings of the DCL command SET AUDIT to determine if an event is enabled for auditing. If the event is enabled for alarms or audits, SYSSAUDIT_EVENT generates an audit record and appends it to the system audit log file (or sends an alarm to a security operator terminal) that identifies the process involved and lists information supplied by its caller.

31.8 Checking Access Protection

The operating system provides two system services that allow a process to check access to objects on the system: SYSSCHKPRO and SYSSCHECK_ACCESS. The SYSSCHKPRO service performs the system access protection check on a user attempting direct access to an object on the system; SYSSCHECK_ACCESS performs a similar check on a third party attempting access to an object. The following table describes the security services that provide access checking:

Service	Description
SYSSCHECK_ACCESS	Invokes a system access protection check on behalf of another user
SYSSCHKPRO	Invokes a system access protection check

The SYSSCHKPRO and SYSSCHECK_ACCESS system services have been extended to support auditing. The *OpenVMS Guide to System Security* describes how to use the auditing function. The *OpenVMS System Services Reference Manual: A-GETUAI* describes how to use the two system services. These services are described in the following sections.

31.8.1 Creating a Security Profile

The SYSS\$CREATE_USER_PROFILE system service returns a user profile, using information in the rights database and the system authorization database to generate the profile. The system services SYSS\$CHECK_ACCESS or SYSS\$CHKPRO accept as input the profile from SYSS\$CREATE_USER_PROFILE.

31.8.2 SYSS\$CHKPRO System Service

The SYSS\$CHKPRO system service invokes the access protection check used by the system. The service does not grant or deny access; rather, it performs the protection check. Subsequently, an application might grant or deny access to the specified object.

To pass the input and output information to SYSS\$CHKPRO, use the **itmlst** argument, which is the address of an item list of descriptors. The SYSS\$CHKPRO service compares the item list of the rights and privileges of the accessor to a list of the protection attributes of the object to be accessed. If the accessor can access the object, SYSS\$CHKPRO returns the status SSS\$_NORMAL; if the accessor cannot access the object, SYSS\$CHKPRO returns the status SSS\$_NOPRIV. The SYSS\$CHKPRO service does not grant or deny access. The subsystem itself must grant or deny access based on the output (SSS\$_NORMAL or SSS\$_NOPRIV) from SYSS\$CHKPRO.

The SYSS\$CHKPRO service also returns an item list of the rights or privileges that allowed the accessor access to the object, as well as the names of security alarms raised by the access attempt. For information about the item codes defined for SYSS\$CHKPRO, see the description of SYSS\$CHKPRO in the *OpenVMS System Services Reference Manual*.

See the *OpenVMS Guide to System Security* for a flowchart describing how SYSS\$CHKPRO evaluates an access request attempt.

31.8.3 SYSS\$CHECK_ACCESS System Service

The SYSS\$CHECK_ACCESS service performs a protection check on a third-party accessor. An example of this is a file server program that uses SYSS\$CHECK_ACCESS to ensure that an accessor (the third party) requesting a file has the required privileges to do so.

You pass the input and output information to SYSS\$CHECK_ACCESS by using the **itmlst** argument, which is the address of an item list of descriptors. You also pass the name of the accessor and the name and type of the object being accessed by using the **usrnam**, **objnam**, and **objtyp** arguments, respectively. The SYSS\$CHECK_ACCESS service compares the rights and privileges of the accessor to a list of the protection attributes of the object to be accessed. If the accessor can access the object, SYSS\$CHECK_ACCESS returns the status SSS\$_NORMAL; if the accessor cannot access the object, SYSS\$CHECK_ACCESS returns the status SSS\$_NOPRIV.

The SYSS\$CHECK_ACCESS service does not grant or deny access. The subsystem itself must explicitly grant or deny access based on the output (SSS\$_NORMAL or SSS\$_NOPRIV) from SYSS\$CHECK_ACCESS.

The SYSS\$CHECK_ACCESS service also returns an item list of the rights or privileges that allowed the accessor to access the object, as well as the names of security alarms raised by the access attempt. For information about the item codes defined for SYSS\$CHECK_ACCESS, see the description of SYSS\$CHECK_ACCESS in the *OpenVMS System Services Reference Manual*.

31.9 SYS\$CHECK_PRIVILEGE

The SYS\$CHECK_PRIVILEGE system service determines whether the caller has the specified privileges or identifiers. The service performs the privilege check and looks at the SET AUDIT settings to determine whether the system administrator enabled privilege auditing. When privilege auditing is enabled, SYS\$CHECK_PRIVILEGE generates an audit record. The audit record identifies the process (subject) and privilege involved, provides the result of the privilege check, and lists supplemental event information supplied by its caller. Privilege audit records usually contain either the DCL command line or the system service name associated with the privilege check.

SYS\$CHECK_PRIVILEGE completes asynchronously; that is, it does not wait for final status. For synchronous completion, use the SYS\$CHECK_PRIVILEGEW service.

31.10 Implementing Site-Specific Security Policies

Occasionally, you may need to write routines that implement site-specific policies or special algorithms. The routines that you write can either replace or augment built-in operating system policies. This section contains instructions for replacing key operating system security routines with routines that are specific to your site. Two types of routines are discussed: loadable system services and shareable images.

31.10.1 Creating Loadable Security Services

This section describes how to create a system service image and how to update the SYS\$LOADABLE_IMAGES:VMS\$SYSTEM_IMAGES.DATA file, which controls site-specific loading of system images. These procedures update the loading of system images for all nodes of a cluster.

Currently, you can replace the following three system services with services specific to your site:

Service	Description
SYSSERAPAT	Generates a security erasure pattern
SYS\$MTACCESS	Controls magnetic tape access
SYS\$HASH_PASSWORD	Applies a hash algorithm to an ASCII password

When you create the system service, you code the source module and define the vector offsets, the entry point, and the program sections for the system service. Then, you can assemble and link the module to create a loadable image.

Once you have created the loadable image, you install it. First, you copy the image into the SYS\$LOADABLE_IMAGES directory and add an entry for it in the operating system's images file using the System Management utility (SYSMAN). Next, you invoke the system images command procedure to generate a new system image data file. Finally, you reboot the system to load your service.

The following sections describe how to create and load the the Get Security Erase Pattern (SYSSERAPAT) system service.

On VAX only systems, you can find an example of the SYSSERAPAT system service in SYS\$EXAMPLES:DOD_ERAPAT.MAR on the operating system. The description here also applies to the Hash Password (SYS\$HASH_PASSWORD) and Magnetic Tape Accessibility (SYS\$MTACCESS) system services. You can find

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31.10 Implementing Site-Specific Security Policies

an example of how to prepare and load the SYSSHASH_PASSWORD service in SYS\$EXAMPLES:HASH_PASSWORD.MAR.

31.10.1.1 Preparing and Loading a System Service

With the following VAX only example, use this procedure to prepare and load a system service, in this case SY\$SERAPAT:

1. Create the source module.
 - a. Include the following macro to define system service vector offsets:

```
$SYSVECTORDEF ; Define system service vector offsets
```

- b. Use the following macro to define the system service entry point:

```
SYSTEM_SERVICE ERAPAT, - ; Entry point name  
                <R4>, - ; Register to save  
                MODE=KERNEL,- ; Mode of system service  
                NARG=3 ; Number of arguments
```

(The code immediately following this macro is the first instruction of the SY\$SERAPAT system service.)

- c. Use the following macros to declare the desired program sections:

```
DECLARE_PSECT EXEC$PAGED_CODE ; Pageable code PSECT  
DECLARE_PSECT EXEC$PAGED_DATA ; Pageable data PSECT  
DECLARE_PSECT EXEC$NONPAGED_DATA ; Nonpageable data PSECT  
DECLARE_PSECT EXEC$NONPAGED_CODE ; Nonpageable code PSECT
```

2. Assemble the source module by using the following command:

```
$ MACRO DOD_ERAPAT+SYS$LIBRARY:LIB.MLB/LIB
```

3. Link the module to create a SY\$SERAPAT.EXE executive loaded image. You can link the module using the command procedure DOD_ERAPAT_LNK.COM in SYS\$EXAMPLES. (A command procedure is also available to link the SYSSHASH_PASSWORD example.) To link the SY\$SERAPAT module, enter the following command:

```
$ @SYS$EXAMPLES:DOD_ERAPAT_LNK.COM
```

4. Prepare the operating system image to be loaded.

- a. Copy the SY\$SERAPAT.EXE image produced by the link command into the SYS\$COMMON:[SYS\$LDR] directory. Note that privilege is required to put files into this directory.
 - b. Add an entry for the SY\$SERAPAT.EXE image in the SYS\$UPDATE:VM\$SYSTEM_IMAGES.IDX data file.

You add an entry by using the SYSMAN command SYS_LOADABLE ADD. (See the *OpenVMS System Management Utilities Reference Manual* for a description of this command.) For example, the following commands add an entry in VM\$SYSTEM_IMAGES.IDX for SY\$SERAPAT.EXE:

```
$ RUN SYS$SYSTEM:SYSMAN  
SYSMAN> SYS_LOADABLE ADD _LOCAL_ SY$SERAPAT -  
_SYSMAN> /LOAD_STEP = SYSINIT -  
_SYSMAN> /SEVERITY = WARNING -  
_SYSMAN> /MESSAGE = "failure to load SY$SERAPAT.EXE"
```

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This entry specifies that the SYSSERAPAT.EXE image is to be loaded by the SYSINIT process during the bootstrap. If there is an error loading the image, the following messages are printed on the console terminal:

```
%SYSINIT-E-failure to load SYSSERAPAT.EXE
-SYSINIT-E-error loading <SYS$LDR>SYSSERAPAT.EXE, status = "status"
```

The following table shows other error messages that may be returned:

Message	Meaning	User Action
NO_PHYSICAL_MEMORY	Physical memory is not available.	Check SYSGEN parameters.
NO_POOL	Amount of nonpaged pool is insufficient.	Check SYSGEN parameters.
MULTIPLE_ISDS	Encountered more than one image section of a given type.	Check link options.
BAD_GSD	An inconsistency was detected.	Verify that the image was linked properly.
NO_SUCH_IMAGE	The requested image cannot be located.	Check image name against images in SYSSLOADABLE_IMAGES.

- c. Invoke the SYSSUPDATE:VMS\$SYSTEM_IMAGES.COM command procedure to generate a new system image data file (VMS\$SYSTEM_IMAGES.DATA). The system bootstrap uses this image data file to load the appropriate images into the system.
- d. Reboot the system, which loads the original SYSSERAPAT.EXE image into the system. Subsequent calls to the SYSSERAPAT system service use the normal operating system routine.

As the default, the system bootstrap loads all images described in VMS\$SYSTEM_IMAGES.DATA. You can disable this feature by setting the special system parameter LOAD_SYS_IMAGES to 0.

31.10.1.2 Removing an Executive Loaded Image

With the following VAX only example, use this procedure to remove an executive loaded image; in this case, SYSSERAPAT.EXE:

1. Enter the following SYSMAN command:

```
SYSMAN> SYS_LOADABLE REMOVE _LOCAL_ SYSSERAPAT
```

2. Invoke the SYSSUPDATE:VMS\$SYSTEM_IMAGES.COM command procedure to generate a new system image data file (VMS\$SYSTEM_IMAGES.DATA). The system bootstrap uses this image data file to load the appropriate images into the system.
3. Reboot the system, which loads the installation-specific SYSSERAPAT.EXE image into the system. Subsequent calls to the SYSSERAPAT system service use the installation-specific routine.

As the default, the system bootstrap loads all images described in the system image data file (VMS\$SYSTEM_IMAGES.DATA). You can disable this functionality by setting the special system parameter LOAD_SYS_IMAGES to 0.

System Security Services

31.10 Implementing Site-Specific Security Policies

31.10.2 Installing Filters for Site-Specific Password Policies

A site security administrator can screen new passwords to make sure they comply with a site-specific password policy. (See the *OpenVMS Guide to System Security* for more information.) This section describes how a security administrator can encode the policy, create a shareable image and install it in SYS\$LIBRARY, and enable the policy by setting a SYSGEN parameter.

Installing and enabling a site-specific password policy image requires both SYSPRV and CMKRNL privileges.

31.10.2.1 Creating a Shareable Image

To compile and link a shareable image that filters passwords for words that are sensitive to your site, perform the following steps:

1. Create the source module VMS\$PASSWORD_POLICY.*.

Bliss and Ada examples of the policy module's interface, called VMS\$PASSWORD_POLICY.*, are located in SYS\$EXAMPLES.

Define two routine names in the source module: POLICY_PLAINTEXT and POLICY_HASH. These routines must be global (see your language reference for instructions on defining a global routine). The Set Password utility looks for these routine names and displays the message SYMNOTFOU either if the names are missing or if the routines are not defined as global.

2. Link the source file.

For VAX only examples, use the VMS\$PASSWORD_POLICY_LNK.COM command procedure, located in SYS\$EXAMPLES.

31.10.2.2 Installing a Shareable Image

To install a shareable image, perform the following steps:

1. Copy the file to SYS\$LIBRARY and install it using the following commands:

```
$ COPY VMS$PASSWORD_POLICY.EXE SYS$COMMON:[SYSLIB]/PROTECTION=(W:RE)
$ INSTALL ADD SYS$LIBRARY:VMS$PASSWORD_POLICY/OPEN/HEAD/SHARE
```

2. Set the system parameter LOAD_PWD_POLICY to 1 as follows:

```
$ RUN SYS$SYSTEM:SYSGEN
SYSGEN> USE ACTIVE
SYSGEN> SET LOAD_PWD_POLICY 1
SYSGEN> WRITE ACTIVE
SYSGEN> WRITE CURRENT
```

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3. To make the changes permanent, add the INSTALL command from step 1 to the SYSSSYSTEM:SYSTARTUP_VMS.COM file and modify the system parameter file, MODPARAMS.DAT, so that the LOAD_PWD_POLICY parameter is set to 1.
4. Run AUTOGEN as follows to ensure that the system parameters are set correctly on subsequent system startups:

```
$ @SYS$UPDATE:AUTOGEN SAVPARAMS SETPARAMS
```

Logical Name and Logical Name Tables

This chapter describes how to create and use logical names and logical name tables. It contains the following sections:

Section 32.1 describes how to use logical name system services and DCL commands, how to use logical and equivalence names, and how to use logical name tables.

Section 32.2 describes how to create user-defined and clusterwide logical name tables.

Section 32.3 describes how to check access and protection of logical names and logical name tables.

Section 32.4 describes how to specify access modes of a logical name.

Section 32.5 describes how to translate logical names.

Section 32.6 describes how to specify attributes.

Section 32.7 describes how to establish logical name table quotas.

Section 32.8 describes interprocess communication.

Section 32.9 describes the format convention for logical names and equivalence names.

Section 32.10 describes how to use logical name and logical name tables system services with example programs.

32.1 Logical Name System Services and DCL Commands

This section 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 certain system services. For further information, see the following chapters:

- Mailbox names and device names for I/O services: Chapter 9
- Common event flag cluster names: Chapter 6
- Global section names: Chapter 21

The operating system's 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 also use logical names to communicate information between processes by creating a logical name in one process in a shared logical name table and translating the logical name in another process.

Logical Name and Logical Name Tables

32.1 Logical Name System Services and DCL Commands

Besides using logical name system services, you can use DCL commands to create and manipulate logical names and logical name tables. Table 32–1 lists the operating system's logical name system services and equivalent DCL commands.

Table 32–1 Logical Name Services and DCL Commands

System Service	Meaning	DCL Command	Meaning
SYSSCRELNM	Create Logical Name	ALLOCATE	Optionally associates a logical name with a device
		ASSIGN	Creates a logical name and assigns an equivalence string to a specific logical name
		DEFINE	Associates an equivalence name with a logical name
		MOUNT	Allows the optional naming of a logical name for a disk or magnetic tape volume
SYSSCRELNT	Create Logical Name Table	CREATE/NAME_TABLE	Creates a new logical name table
SYSDDELLNM	Delete Logical Name	DEASSIGN	Cancels a logical name assignment
SYSTRNLNM	Translate Logical Name	SHOW LOGICAL	Displays translations and the logical name table for a specified logical name
		SHOW TRANSLATION	Displays the first translation found for the specified logical name

As the names of the logical name system services imply, when you use the logical name system services, you are concerned with creating, deleting, and translating logical names and with creating and deleting logical name tables.

The following sections describe various concepts you should be aware of when you use the logical name system services. For further discussion of logical names, see the *OpenVMS User's Manual*.

32.1.1 Logical Names, Equivalence Names, and Search Lists

A **logical name** is a user-specified character string that can represent a file specification, device name, logical name table name, application-specific information, or another logical name. Typically, for process-private purposes, you specify logical names that are easy to use and to remember. System managers and privileged users choose mnemonics for files, system devices, and search lists that are frequently accessed by all users.

An **equivalence string**, or an **equivalence name**, is a character string that denotes the actual file specification, device name, or character string. An equivalence name can also be a logical name. In this case, further translation is necessary to reveal the actual equivalence name.

A multivalued logical name, commonly called a **search list**, is a logical name that has more than one equivalence string. Each equivalence string in the search list is assigned an index number starting at zero.

Logical Name and Logical Name Tables

32.1 Logical Name System Services and DCL Commands

Logical names and their equivalence strings are stored in logical name tables. Logical names can have a maximum length of 255 characters. Equivalence strings can have a maximum of 255 characters. You can establish logical name and equivalence string pairs as follows:

- At the command level, with the DCL commands ALLOCATE, ASSIGN, DEFINE, or MOUNT
- In a program, with the Create Logical Name (SYSSCRELNM), Create Mailbox and Assign Channel (SYSSCREMBX), or Mount Volume (SYSSMOUNT) system service

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 DEFINE command to establish the equivalence name TTA2.

To create a logical name in a program, you must define character-string descriptors for the name strings and call the system service within your program.

32.1.2 Logical Name Tables

A logical name table contains logical name and equivalence string pairs. Each table is an independent name space. When you translate a logical name, you specify the table containing the name. A logical name table is referred to by its name, which is itself a logical name, or by another logical name that translates into the table name.

Logical name tables can be created in process space or in system space. Tables created in process space are accessible only by that process. Tables created in system space are potentially shareable among many processes. OpenVMS creates a number of logical name tables with specific characteristics. These predefined logical name tables have names beginning with the prefix LNMS.

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

- Directory tables
- Default tables
- User-defined name tables

32.1.2.1 Logical Name Directory Tables

Because the names of logical name tables are logical names, table names must reside in logical name tables. Two special tables called **directories** exist for this purpose. Table names are translated from these logical name directory tables. Logical name and equivalence name pairs for logical name tables are maintained in the following two directory tables:

- Process directory table (LNMSPROCESS_DIRECTORY)
- System directory table (LNMSYSTEM_DIRECTORY)

The process directory table contains the names of all process-private user-defined logical name tables created through the SYSSCRELNT system service. In addition, the process directory table contains system-assigned logical name table names and the name of the process logical name table LNMSPROCESS_TABLE.

The system directory table contains the names of potentially shareable logical name tables and system-assigned logical name table names. Typically, you must have the SYSPRV privilege to create a logical name in the system directory table. For a discussion of privileges, see Section 32.3.

Logical Name and Logical Name Tables

32.1 Logical Name System Services and DCL Commands

Logical names other than logical name table names can exist within these tables, but are strongly discouraged. The length of the logical names and table names created in either of these tables must not exceed 31 characters. Logical table names and logical names created in the directory tables must consist of uppercase alphanumeric characters, dollar signs (\$), and underscores (_). Equivalence strings must not exceed 255 characters.

32.1.2.2 Process, Job, Group, System and Clusterwide Default Logical Name Tables

OpenVMS creates a number of logical name tables automatically, some at system initialization and some at process creation. Some of these tables are accessible to all processes, and some are accessible only to selected processes. These tables are called the **default logical name tables**.

Each default logical name table has a logical name associated with it in addition to its table name. The default logical name table names and the common logical names used to refer to them are as follows:

Table	Name	Logical Name
Process	LNMS\$PROCESS_TABLE	LNMS\$PROCESS
Job	LNMS\$JOB_XXXXXXXX ¹	LNMS\$JOB
Group	LNMS\$GROUP_GGGGGG ²	LNMS\$GROUP
System	LNMS\$SYSTEM_TABLE, LNMS\$SYSCLUSTER	LNMS\$SYSTEM
Clusterwide system table	LNMS\$SYSCLUSTER_TABLE	LNMS\$SYSCLUSTER
Clusterwide parent table	LNMS\$CLUSTER_TABLE	LNMS\$CLUSTER

¹The letter *x* represents a numeral in an 8-digit hexadecimal number that uniquely identifies the job logical name table.

² The letter *g* represents a numeral in a 6-digit octal number that contains the user's group number.

The length of the logical names created in these tables cannot exceed 255 characters, with no restriction on the types of characters used. Equivalence strings cannot exceed 255 characters. By convention, a Compaq-created logical name begins with a facility-specific prefix, followed by a dollar sign (\$) and a name within that facility. You are strongly encouraged to define logical names without the dollar sign (\$) to avoid inadvertent conflicts.

32.1.2.2.1 Process Logical Name Table The process logical name table LNMS\$PROCESS_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. The process logical name table contains the following process-permanent logical names:

Logical Name	Meaning
SYSS\$INPUT	Default input stream
SYSS\$OUTPUT	Default output stream
SYSS\$COMMAND	Original first-level (SYSS\$INPUT) input stream

Logical Name and Logical Name Tables

32.1 Logical Name System Services and DCL Commands

Logical Name	Meaning
SYSS\$ERROR	Default device to which the system writes error messages

SYSS\$COMMAND is created only for processes that execute LOGINOUT.

Usually, you create logical names only in your process logical name table. Most entries in the process logical name table are made in user or supervisor mode.

Process logical names that are created in user mode are deleted whenever the creating process runs an image down. The following DCL commands illustrate this behavior with supervisor mode and /TABLE=LNMS\$PROCESS as the defaults (default mode and default table) for the DEFINE command:

```
$ DEFINE/USER ABC XYZ
$ SHOW TRANSLATION ABC
  ABC   = XYZ
$ DIRECTORY
  .
  .
  .
$ SHOW LOGICAL ABC
  ABC   = (undefined)
```

The DCL command DIRECTORY performs image rundown when it is finished operating. At that time, all user-mode process-private logical names are deleted, including the logical name ABC.

32.1.2.2.2 Job Logical Name Table The job logical name table is a shareable table that is accessible by all processes within the same job tree. Whenever a detached process is created, a job logical name table is created for this process and for all of its potential subprocesses. At the same time, the process-private logical name LNMS\$JOB is created in the process directory logical name table LNMS\$PROCESS_DIRECTORY. The logical name LNMS\$JOB translates to the name of the job logical name table.

Because the job logical name table already exists for the main process, only the process-private logical name LNMS\$JOB is created when a subprocess is created.

The job logical name table contains the following three process-permanent logical names for processes that execute LOGINOUT:

Logical Name	Meaning
SYSS\$LOGIN	Original default device and directory
SYSS\$LOGIN_DEVICE	Original default device
SYSS\$SCRATCH	Default device and directory to which temporary files are written

Instead of creating these logical names within the process logical name table LNMS\$PROCESS_TABLE for every process within a job tree, LOGINOUT creates these logical names once when it is executed for the process at the root of the job tree.

Additionally, the job logical name table can contain the following logical names:

- The logical name optionally specified and associated with a newly created temporary mailbox

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32.1 Logical Name System Services and DCL Commands

- The logical name optionally specified and associated with a privately mounted volume

You do not need special privileges to modify the job logical name table. For a discussion of privileges, see Section 32.3.

32.1.2.2.3 Group Logical Name Table The group logical name table contains names that cooperating processes in the same group can use. You need the GRPNAM privilege to add or delete a logical name in the group logical name table. For a discussion of privileges, see Section 32.3.

A group logical name table is created when a top-level process with a unique group code is created. The logical name LNM\$GROUP exists in each process's process directory LNM\$PROCESS_DIRECTORY. This logical name translates into the name of the group logical name table.

32.1.2.2.4 System Logical Name Table The system logical name table LNM\$SYSTEM_TABLE contains names that all processes in the system can access. This table includes the default names for all system-assigned logical names. You need the SYSNAM or SYSPRV privilege to add or delete a logical name in the system logical name table. For a discussion of privileges, see Section 32.3.

The system logical table contains system-assigned logical names accessible to all processes in the system. For example, the logical names SY\$LIBRARY and SY\$SYSTEM provide logical names that all users can access to use the device and directory that contain system files.

Logical Name	Equivalence Name
SY\$LIBRARY	SY\$SYSROOT:[SY\$LIB]
SY\$SYSTEM	SY\$SYSROOT:[SY\$EXE]
...	...
...	...
...	...

The Logical Names section of the *OpenVMS User's Manual* contains a list of these system-assigned logical names.

32.1.2.2.5 Clusterwide Logical Name Table The clusterwide system logical name table LNM\$SYSCLUSTER_TABLE contains names that all processes in the cluster can access. This is the clusterwide table that contains system logical names. Because this table exists on all systems, the programs and command procedures that use clusterwide logical names are transportable to both clustered and nonclustered systems. The names in this table are available to anyone translating a logical name using SHOW LOGICAL/SYSTEM and specifying a table name of LNM\$SYSTEM, or LNM\$DCL_LOGICAL (DCL's default table search list), or LNM\$FILE_DEV (system and RMS default).

LNM\$SYSCLUSTER is the logical name for LNM\$SYSCLUSTER_TABLE. It is provided for convenience in referencing LNM\$SYSCLUSTER_TABLE and it is consistent in format with LNM\$SYSTEM_TABLE and its logical name, LNM\$SYSTEM.

You need either the SYSNAM or SYSPRV privilege or write access to the table to create or delete a name in this table.

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32.1 Logical Name System Services and DCL Commands

The definition of LNM\$SYSTEM has been expanded to include LNM\$SYSCLUSTER. When a system logical name is translated, the search order is LNM\$SYSTEM_TABLE, LNM\$SYSCLUSTER.

The clusterwide logical name table LNM\$CLUSTER_TABLE is the parent table for all logical names, including LNM\$SYSCLUSTER_TABLE. When you create a new table using LNM\$CLUSTER_TABLE as the parent table, the new table will be available clusterwide.

LNM\$CLUSTER is the logical name for LNM\$CLUSTER_TABLE. It is provided for convenience in referencing LNM\$CLUSTER_TABLE.

You need either the SYSPRV privilege or write access to the table to create or delete a name in this table.

Logical names in these two tables and their descendant tables are clusterwide. Creation and deletion of cluster wide logical names are replicated on other nodes of the cluster. Creation and deletion of clusterwide logical name tables are replicated on other nodes of the cluster. When a node boots into a cluster, it receives the current set of clusterwide logical names.

LNM\$SYSCLUSTER_TABLE and LNM\$CLUSTER_TABLE are created on all systems, regardless of whether they are cluster nodes. Their existence enables OpenVMS to maintain a consistent application environment.

32.1.3 Logical Name Table Names and Search Lists

The process, job, group, and system tables are typically referred to indirectly. For example, the process table is usually specified as LNM\$PROCESS. This indirect reference enables you to redefine LNM\$PROCESS as multiple equivalence names and thus include one or more of your own tables in it.

The system table is specified as LNM\$SYSTEM. The logical name LNM\$SYSTEM is defined as LNM\$SYSTEM_TABLE, LNM\$SYSCLUSTER. Thus, it includes both systemwide names specific to the node and systemwide names common to all nodes in the cluster. When a system name is translated, the search order is LNM\$SYSTEM_TABLE, LNM\$SYSCLUSTER.

As described in the *OpenVMS User's Manual*, OpenVMS automatically defines a number of logical names, some of which are names of logical name tables. In addition to the table names in the table in Section 32.1.2.2, OpenVMS defines LNM\$FILE_DEV and LNM\$DCL_LOGICAL.

RMS and other system components specify the table LNM\$FILE_DEV for file specification and device name translations. Its definition is LNM\$PROCESS, LNM\$JOB, LNM\$GROUP, LNM\$SYSTEM. Thus, the precedence order for resolving logical names using this search list is as follows:

```
process-->job-->group-->system-->clusterwide system
```

The table name LNM\$DCL_LOGICAL is used for the SHOW LOGICAL and SHOW TRANSLATION DCL commands and for the logical name lexical functions. Its definition is LNM\$FILE_DEV.

Logical Name and Logical Name Tables

32.1 Logical Name System Services and DCL Commands

32.1.4 Specifying the Logical Name Table Search List

Logical names exist as entries within logical name tables. When a logical name is to be created, deleted, or translated, you must specify or take the default name that designates the logical name table that contains the logical name. This name possesses one or more of the following characteristics:

- It is the name of a logical name table.
- It is a logical name that iteratively translates in the process or system directory table to the name of a logical name table.
- It is a multivalued logical name (search list) that iteratively translates to the names of several logical name tables. The tables are used in the order in which they appear.

As mentioned in Section 32.1.2, predefined logical names exist for certain logical name tables. These predefined names begin with the prefix LNMS\$. You can redefine these names to modify the search order or the tables used.

Instead of a fixed set of logical name tables and a rigidly defined order (process, job, group, system) for searching those tables, you can specify which tables are to be searched and the order in which they are to be searched. Logical names in the directory tables are used to specify this searching order. By convention, each class of logical name (for example, device or file specification) uses a particular predefined name for this purpose.

For example, LNMS\$FILE_DEV is the logical name that defines the list of logical name tables used whenever file specifications or device names are translated by OpenVMS RMS or the I/O services. LNMS\$FILE_DEV is the default for file specifications and device names. This name must translate to a list of one or more logical name table names that specify the tables to be searched when translating file specifications.

By default, LNMS\$FILE_DEV specifies that the process, job, group, and system tables are all searched, in that order, and that the first match found is returned.

Logical name table names are translated from two tables: the process logical name directory table LNMS\$PROCESS_DIRECTORY and the system logical name directory table LNMS\$SYSTEM_DIRECTORY. The LNMS\$FILE_DEV logical name table must be defined in one of these tables.

Thus, if identical logical names exist in the process and group tables, the process table entry is found first, and the job and group tables are 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-mode entries second, and so on.

If you want to change the list of tables used for device and file specifications, you can redefine LNMS\$FILE_DEV in the process directory table LNMS\$PROCESS_DIRECTORY.

32.2 Creating User-Defined and Clusterwide Logical Name Tables

You can create process-private tables and shareable tables by calling the SYSS\$CRELNT system service in a program, or with the DCL command CREATE /NAME_TABLE. However, to create a shareable table you must have create (C) access to the parent table and either SYSPRV privilege or write (W) access to LNMS\$SYSTEM_DIRECTORY. If granted access, processes other than the creating process can use shareable tables. For a discussion of privileges, see Section 32.3.

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32.2 Creating User-Defined and Clusterwide Logical Name Tables

Processes other than the creating process cannot use logical names contained in process-private tables.

You can assign protection to these shareable tables through the **promsk** argument of the SYS\$CRELNT system service. The **promsk** argument allows you to specify the type of access for system, owner, group, and world users, as follows:

- Read privileges allow access to names in the logical name table.
- Write privileges allow creation and deletion of names within the logical name table.
- Delete privileges allow deletion of the logical name table.
- Create privilege to a table allows creation of children tables.

You can apply the following types of ownership and access to a shareable logical name table:

- OWNERSHIP: SYSTEM(S), GROUP(G), or WORLD(W)
- ACCESS: READ(R), WRITE(W), CREATE(C), or DELETE(D)

If the **promsk** argument is omitted, complete access is granted to system and owner, and no access is granted to group and world.

When a shareable table is created, both the specified **promsk** argument and the current default security profile for tables are applied.

In addition, you can specify finer-grained access rights by modifying the access control list using either the DCL command SET SECURITY or the SYS\$SET_SECURITY system service. For more information, see Chapter 25 and *OpenVMS Guide to System Security*.

The length of logical names created in user-defined logical name tables cannot exceed 255 characters. Equivalence strings cannot exceed 255 characters.

32.2.1 Creating Clusterwide Logical Name Tables

You might want to create additional clusterwide logical name tables for the following purposes:

- For use by a multiprocess clusterwide application
- For sharing by members of a UIC group

You can create additional clusterwide logical name tables in the same way that you can create additional process, job, and group logical name tables—with the CREATE/NAME_TABLE command or with the \$CRELNT system service. When creating a clusterwide logical name table, you must specify the /PARENT_TABLE qualifier and provide a value for the qualifier that is a clusterwide name. Any existing clusterwide table used as the parent table will make the new table clusterwide.

The following example shows how to create a clusterwide logical name table:

```
$ CREATE/NAME_TABLE/PARENT_TABLE=LNM$CLUSTER_TABLE -  
_ $ new_clusterwide_logical_name_table
```

Logical Name and Logical Name Tables

32.2 Creating User-Defined and Clusterwide Logical Name Tables

To create clusterwide logical names that will reside in the clusterwide logical name table you created, you define the new clusterwide logical name with the `DEFINE` command, specifying your new clusterwide table's name with the `/TABLE` qualifier, as shown in the following example:

```
$ DEFINE/TABLE=new_clusterwide_logical_name_table logical_name -  
_ $ equivalence_string
```

32.3 Checking Access and Protection

When a user tries to access a logical name table, the operating system compares the security profile of the user with the security profile of the table. The operating system uses the following sequence:

1. Scans the table's access control list for an entry matching any of the user's rights identifiers.
2. Evaluates the table's protection mask against the user's UIC.
3. Looks for special privileges.

The system checks the privileges in the user authorization file (UAF) granted to you when your system manager sets up your account. Privileges allow you to perform the functions listed in Table 32–2.

Table 32–2 Summary of Privileges

Privilege	Function
GRPNAM	Creates or deletes a logical name in your group logical name table
GRPPRV	Creates or deletes a logical name in your group logical name table
SYSNAM	Creates executive-mode or kernel-mode logical names; creates or deletes a logical name in the system logical name table; deletes a logical name or table at an inner access mode
SYSPRV	Creates or deletes a logical name in the system logical name table Creates or deletes a shareable table

The system also checks for read, write, and delete access.

For example, a user without `SYSPRV` privilege but with write access to `LNMS$SYSTEM_DIRECTORY` can create or delete a shareable table.

All users can create, delete, and translate their own process-private logical names and process-private logical name tables.

32.4 Specifying Access Modes

You can specify the access mode of a logical name when you define the logical name. If you do not specify an access mode, then the access mode defaults to that of the caller of the `SYSSCRELNM` system service. If you specify the **acmode** argument and the process has `SYSNAM` privilege, the logical name is created with the specified access mode. Otherwise, the access mode cannot have more privileges than the mode from which the service was requested. For information about access modes, see Chapter 20 and the discussion of `SYSSCRELNM` in the *OpenVMS System Services Reference Manual*.

Logical Name and Logical Name Tables

32.4 Specifying Access Modes

A logical name table can contain multiple definitions of the same logical name with different access modes. If a request to translate such a logical name specifies the **acmode** argument, then the SYS\$STRNLNM system service ignores all names defined at a less privileged mode. A request to delete a logical name includes the access mode of the logical name. Unless the process has the SYSNAM privilege, the mode specified can be no more privileged than the caller.

By default, the command interpreter places entries made from the command stream into the process-private logical name table; these are supervisor-mode entries and are not deleted at image exit (except for the logical names defined by the DCL commands ASSIGN/USER and DEFINE/USER). During certain system operations, such as the activation of an image installed with privilege, only executive-mode and kernel-mode logical names are used.

Logical names or logical name table names, which either an image running in user mode or the DCL commands ASSIGN/USER and DEFINE/USER have placed in a process-private logical name table, are automatically deleted at image exit. Shareable user-mode names, however, survive image exit and process deletion.

32.5 Translating Logical Names

Only one entry can exist for a particular logical name of a given access mode in a logical name table. However, a logical name table can contain entries for the same logical name at different access modes. Different logical name tables can contain entries for the same logical name.

Because identical logical names can exist in more than one logical name table, the translation that the system uses depends on the order in which it searches the logical name tables. For example, when the system attempts to translate a logical name to identify the location of a file, it uses the logical name LNM\$FILE_DEV to provide the list of tables in which to look for the name.

If, for example, a logical name exists in both the process and the group logical name tables, the logical name within the process table is used.

By default, the DEFINE and DEASSIGN commands place names in, and delete names from, your process table. However, you can request a different table with the /TABLE qualifier, as shown in the following example:

```
$ DEFINE/TABLE=LNM$SYSTEM REVIEWERS DISK3:[PUBLIC]REVIEWERS.DIS
```

Any number of logical names can have the same equivalence name. Consider the following examples of the logical name TERMINAL defined in several tables. The logical name TERMINAL translates differently depending on the table specified.

Process Logical Name Table for Process A

The following process logical name table equates the logical name TERMINAL to the specific terminal TTA2. The INFILE and OUTFILE logical names are equated to disk specifications. The logical names were created from supervisor mode.

Logical Name	Equivalence Name	Access Mode
INFILE	DM1:[HIGGINS]TEST.DAT	Supervisor
OUTFILE	DM1:[HIGGINS]TEST.OUT	Supervisor

Logical Name and Logical Name Tables

32.5 Translating Logical Names

Logical Name	Equivalence Name	Access Mode
TERMINAL	TTA2:	Supervisor
...
...

To determine the equivalence string for the logical name TERMINAL in the preceding table, enter the following command:

```
$ SHOW LOGICAL TERMINAL
```

The system returns the equivalence string TTA2:.

Job Logical Name Table

The portion of the following job logical name table assigns the logical name TERMINAL to a virtual terminal VTA14. The logical name SYSS\$LOGIN is the device and directory for the process when you log in. The SYSS\$LOGIN logical name is defined in executive mode.

Logical Name	Equivalence Name	Access Mode
SYSS\$LOGIN	DBA9:[HIGGINS]	Executive
TERMINAL	VTA14:	User
...
...

To determine the equivalence string of the logical name TERMINAL defined in the preceding table, enter the following command:

```
$ SHOW LOGICAL/JOB TERMINAL
```

The system returns the equivalence string VTA14: as the translation.

User-Defined Logical Name Table

The following user-defined logical name table (called LOG_TBL for purposes of this discussion) contains a definition of TERMINAL as the mailbox device MBA407. The multivalued logical name (search list) XYZ has two translations: DISK1 and DISK3.

Logical Name	Equivalence Name	Access Mode
TERMINAL	MBA407:	Supervisor
XYZ	DISK1:,DISK3:	Supervisor
...
...

To determine the equivalence string for the logical name TERMINAL in the preceding user-defined table, enter the following command:

```
$ SHOW LOGICAL/TABLE=LOG_TBL TERMINAL
```

The system returns the equivalence string MBA407. In order to use this definition of TERMINAL as a device or file specification, you must redefine the logical name LNM\$FILE_DEV to reference the user-defined table, as follows:

```
$ DEFINE/TABLE=LNM$PROCESS_DIRECTORY LNM$FILE_DEV LOG_TBL, -
_$ LNM$PROCESS, LNM$JOB, LNM$GROUP, LNM$SYSTEM
```


In this example, the DCL command DEFINE is used to redefine the default search list LNM\$FILE_DEV. The /TABLE qualifier specifies the table LNM\$PROCESS_DIRECTORY that is to contain the redefined search list. The system searches the tables defined by LNM\$FILE_DEV in the following order: LOG_TBL, LNM\$PROCESS, LNM\$JOB, LNM\$GROUP, and LNM\$SYSTEM.

Logical Name Supersession

If the logical name TERMINAL is equated to TTA2 in the process table, as shown in the previous examples, and the process subsequently equates the logical name TERMINAL to TTA3, the equivalence of TERMINAL TTA2 is replaced by the new equivalence name. The successful return status code SSS_SUPERSEDE indicates that a new entry replaced an old one.

The definitions of TERMINAL in the job table and in the user-defined table LOG_TBL are unaffected.

32.6 Specifying Attributes

Generally, attributes specified through the logical name system services perform two functions: they affect the creation of logical names or govern how the system service operates, and they affect the translation of logical names and equivalence strings.

Attributes that affect the creation of the logical names are specified optionally in the **attr** argument of a system service call. The **attr** argument attributes that are available from the SYSSCRELNM system service are as follows:

Attribute	Meaning
LNMSM_CONFINE	Prevents this process-private logical name from being copied to subprocesses. Subprocesses are created by the DCL command SPAWN or by the run-time library LIB\$SPAWN routine.
LNMSM_NO_ALIAS	Prevents creation of a duplicate logical name in the specified logical name table at an outer access mode. If another logical name already exists in the table at an outer access mode, that name is deleted.

The **attr** argument attributes that are available from the SYSSCRELNT system service are as follows:

Attribute	Meaning
LNMSM_CONFINE	Prevents this process-private logical table from being copied to subprocesses. Subprocesses are created by the DCL command SPAWN or by the run-time library LIB\$SPAWN routine.
LNMSM_CREATE_IF	Prevents creation of a nonclusterwide logical name table if the specified table already exists at the specified access mode in the appropriate directory table. This attribute applies only to local tables.
LNMSM_NO_ALIAS	Prevents creation of a logical name table at an outer access mode in a directory table if the table name already exists in the directory table.

The **attr** argument attributes that are available from the SYSSTRNLNM system service are as follows:

Logical Name and Logical Name Tables

32.6 Specifying Attributes

Attribute	Meaning
LNMSM_CASE_BLIND	Governs the translation process and causes SYSSTRNLNM to ignore uppercase and lowercase differences in letters when searching for logical names.
LNMSM_INTERLOCKED	Ensures that any clusterwide logical name modifications in progress are completed before the name is translated.

The translation attributes LNMSM_CONCEALED and LNMSM_TERMINAL associated with logical names and equivalence strings are specified optionally through the LNMS_ATTRIBUTES item code in the **itmlst** argument of the SYSSCRELNM system service call. The equivalence name attributes for SYSSCRELNM are as follows:

Attribute	Meaning
LNMSM_CONCEALED	Indicates that the equivalence string at the current index value for the logical name is an OpenVMS RMS concealed device name.
LNMSM_TERMINAL	Indicates that the equivalence strings cannot be translated further.

When the item code LNMS_ATTRIBUTES is specified through SYSSTRNLNM, the system returns the current attributes associated with the logical name and equivalence string at the current index value. Since a logical name can have more than one equivalence name, each equivalence name is identified by an index value. The item code LNMS_INDEX of SYSSTRNLNM searches for an equivalence name that has the specified index value.

The equivalence returned attributes for SYSSTRNLNM are as follows:

Attribute	Meaning
LNMSM_CONCEALED	Indicates that the equivalence string at the current index value for the logical name is an OpenVMS RMS concealed device name.
LNMSM_CONFINE	Indicates that the logical name cannot be used by spawned subprocesses. Subprocesses are created by the DCL command SPAWN or by the run-time library LIB\$SPAWN routine.
LNMSM_CRELOG	Indicates that the logical name was created by the SYSSCRELOG system service.
LNMSM_EXISTS	Indicates that the equivalence string at the specified index value exists.
LNMSM_NO_ALIAS	Indicates that if the logical name already exists in the table, it cannot be created in that table at an outer access mode.
LNMSM_TABLE	Indicates that the logical name is the name of a logical name table.
LNMSM_TERMINAL	Indicates that the equivalence strings cannot be translated further.
LNMSV_CLUSTERWIDE	Indicates that the logical name is clusterwide.

The attributes of multiple equivalence strings do not have to match. For more information about attributes, refer to the appropriate system service in the *OpenVMS System Services Reference Manual*.

32.7 Establishing Logical Name Table Quotas

A logical name table **quota** is the number of bytes allocated in memory for logical names contained in a logical name table. Logical name table quotas are established in the following instances:

- When the system is initialized
- When a process is created
- When logical name tables are created

Each logical name table has a quota associated with it that limits the number of bytes of memory (either process pool or system paged pool) that can be occupied by the names defined in the table. The quota for a table is established when the table is created.

If no quota is specified, the newly created table has unlimited quota. Note that this table can expand to consume all available process or system memory, and all users with write access to such a shareable table can cause the unlimited consumption of system paged pool.

32.7.1 Directory Table Quotas

When the system is initialized, unlimited quota is automatically established for the system directory table LNM\$SYSTEM_DIRECTORY.

When you log in to the system, unlimited quota is automatically established for the process directory table LNM\$PROCESS_DIRECTORY.

32.7.2 Default Logical Name Table Quotas

The process, group, system, clusterwide system, and clusterwide parent logical name tables have unlimited quota.

32.7.3 Job Logical Name Table Quotas

Because the job logical name table is a shareable table, and because you do not need special privileges to create logical names within it, the quota allocated to this logical name table is constrained at the time the table is created. The following three mechanisms specify the quota for the job logical name table at the time of its creation:

- For all processes that activate LOGINOUT, the quota for the job logical name table is obtained from the system authorization file. This allows the quota for the job to be specified on a user-by-user basis. You can modify the job logical name table quota by specifying a value with the DCL command AUTHORIZE /JTQUOTA.
- For all processes that do not activate LOGINOUT, the quota for the job logical name table can be specified as a quota list item (PQL\$_JTQUOTA) in the call to the Create Process (SYSSCREPRC) system service. If a detached process is to be created by means of the DCL command RUN/DETACHED, then you can use the /JOB_TABLE_QUOTA qualifier to specify the SYSSCREPRC quota list item.

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- For all processes that do not activate LOGINOUT and do not specify a PQLS_JTQUOTA quota list item in their call to SYSSCREPRC, the quota for the job logical name table is taken from the dynamic System Generation utility (SYSGEN) parameter PQLS_DJTQUOTA. You can use SYSGEN to display both PQLS_DJTQUOTA and PQLS_MJTQUOTA, the default and minimum job logical name table quotas, respectively.

32.7.4 User-Defined Logical Name Table Quotas

User-defined logical name tables can be created with either an explicit limited quota or no quota limit.

The presence of user-defined logical name table quotas eliminates the need for a privilege (for example, SYSNAM or GRPNAM) to control consumption of paged pool when you create logical names in a shareable table.

32.8 Interprocess Communication

Although logical names typically represent device and file names, shareable logical names can also be used to pass information among cooperating processes. When a process creates a shareable logical name, it can store up to 255 bytes of information in each equivalence name. The processes can agree to any arbitrary form for the information. Cooperating processes can translate the shareable name to retrieve the data in its equivalence names.

The operating system ensures one process cannot change a logical name at the same time another process is either translating the name or trying to change it. In other words, the synchronization provided by OpenVMS allows multiple concurrent readers or a single writer to access shared logical names that are not clusterwide.

Each instance of OpenVMS has its own shareable logical name database. When a process creates a new shareable logical name, that name can be translated immediately by any other process in the system with access to the containing table.

On an OpenVMS cluster, each node has its own shareable logical name database. In addition, the clusterwide tables and their names are replicated on each node of the cluster. Cluster communication and replication time can delay the time when a clusterwide logical name is visible on other cluster nodes. For increased performance, the default synchronization provided by OpenVMS for clusterwide logical names allows a single writer to access shared logical names, but it does not block concurrent readers.

Synchronization provided by OpenVMS may therefore be insufficient for a given application. In particular, the following circumstances require that an application provide additional synchronization:

- Retrieval of the most recent version of a clusterwide logical name
- Multiple modifiers of a given logical name, clusterwide or local

If you have an application where a logical name translator must be certain of getting the most recent definition of a clusterwide logical name, you should specify in the application the LNMSM_INTERLOCKED attribute in the **attr** argument. Use of this attribute synchronizes the translation with any pending changes to clusterwide names and ensures that the translation retrieves the most recent definition of the name. Use of this attribute to translate a local name adds a small amount of overhead but is otherwise harmless.

No logical name service provides an atomic modify of a logical name, clusterwide or local; it is thus not possible in one system service call to read the information in a logical name's equivalence names and recreate it with updated information. This means that if you have an interprocess application in which multiple processes modify a logical name, you must provide additional synchronization to create a critical section containing the SYS\$TRNLNM and SYS\$CRELNM calls. For example, your application could take the following steps:

1. Call SYS\$ENQ to acquire a restrictive lock on an application-specific resource name.
2. Call SYS\$TRNLNM to retrieve the current equivalence names, modify them, and call SYS\$CRELNM to recreate the logical name. Use the LNM\$M_INTERLOCKED attribute if the name could be clusterwide.
3. Call SYS\$DEQ to release the lock.

Because locks synchronize processes running on multiple cluster nodes, this method synchronizes processes that are running on a single node or multiple nodes.

32.9 Using Logical Name and Equivalence Name Format Conventions

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

If a logical name string presented in I/O services is preceded by an underscore (), the I/O services bypass logical name translation, drop the underscore, and treat the logical name as a physical device name.

When you log in, 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 by a 4-byte header that contains the following information:

Byte	Contents
0	^X1B (escape character)
1	^X00
2-3	OpenVMS 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, you must prepare the program both to check for the existence of this header and to use only the desired part of the equivalence string. The following program demonstrates how to do this:

```
#include <stdio.h>
#include <lnmdef.h>
#include <ssdef.h>
#include <descrip.h>
#include <ctype.h>
#include <string.h>

#define HEADER 4
```

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32.9 Using Logical Name and Equivalence Name Format Conventions

```
/* Define an item descriptor */
struct {
    unsigned short buflen, item_code;
    void *bufaddr;
    void *retlenaddr;
    unsigned int terminator;
}item_lst;

main() {
    unsigned int status,len,i;
    char resstring[LNM$C_NAMLENGTH];
    $DESCRIPTOR(tabdesc,"LNM$FILE_DEV");
    $DESCRIPTOR(logdesc,"SYS$OUTPUT");

    item_lst.buflen = LNM$C_NAMLENGTH;
    item_lst.item_code = LNM$_STRING;
    item_lst.bufaddr = resstring;
    item_lst.retlenaddr = 0;
    item_lst.terminator = 0;

/* Translate the logical name */
    status = SYS$TRNLNM( 0, /* attr - attributes of the logical name */
        &tabdesc, /* tabnam - logical name table */
        &logdesc, /* lognam - logical name */
        0, /* acmode - accessm mode */
        &item_lst); /* itmlst - item list */
    if((status & 1) != 1)
        LIB$SIGNAL( status );

/*
    Examine 4-byte header
    Is first character an escape char?
    If so, dump the header
*/
    if( resstring[0] == 0x1B) {
        printf("\nDumping the header...\n");
        for(i = 0; i < HEADER; i++)
            printf(" Byte %d: %X\n",i,resstring[i]);

        printf("\nEquivalence string: %s\n",(resstring + HEADER));
    }
    else
        printf("Header not found\n");
}
}
```

32.10 Using Logical Names and Logical Name Table System Services in Programs

The following sections describe by programming examples how to use `SYSS$CRELNM`, `SYSS$CRELNT`, `SYSS$DELLNM`, and `SYS$TRNLNM` system services.

32.10.1 Using `SYSS$CRELNM` to Create a Logical Name

To perform an assignment in a program, you must provide character-string descriptors for the name strings, select the table to contain the logical name, and use the `SYSS$CRELNM` system service as shown in the following example. In either case, the result is the same: the logical name `DISK` is equated to the physical device name `DUA2` in table `LNMSJOB`.

Logical Name and Logical Name Tables

32.10 Using Logical Names and Logical Name Table System Services in Programs

```
#include <stdio.h>
#include <lnmdef.h>
#include <descrip.h>
#include <string.h>
#include <ssdef.h>

/* Define an item descriptor */
struct itm {
    unsigned short buflen, item_code;
    void *bufaddr;
    void *retlenaddr;
};

/* Declare an item list */
struct {
    struct itm items2];
    unsigned int terminator;
}itm_lst;

main() {
    static char eqvnam[] = "DUA2:";
    unsigned int status, lnmatr;
    $DESCRIPTOR(logdesc,"DISK");
    $DESCRIPTOR(tabdesc,"LNM$JOB");

    lnmatr = LNM$M_TERMINAL;

/* Initialize the item list */
    itm_lst.items[0].buflen = 4;
    itm_lst.items[0].item_code = LNM$ATTRIBUTES;
    itm_lst.items[0].bufaddr = &lnmatr;
    itm_lst.items[0].retlenaddr = 0;

    itm_lst.items[1].buflen = strlen(eqvnam);
    itm_lst.items[1].item_code = LNM$STRING;
    itm_lst.items[1].bufaddr = eqvnam;
    itm_lst.items[1].retlenaddr = 0;
    itm_lst.terminator = 0;

/* Create the logical name */
    status = SYS$CRELNM(0, /* attr - attributes */
                      &tabdesc, /* tabnam - logical table name */
                      &logdesc, /* lognam - logical name */
                      0, /* acmode - access mode 0 means use the */
                      /* access mode of the caller=user mode */
                      &itm_lst); /* itm_lst - item list */
    if((status & 1) != 1)
        LIB$SIGNAL(status);
}
```

Note that the translation attribute is specified as terminal. This attribute indicates that iterative translation of the logical name DISK ends when the equivalence string DUA2 is returned. In addition, because the **acmode** argument was not specified, the access mode of the logical name DISK is the access mode from which the image requested the SYS\$CRELNM service.

The following example shows how a process-private logical name with multiple equivalence names can be created in user mode by an image:

Logical Name and Logical Name Tables

32.10 Using Logical Names and Logical Name Table System Services in Programs

```
#include <stdio.h>
#include <lnmdef.h>
#include <ssdef.h>
#include <descrip.h>

/* Define an item descriptor */
struct lst {
    unsigned short buflen, item_code;
    void *bufaddr;
    void *retlenaddr;
};

/* Declare an item list */
struct {
    struct lst items[2];
    unsigned int terminator;
}item_lst;

/* Equivalence name strings */
static char eqvnam1[] = "XYZ";
static char eqvnam2[] = "DEF";

main() {
    unsigned int status;
    $DESCRIPTOR(logdesc,"ABC");
    $DESCRIPTOR(tabdesc,"LNM$PROCESS");

    item_lst.items[0].buflen = strlen(eqvnam1);
    item_lst.items[0].item_code = LNM$STRING;
    item_lst.items[0].bufaddr = eqvnam1;
    item_lst.items[0].retlenaddr = 0;

    item_lst.items[1].buflen = strlen(eqvnam2);
    item_lst.items[1].item_code = LNM$STRING;
    item_lst.items[1].bufaddr = eqvnam2;
    item_lst.items[1].retlenaddr = 0;
    item_lst.terminator = 0;

/* Create a logical name */
    status = SYS$CRELNM( 0, /* attr - attributes of logical name */
        &tabdesc, /* tabnam - name of logical name table */
        &logdesc, /* lognam - name of logical name */
        0, /* acmode - access mode 0 means use the */
        /* access mode of the caller=user mode */
        &item_lst); /* itm_lst - item list */
    if((status & 1) != 1)
        LIB$SIGNAL(status);
}
```

In the preceding example, logical name ABC was created and represents a search list with two equivalence strings, XYZ and DEF. Each time the LNM\$STRING item code of the **itm_lst** argument is invoked, an index value is assigned to the next equivalence string. The newly created logical name and its equivalence string are contained in the process logical name table LNM\$PROCESS_TABLE.

The following example illustrates the creation of a logical name in supervisor mode through DCL:

```
$ DEFINE/SUPERVISOR_MODE/TABLE=LNM$PROCESS ABC XYZ,DEF
```

In the preceding example, supervisor mode and /TABLE=LNM\$PROCESS are the defaults (default mode and default table) for the DEFINE command.

32.10 Using Logical Names and Logical Name Table System Services in Programs

32.10.2 Using SYS\$CRELNT to Create Logical Name Tables

The Create Logical Name Table (SYS\$CRELNT) system service creates logical name tables. Logical name tables can be created in any access mode depending on the privileges of the calling process. A user-specified logical name that identifies a process-private created logical name table is stored in the process directory table LNM\$PROCESS_DIRECTORY. The name of a shareable table is stored in the system directory table LNM\$SYSTEM_DIRECTORY.

The following example illustrates a call to the SYS\$CRELNT system service:

```
#include <stdio.h>
#include <ssdef.h>
#include <lnmdef.h>
#include <descrip.h>

main() {
    unsigned int status, tab_attr=LNM$M_CONFINE, tab_quota=5000;
    $DESCRIPTOR(tabdesc,"LOG_TABLE");
    $DESCRIPTOR(pardesc,"LNM$PROCESS_TABLE");

    /* Create the logical name table */
    status = SYS$CRELNT(&tab_attr, /* attr - table attributes */
        0, /* resnam - logical table name */
        0, /* reslen - length of table name */
        &tab_quota, /* quota - max no. of bytes allocated */
        /* for names in this table */
        0, /* promsk - protection mask */
        &tabdesc, /* tabnam - name of new table */
        &pardesc, /* partab - name of parent table */
        0); /* acmode - access mode */

    if((status & 1) != 1) {
        LIB$SIGNAL(status);
    }
}
```

In this example, a user-defined table LOG_TABLE is created with an explicit quota of 5000 bytes. The name of the newly created table is an entry in the process-private directory LNM\$PROCESS_DIRECTORY. The quota of 5000 bytes is deducted from the parent table LNM\$PROCESS_TABLE. Because the CONFINE attribute is associated with the logical name table, the table cannot be copied from the process to its spawned processes.

32.10.3 Using SYS\$DELLNM to Delete Logical Names

The Delete Logical Name (SYS\$DELLNM) system service deletes entries from a logical name table. When you write a call to the SYS\$DELLNM 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 the process logical name TERMINAL from the job logical name table:

```
#include <stdio.h>
#include <lnmdef.h>
#include <ssdef.h>
#include <descrip.h>

main() {
    unsigned int status;
    $DESCRIPTOR(logdesc,"DISK");
    $DESCRIPTOR(tabdesc,"LNM$JOB");
```

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32.10 Using Logical Names and Logical Name Table System Services in Programs

```
/* Delete the logical name */
    status = SYS$DELLNM(&tabdesc, /* tabnam - logical table name */
                       &logdesc, /* lognam - logical name */
                       0);        /* acmode - access mode */
    if ((status & 1) != 1)
        LIB$SIGNAL(status);
}
```

For information about access modes and the deletion of logical names, see Chapter 20 and Appendix B.

32.10.4 Using SYS\$TRNLNM to Translate Logical Names

The Translate Logical Name (SYS\$TRNLNM) system service translates a logical name to its equivalence string. In addition, SYS\$TRNLNM returns information about the logical name and equivalence string.

The system service call to SYS\$TRNLNM specifies the tables to search for the logical name. The **tabnam** argument can be either the name of a logical name table or a logical name that translates to a list of one or more logical name tables.

Because logical names can have many equivalence strings, you can specify which equivalence string you want to receive.

A number of system services that require a device name accept a logical name and translate the logical name iteratively until a physical device name is found (or until the system default number of logical name translations has been performed, typically 10). These services implicitly use the logical name table name LNM\$FILE_DEV. For more information about LNM\$FILE_DEV, refer to Section 32.1.4.

The following system services perform iterative logical name translation automatically:

- Allocate Device (SYS\$ALLOC)
- Assign I/O Channel (SYS\$ASSIGN)
- Broadcast (SYS\$BRDCST)
- Create Mailbox (SYS\$CREMBX)
- Deallocate Device (SYS\$DALLOC)
- Dismount Volume (SYS\$DISMOU)
- Get Device/Volume Information (SYS\$GETDVI)
- Mount Volume (SYS\$MOUNT)

In many cases, however, a program must perform the logical name translation to obtain the equivalence name for a logical name outside the context of a device name or file specification. In that case, you must supply the name of the table or tables to be searched. The SYS\$TRNLNM system service searches the user-specified logical name tables for a specified logical name and returns the equivalence name. In addition, SYS\$TRNLNM returns attributes that are specified optionally for the logical name and equivalence string.

The following example shows a call to the SYS\$TRNLNM system service to translate the logical name ABC:

32.10 Using Logical Names and Logical Name Table System Services in Programs

```

#include <stdio.h>
#include <lnmdef.h>
#include <descrip.h>
#include <ssdef.h>

/* Define an item descriptor */
struct itm {
    unsigned short buflen, item_code;
    void *bufaddr;
    void *retlenaddr;
};

/* Declare an item list */
struct {
    struct itm items[2];
    unsigned int terminator;
}trnlst;

main() {
    char eqvbuf1[LNMS$C_NAMLENGTH], eqvbuf2[LNMS$C_NAMLENGTH];
    unsigned int status, trnattr=LNMS$M_CASE_BLIND;
    unsigned int eqvdesc1, eqvdesc2;
    $DESCRIPTOR(logdesc,"ABC");
    $DESCRIPTOR(tabdesc,"LNM$FILE_DEV");

    /* Assign values to the item list */

    trnlst.items[0].buflen = LNMS$C_NAMLENGTH;
    trnlst.items[0].item_code = LNMS$STRING;
    trnlst.items[0].bufaddr = eqvbuf1;
    trnlst.items[0].retlenaddr = &eqvdesc1;

    trnlst.items[1].buflen = LNMS$C_NAMLENGTH;
    trnlst.items[1].item_code = LNMS$STRING;
    trnlst.items[1].bufaddr = eqvbuf2;
    trnlst.items[1].retlenaddr = &eqvdesc2;
    trnlst.terminator = 0;

    /* Translate the logical name */
    status = SYS$TRNLNM(&trnattr, /* attr - attributes */
                       &tabdesc, /* tabnam - table name */
                       &logdesc, /* lognam - logical name */
                       0, /* acmode - access mode */
                       &trnlst); /* itmlst - item list */
    if((status & 1) != 1)
        LIB$SIGNAL(status);
}

```

This call to the SYS\$TRNLNM system service results in the translation of the logical name ABC. In addition, LNM\$FILE_DEV is specified in the **tabnam** argument as the search list that SYS\$TRNLNM is to use to find the logical name ABC. The logical name ABC was assigned two equivalence strings. The LNMS\$STRING item code in the **itmlst** argument directs SYS\$TRNLNM to look for an equivalence string at the current index value. Note that the LNMS\$STRING item code is invoked twice. The equivalence strings are placed in the two output buffers, EQVBUF1 and EQVBUF2, described by TRNLST.

The attribute LNMS\$M_CASE_BLIND governs the translation process. The SYS\$TRNLNM system service searches for the equivalence strings without regard to uppercase or lowercase letters. The SYS\$TRNLNM system service matches any of the following character strings: ABC, aBC, AbC, abc, and so forth.

Logical Name and Logical Name Tables

32.10 Using Logical Names and Logical Name Table System Services in Programs

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.

32.10.5 Using SYS\$CRELNM, SYS\$TRNLNM, and SYS\$DELLNM in a Program Example

In the following example, the Fortran program CALC.FOR creates a spawned subprocess to perform an iterative calculation. The logical name REP_NUMBER specifies the number of times that REPEAT should perform the calculation. Because the two processes are part of the same job, REP_NUMBER is placed in the job logical name table LNMSJOB. (Note that logical name table names are case sensitive. Specifically, LNMSJOB is a system-defined logical name that refers to the job logical name table; lnm\$job is not.)

```
PROGRAM CALC
! Status variable and system routines

INCLUDE '($LNMDEF)'
INCLUDE '($SYSSRVNAM)'
INTEGER*4 STATUS

INTEGER*2 NAME_LEN,
2 NAME_CODE
INTEGER*4 NAME_ADDR,
2 RET_ADDR /0/,
2 END_LIST /0/

COMMON /LIST/ NAME_LEN,
2 NAME_CODE,
2 NAME_ADDR,
2 RET_ADDR,
2 END_LIST

CHARACTER*3 REPETITIONS_STR
INTEGER REPETITIONS

EXTERNAL CLI$M_NOLOGNAM,
2 CLI$M_NOCLISYM,
2 CLI$M_NOKEYPAD,
2 CLI$M_NOWAIT

NAME_LEN = 3
NAME_CODE = (LNM$_STRING)
NAME_ADDR = %LOC(REPETITIONS_STR)
STATUS = SYS$CRELNM (,'LNM$JOB','REP_NUMBER',,NAME_LEN)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

MASK = %LOC (CLI$M_NOLOGNAM) .OR.
2 %LOC (CLI$M_NOCLISYM) .OR.
2 %LOC (CLI$M_NOKEYPAD) .OR.
2 %LOC (CLI$M_NOWAIT)
STATUS = LIB$GET_EF (FLAG)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))
STATUS = LIB$SPAWN ('RUN REPEAT',,,MASK,,,,FLAG)
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

END
```

32.10 Using Logical Names and Logical Name Table System Services in Programs

```

PROGRAM REPEAT
INTEGER STATUS,
2   SYS$TRNLNM,SYS$DELLNM
INTEGER*4 REITERATE,
2   REPEAT_STR_LEN
CHARACTER*3 REPEAT_STR
! Item list for SYS$TRNLNM
INTEGER*2 NAME_LEN,
2   NAME_CODE
INTEGER*4 NAME_ADDR,
2   RET_ADDR,
2   END_LIST /0/
COMMON /LIST/ NAME_LEN,
2   NAME_CODE,
2   NAME_ADDR,
2   RET_ADDR,
2   END_LIST

NAME_LEN = 3
NAME_CODE = (LNM$_STRING)
NAME_ADDR = %LOC(REPEAT_STR)
RET_ADDR = %LOC(REPEAT_STR_LEN)
STATUS = SYS$TRNLNM (,
2   'LNM$JOB',      ! Logical name table
2   'REP_NUMBER',  ! Logical name
2   NAME_LEN)      ! List requesting equivalence string
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

READ (UNIT = REPEAT_STR,
2   FMT = '(I3)') REITERATE

DO I = 1, REITERATE
END DO

STATUS = SYS$DELLNM ('LNM$JOB',      ! Logical name table
2   'REP_NUMBER',) ! Logical name
IF (.NOT. STATUS) CALL LIB$SIGNAL (%VAL(STATUS))

END

```

Image Initialization

This chapter describes the system declaration mechanism, including `LIB$INITIALIZE`, which performs calls to any initialization routine declared for the image by the user. However, use of `LIB$INITIALIZE` is discouraged and should be used only when no other method is suitable. This chapter contains the following sections:

Section 33.1 describes the steps to perform image initialization.

Section 33.2 describes the argument list that is passed from the command interpreter, the debugger, or `LIB$INITIALIZE` to the main program.

Section 33.3 describes how a library or user program can declare an initialization routine.

Section 33.4 describes how the `LIB$INITIALIZE` dispatcher calls the initialization routine in a list.

Section 33.5 describes the options available to an initialization routine.

Section 33.6 illustrates with a code example several functions of an initialization routine on both VAX and Alpha systems.

33.1 Initializing an Image

In most cases, both user and library routines are self-initializing. This means that they can process information with no special action required by the calling program. Initialization is automatic in two situations:

- When the routine's statically allocated data storage is initialized at compile or link time
- When a statically allocated flag is tested and set on each call so that initialization occurs only on the first call

Any special initialization, such as a call to other routines or to system services, can be performed on the first call before the main program is initialized. For example, you can establish a new environment to alter the way errors are handled or the way messages are printed.

Such special initialization is required only rarely; however, when it is required, the caller of the routine does not need to make an explicit initialization call. The run-time library provides a system declaration mechanism that performs all such initialization calls before the main program is called. Thus, special initialization is invisible to later callers of the routine.

On VAX systems, before the main program or main routine is called, a number of system initialization routines are called as specified by a 1-, 2-, or 3-longword initialization list set up by the linker.

Image Initialization

33.1 Initializing an Image

On Alpha systems, before the main program or main routine is called, a number of system initialization routines are called as specified by a 1-, 2-, or 3-quadword initialization list set up by the linker.

On VAX systems, the initialization list consists of the following (in order):

- The addresses of the debugger (if present)
- The LIB\$INITIALIZE routine (if present)
- The entry point of the main program or main routine

On Alpha systems, the initialization list consists of the following (in order):

- The procedure value addresses of the debugger (if present)
- The LIB\$INITIALIZE routine (if present)
- The entry point of the main program or main routine

The following initialization steps take place:

1. The image activator maps the user program into the address space of the process and sets up useful information, such as the program name. Then it starts the command language interpreter (CLI).
2. The CLI sets up an argument list and calls the next routine in the initialization list (debugger, LIB\$INITIALIZE, main program, or main routine).
3. On VAX systems, the debugger, if present, initializes itself and calls the next routine in the initialization list (LIB\$INITIALIZE, main program, or main routine).

On Alpha systems, the CLI calls the debugger, if present, to set the initial breakpoints. Then the CLI calls the next entry in the vector.

4. The LIB\$INITIALIZE library routine, if present, calls each library and user initialization routine declared using the system LIB\$INITIALIZE mechanism. Then it calls the main program or main routine.
5. The main program or main routine executes and, at the user's discretion, accesses its argument list to scan the command or to obtain information about the image. The main program or main routine can then call other routines.
6. Eventually, the main program or main routine terminates by executing a return instruction (RET) with R0 set to a standard completion code to indicate success or failure, where bit <0> equals 1 (success) or 0 (failure).
7. The completion code is returned to LIB\$INITIALIZE (if present), the debugger (if present), and, finally, to the CLI, which issues a SYS\$EXIT system service with the completion status as an argument. Any declared exit handlers are called at this point.

Note

Main programs should not call the SYS\$EXIT system service directly. If they do, other programs cannot call them as routines.

Image Initialization

33.1 Initializing an Image

Figure 33–1 and Figure 33–2 illustrate the sequence of calls and returns in a typical image initialization. Each box is a routine activation as represented on the image stack. The top of the stack is at the top of the figure. Each upward arrow represents the result of a call instruction that creates a routine activation on the stack to which control is being transferred. Each downward arrow represents the result of a RET (return) instruction. A RET instruction removes the routine activation from the stack and causes control to be transferred downward to the next box.

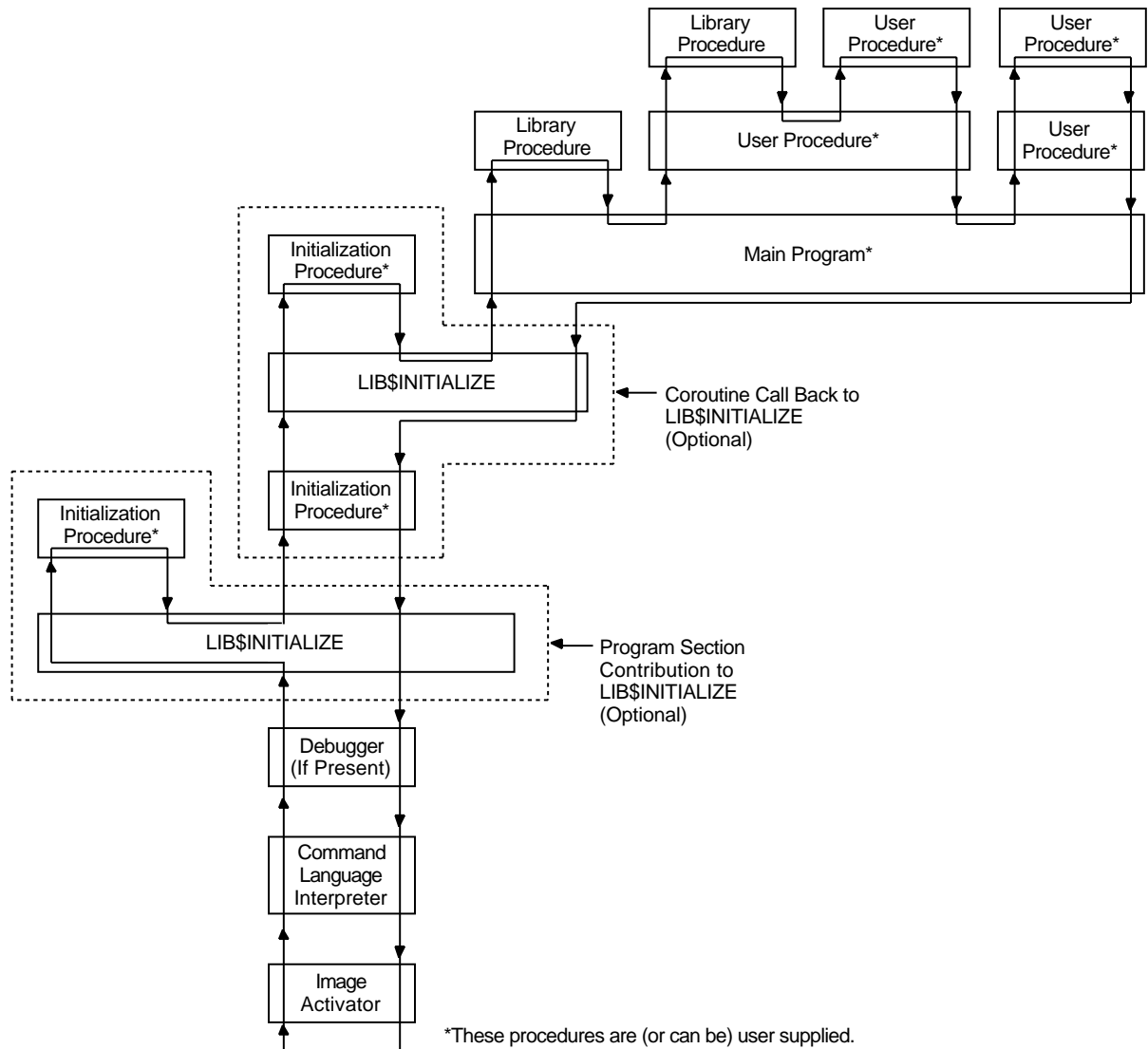
A user program can alter the image initialization sequence by making a program section (PSECT) contribution to PSECT LIB\$INITIALIZE and by declaring EXTERNAL LIB\$INITIALIZE. This adds the optional initialization steps shown in Figure 33–1 and Figure 33–2 labeled “Program Section Contribution to LIB\$INITIALIZE.” (A program section is a portion of a program with a given protection and set of storage management attributes. Program sections that have the same attributes are gathered together by the linker to form an image section.) If the initialization routine also performs a coroutine call back to LIB\$INITIALIZE, the optional steps labeled “Coroutine Call Back to LIB\$INITIALIZE” in Figure 33–1 and Figure 33–2 are added to the image initialization sequence.

On VAX systems, Figure 33–1 shows the call instruction calling the debugger, if present, and the debugger then directly calling LIB\$INITIALIZE and the main program.

Image Initialization

33.1 Initializing an Image

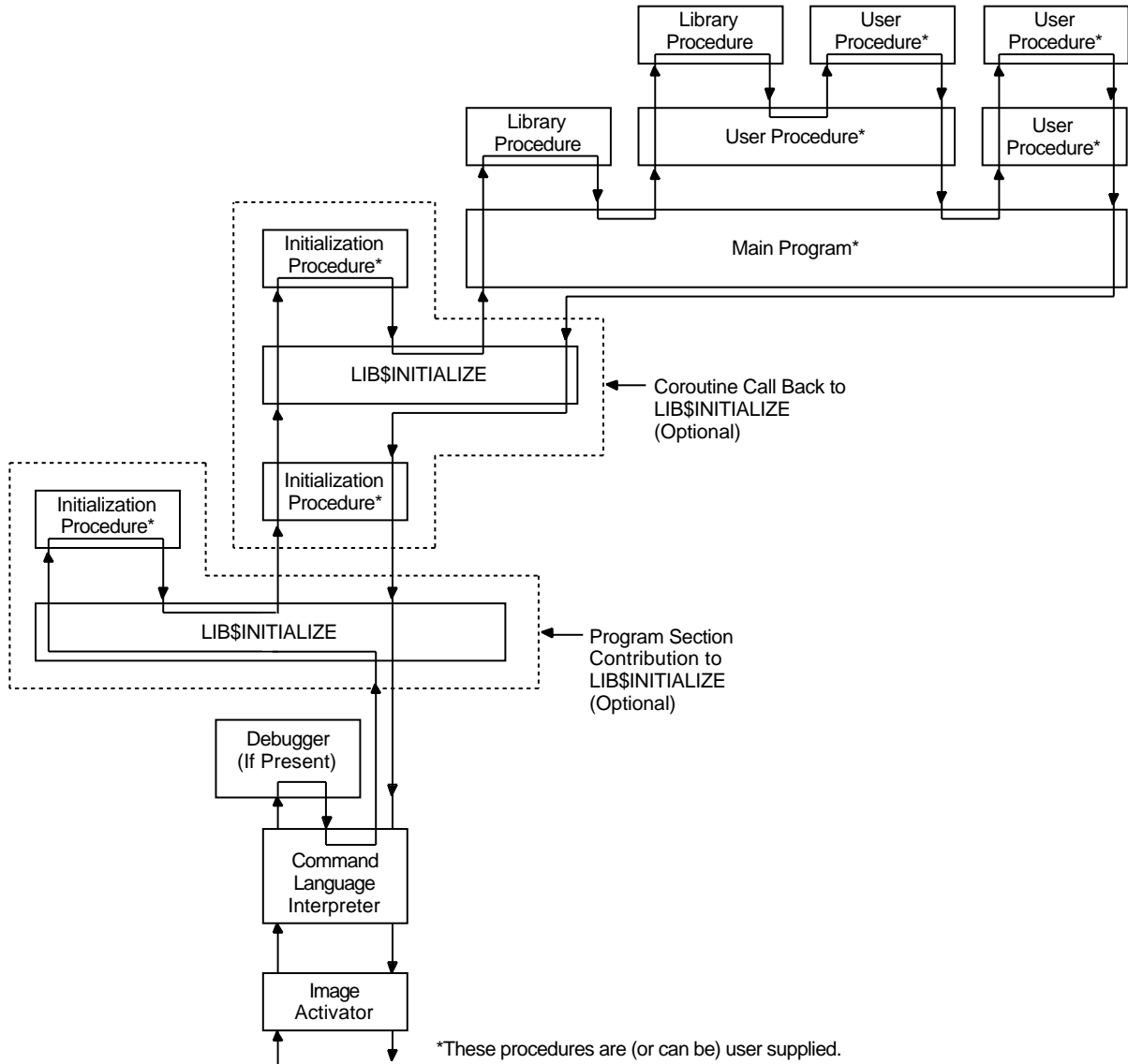
Figure 33-1 Sequence of Events During Image Initialization on VAX Systems



ZK-1977-GE

On Alpha systems, Figure 33-2 shows the call instruction calling the debugger, if present, to set a breakpoint at the main program's entry point.

Figure 33–2 Sequence of Events During Image Initialization on Alpha Systems



ZK-5911A-GE

33.2 Initializing an Argument List

The following argument list is passed from the CLI, the debugger, or LIB\$INITIALIZE to the main program. This argument list is the same for each routine activation.

(start ,cli-coroutine [,image-info])

The **start** argument is the address of the entry in the initialization vector that is used to perform the call.

The **cli-coroutine** argument is the address of a CLI coroutine to obtain command arguments. For more information, see the *OpenVMS Utility Routines Manual*.

The **image-info** argument is useful image information, such as the program name.

Image Initialization

33.2 Initializing an Argument List

The debugger or LIB\$INITIALIZE, or both, can call the next routine in the initialization chain using the following coding sequence:

```
.
.
.
ADDL    #4, 4(AP)      ; Step to next initialization list entry
MOVL   @4(AP), R0     ; R0 = next address to call
CALLG  (AP), (R0)     ; Call next initialization routine
.
.
.
```

This coding sequence modifies the contents of an argument list entry. Thus, the sequence does not follow the OpenVMS calling standard. However, the argument list can be expanded in the future without requiring any change either to the debugger or to LIB\$INITIALIZE.

33.3 Declaring Initialization Routines

Any library or user program module can declare an initialization routine. This routine is called when the image is started. The declaration is made by making a contribution to the LIB\$INITIALIZE program section, which contains a list of routine entry point addresses to be called before the main program or main routine is called.

The following VAX MACRO example declares an initialization routine by placing the routine entry address INIT_PROC in the list:

```
.EXTRN LIB$INITIALIZE      ; Cause library initialization
                          ; Dispatcher to be loaded

.PSECT LIB$INITIALIZE, NOPIC, USR, CON, REL, GBL, NOSHR, NOEXE, RD, NOWRT, LONG

.LONG INIT_PROC           ; Contribute entry point address of
                          ; initialization routine.

.PSECT ...
```

The .EXTRN declaration links the initialization routine dispatcher, LIB\$INITIALIZE, into your program's image. The reference contains a definition of the special global symbol LIB\$INITIALIZE, which is the routine entry point address of the dispatcher. The linker stores the value of this special global symbol in the initialization list along with the starting address of the debugger and the main program. The GBL specification ensures that the PSECT LIB\$INITIALIZE contribution is not affected by any clustering performed by the linker.

Note that moving modules and PSECTS around to affect symbol resolution may result in unintended memory placement within your image. If, for example, you add a CLUSTER statement to your linker options file, the initialization code may not run because the CLUSTER statement in the linker option file may cause the various LIB\$INITIALIZE PSECTS to become separated. To remedy this possible condition, either add to your options file a CLUSTER or COLLECT statement like the following:

```
CLUSTER = <cluster name>,,,<module>, SYS$LIBRARY:STARLET.OLB/include = LIB$INITIALIZE
COLLECT = <cluster name>, LIB$INITIALIZDZ, LIB$INITIALIZD_, LIB$INITIALIZE,LIB$INITIALIZE$
```

33.4 Dispatching to Initialization Routines

The LIB\$INITIALIZE dispatcher calls each initialization routine in the list with the following argument list:

CALL init-proc (init-coroutine ,cli-coroutine [, image-info])

The **init-coroutine** argument is the address of a library coroutine to be called to effect a coroutine linkage with LIB\$INITIALIZE.

The **cli-coroutine** is the address of a CLI coroutine used to obtain command arguments.

The **image-info** argument is useful image information, such as the program name.

33.5 Initialization Routine Options

An initialization routine can be used to do the following:

- Set up an exit handler by calling the Declare Exit Handler (\$DCLEXH) system service, although exit handlers are generally set up by using a statically allocated first-time flag.
- Initialize statically allocated storage, although this is done preferably at image activation time using compile-time and link-time data initialization declarations or by using a first-time call flag in its statically allocated storage.
- Call the initialization dispatcher (instead of returning to it) by calling the **init-coroutine** argument. This achieves a coroutine link. Control returns to the initialization routine when the main program returns control. Then the initialization routine should also return control to pass back the completion code returned by the main program (to the debugger or CLI, or both).
- Establish a condition handler in the current frame before performing the preceding actions. This leaves the initialization routine condition handler on the image stack for the duration of the image execution. This occurs after the CLI sets up the catchall stack frame handler and after the debugger sets up its stack frame handler. Thus, the initialization routine handler can override either of these handlers, because it will receive signals before they do.

33.6 Initialization Example

The following VAX MACRO code fragment, which works on both VAX and Alpha systems, shows how an initialization routine does the following:

- Establishes a handler
- Calls the **init-coroutine** argument routine, so that the coroutine calls the initialization dispatcher
- Gains control after the main program returns
- Returns to the normal exit processing

```
.ENTRY INIT_PROC, ^M<>      ; No registers used
MOVAL HANDLER, (FP)        ; Establish handler
...                        ; Perform any other initialization
```

Image Initialization

33.6 Initialization Example

```
CALLG (AP), @INIT_CO_ROUTINE(AP)
10$:                                ; Continue initialization which
                                    ; then calls main program or
                                    ; routine.
...                                  ; Return here when main program
RET                                 ; returns with R0 = completion
                                    ; Status return to normal exit
                                    ; processing with R0 = completion
                                    ; status

.ENTRY HANDLER, ^M<...>            ; Register mask
...                                  ; handle condition
                                    ; could unwind to 10$
MOVL #..., R0                       ; Set completion status with a
                                    ; condition value
RET                                 ; Resignal or continue depending
                                    ; on R0 being SS$_RESIGNAL or
                                    ; SS$_CONTINUE.
```

Part III

Appendixes

This part of this second volume describes the generic macros used for calling system services, OpenVMS data types, and the distributed name services on OpenVMS VAX systems.

Generic Macros for Calling System Services

This appendix describes the use of generic macros to specify argument lists with appropriate symbols and conventions in the system services interface to MACRO assemblers.

System service macros generate argument lists and CALL instructions to call system services. These macros are located in the system library SYSS\$LIBRARY:STARLET.MLB. When you assemble a source program, this library is searched automatically for unresolved references.

Knowledge of VAX MACRO rules for assembly language programming is required for understanding the material presented in this appendix. The *VAX MACRO and Instruction Set Reference Manual* contains the necessary prerequisite information.

Each system service has four macros associated with it. These macros allow you to define symbolic names for argument offsets, construct argument lists for system services, and call system services. Table A-1 lists the generic macros and the functions they serve.

Table A-1 Generic Argument List Macros of the System Service Interface

Macro	Function
<i>\$name</i> DEF	Defines symbolic names for the argument list offsets
<i>\$name</i>	Defines symbolic names for the argument list offsets and constructs the argument list
<i>\$name</i> _S	Calls the system service and constructs the argument list
<i>\$name</i> _G	Calls the system service and uses the argument list constructed by <i>\$name</i> macro

Generic Macros for Calling System Services

A.1 Using Macros to Construct Argument Lists

A.1 Using Macros to Construct Argument Lists

You can use two generic macros for constructing argument lists for system services:

\$name
\$name_S

The macro you use depends on which macro you are going to use to call the system service. If you use the *\$name_G* macro to call a system service, you should use the *\$name* macro to construct the argument list. If you use the *\$name_S* macro to call a system service, you can also use it to construct the argument list.

A.1.1 Specifying Arguments with the *\$name_S* Macro and the *\$name* Macro

When you use the *\$name_S* or the *\$name* macro to construct an argument list for a system service, you can specify arguments in any one of three ways:

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

For example, `$MYSERVICE` can have the following format:

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

For purposes of this example, assume that **arga** and **argb** require you to specify numeric values and that **argc** and **argd** require you to specify addresses.

Examples A-1 and A-2 show valid ways of writing the *\$name_S* macro to call `$MYSERVICE`.

Example A-1 Using Keywords with the *\$name_S* Macro

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

Example A-2 Specifying Arguments in Positional Order with the *\$name_S* Macro

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

(continued on next page)

Generic Macros for Calling System Services

A.1 Using Macros to Construct Argument Lists

Example A-2 (Cont.) Specifying Arguments in Positional Order with the *\$name_S* Macro

The argument list is pushed on the stack, as follows:

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

Note that all arguments, whether specified positionally or with keywords, must be valid assembler expressions because they are used as source operands in instructions.

Examples A-3 and A-4 show valid ways of writing a *\$name* macro to construct an argument list for a later call to *\$MYSERVICE*.

Example A-3 Using Keywords with the *\$name* Macro

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

Example A-4 Specifying Arguments in Positional Order with the *\$name* Macro

```
LIST:    $MYSERVICE -
          1, , , MYARGD
```

Both methods generate the following:

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

Note that all arguments, whether specified positionally or by keyword, must be expressions that the assembler can evaluate to generate *.LONG* or *.ADDRESS* data directives. Contrast this to the arguments for the *\$name_S* macro, which must be valid assembler expressions because they are used as source operands in instructions.

Generic Macros for Calling System Services

A.1 Using Macros to Construct Argument Lists

A.1.2 Conventions for Specifying Arguments to System Services

You must specify the arguments according to the VAX MACRO assembler rules for specifying and addressing operands.

The way to specify a particular argument depends on the following factors:

- Whether the system service requires an address or a value as the argument. In the *OpenVMS System Services Reference Manual*, the descriptions of the arguments following a system service macro format always indicate whether the argument is an address. A Boolean value, number, or mask takes a value as the argument.
- The system service macro being used. The expansions of the *\$name* and *\$name_S* macros in the examples in Section A.1.1 show the code generated by each macro.

If you are unsure whether you specified 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 MACRO and Instruction Set Reference Manual* for details.

A.1.3 Defining Symbolic Names for Argument List Offsets: *\$name* and *\$nameDEF*

You can refer symbolically to arguments in the argument list. 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:

- Your program is easier to read.
- If an argument list for a system service changes with a later release of a system, the symbols remain the same.

You form the offset names for all system service argument lists by following the service macro name with *\$_* and the keyword name of the argument. In the following example, *name* is the name for the system service macro and *keyword* is the keyword argument:

```
name$_keyword
```

Similarly, you can define a symbolic name for the number of arguments a particular macro requires, as follows:

```
name$_NARGS
```

You can define symbolic names for argument list offsets automatically whenever you use the *\$name* macro for a particular system service. 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 *QIOS_NARGS* and the symbolic names for the *\$QIO* argument list offsets.

Generic Macros for Calling System Services

A.1 Using Macros to Construct Argument Lists

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

For example, the *\$READEF* and *\$READEFDEF* macros define the values listed in the following table.

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

Thus, you can specify the *\$READEF* macro 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 to call the service. The following lines show how you can do this with a call to the *\$name_G* macro.

```
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.

A.2 Using Macros to Call System Services

You can use two generic macros for writing calls to system services:

\$name_S
\$name_G

Which macro you use depends on how the argument list for the system service is constructed.

- The *\$name_S* macro requires you to supply the arguments to the system service in the system service macro. The macro generates code to push the argument list onto the call stack during program execution. With this macro, you can use registers to contain or point to arguments so that you can write reentrant programs.
- The *\$name_G* macro 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 macro, you can use the same argument list, with modifications if necessary, for more than one invocation of the macro.

The *\$name_S* macro generates a *CALLS* instruction; the *\$name_G* macro generates a *CALLG* 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 macros.

Generic Macros for Calling System Services

A.2 Using Macros to Call System Services

A.2.1 The *\$name_S* Macro

The *\$name_S* macro call has the following format:

```
$name_S arg1, ..., 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 following format:

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

In this format, *n* is the number of arguments on the stack.

A.2.1.1 Example of *\$name_S* Macro Call

Because a *\$name_S* macro constructs the argument list at execution time, you can supply addresses and values by using register addressing modes. You can use the following line to execute the \$READEF_S macro:

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

R10 contains the address of the longword that will receive the status of the flags.

This macro instruction is expanded as follows.

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

A.2.2 The *\$name_G* Macro

The *\$name_G* macro requires a single operand:

```
$name_G label
```

In this format, **label** is the address of the argument list.

A.2.3 The *\$name* Macro

Macros are provided to create argument lists for the *\$name_G* macro. The *\$name_G* macro (used with the *\$name* macro) is especially useful for doing the following:

- Making calls to system services that have long argument lists
- Calling services repeatedly during the execution of a single program with the same, or essentially the same, argument list

The format of the macros is as follows:

```
label: $name arg1,...,argn
```

Generic Macros for Calling System Services

A.2 Using Macros to Call System Services

label

Symbolic address of the generated argument list. This is the label given as an argument in the *\$name_G* macro.

\$name

The service macro name.

arg1,...,argn

Arguments to be placed in successive longwords in the argument list.

A.2.4 Example of *\$name* and *\$name_G* Macro Calls

The example that follows shows how you can write a call to the Read Event Flags (*\$READEF*) system service using an argument list created by *\$name*.

The *\$READEF* system service has the following macro format:

```
$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 that will receive the contents of the cluster.

You can specify these arguments using the *\$name* macro, as follows:

```
READLST:
    $READEF EFN=1, -           ; Argument list for $READEF
    STATE=TESTFLAG
```

This *\$READEF* macro generates the following code:

```
READLST:
    .LONG 2           ; Argument list for $READEF
    .ADDRESS 1
    .ADDRESS -
    TESTFLAG
```

Executing the *\$READEF* macro requires only the following line:

```
$READEF_G READLST
```

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

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

SYSS\$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.

OpenVMS Data Types

As part of the OpenVMS common language environment, the OpenVMS system routine data types provide compatibility between procedure calls that support many different high-level languages. Specifically, the OpenVMS data types apply to both Alpha and VAX architectures as the mechanism for passing argument data between procedures. This appendix describes the context and structure of the OpenVMS system routine data types and identifies the associated declarations to each of the specific high-level language implementations.

B.1 OpenVMS Data Types

The OpenVMS usage entry in the documentation format for system routines indicates the OpenVMS data type of the argument. Most data types can be considered conceptual types; that is, their meaning is unique in the context of the OpenVMS operating system. The OpenVMS data type **access_mode** is one example. The storage representation of this OpenVMS type is an unsigned byte, and the conceptual content of this unsigned byte is the fact that it designates a hardware access mode and therefore has only four valid values: 0, kernel mode; 1, executive mode; 2, supervisor mode; and 3, user mode. However, some OpenVMS data types are not conceptual types; that is, they specify a storage representation but carry no other semantic content in the OpenVMS context. For example, the data type **byte_signed** is not a conceptual type.

Note

The OpenVMS usage entry is not a traditional data type such as the OpenVMS standard data types—byte, word, longword, and so on. It is significant only within the OpenVMS operating system environment and is intended solely to expedite data declarations within application programs.

To use the OpenVMS usage entry, perform the following steps:

1. Find the data type in Table B-1 and read its definition.
2. Find the same OpenVMS data type in the appropriate high-level language implementation table (Tables B-2 through B-13) and its corresponding source-language type declaration.
3. Use this code as your type declaration in your application program. Note that, in some instances, you might have to modify the declaration.

For both Alpha and VAX architectures, Table B-1 lists and describes the standard OpenVMS data type declarations for the OpenVMS usage entry of any system routine call.

OpenVMS Data Types

B.1 OpenVMS Data Types

Table B-1 OpenVMS Usage Data Type Entries

Data Type	Definition
access_bit_names	Homogeneous array of 32 quadword descriptors; each descriptor defines the name of one of the 32 bits in an access mask. The first descriptor names bit <0>, the second descriptor names bit <1>, and so on.
access_mode	Unsigned byte denoting a hardware access mode. This unsigned byte can contain one of four values: 0, kernel mode; 1, executive mode; 2, supervisor mode; and 3, user mode.
address	Unsigned longword denoting a position in virtual memory. On Alpha systems, the address can be represented by a 64-bit value, in which case the high-order 33 bits of that value must be the same (for example, the 64-bit value must equal the sign-extended 32-bit value).
address_range	Unsigned quadword denoting a range of virtual addresses that identifies an area of memory. The first longword specifies the beginning address in the range; the second longword specifies the ending address in the range.
arg_list	<p>Procedure call argument list containing a sequence of entries together with a count of the number of argument entries.</p> <p>On Alpha systems², an argument list is represented as quadword entities in hardware registers (R16-21 or F16-21). The AI register (R25) contains the argument count. When there are more than six arguments, the argument list overflows onto the stack. See Figure 18-5 for more information.</p> <p>On VAX systems¹, an argument list (shown in the following figure) is represented as a vector of longwords, where the first longword contains the count and each remaining longword contains one argument.</p>
	<p style="text-align: center;">VAX Specific</p> <p style="text-align: right;">:arglst</p>
	ZK-4721A-GE
ast_procedure	The procedure value of a procedure to be called at asynchronous system trap (AST) level. (Procedures that are not to be called at AST level are of type procedure .)
boolean	Unsigned longword denoting a Boolean truth value flag. This longword can have one of two values: 1 (<i>true</i>) or 0 (<i>false</i>).
buffer	Generic term for temporary memory.
buffer_length	Generic term for temporary memory that indicates the size of a buffer.
byte_signed	Same as the data type byte integer (signed) in Table 17-3.
byte_unsigned	Same as the data type byte (unsigned) in Table 17-3.

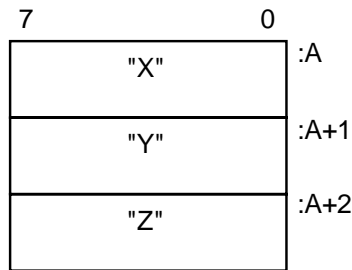
¹VAX specific.

²Alpha specific.

(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

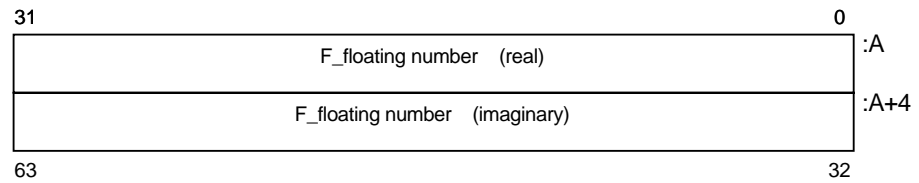
Data Type	Definition
channel	Unsigned word integer that is an index to an I/O channel.
char_string	String of from 0 to 65535 eight-bit characters. This OpenVMS data type is the same as the data type character string in Table 17-3. The following diagram shows the character string XYZ:



ZK-4202-GE

complex_number One of the OpenVMS standard complex floating-point data types. The six complex floating point numbers are F_floating complex, D_floating complex, G_floating complex, S_floating, T_floating, and X_floating.

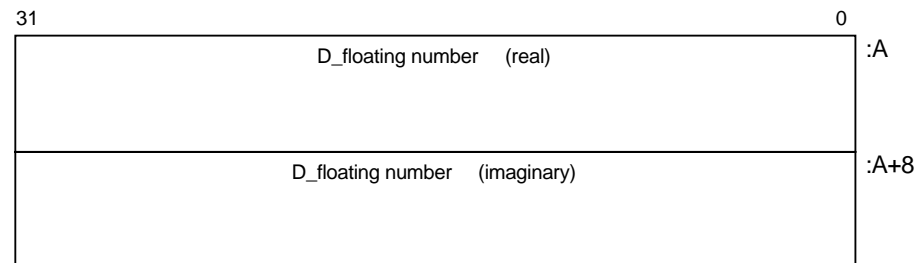
As shown in the following figure, an F_floating point complex number (real, imaginary) is composed of two F_floating point numbers: the first is the real part of the complex number; the second is the imaginary part. For more structure detail, see *floating_point* described later in this table.



ZK-4720A-GE

As shown in the following figure, a D_floating point complex number (real, imaginary) is composed of two D_floating point numbers: the first is the real part of the complex number; the second is the imaginary part.

For more structure detail, see *floating_point* described later in this table.



ZK-4719A-GE

(continued on next page)

OpenVMS Data Types

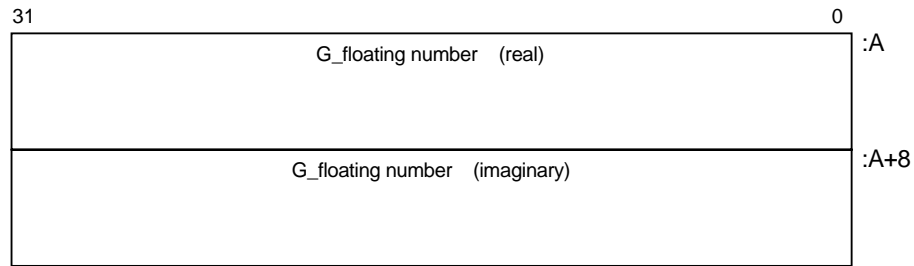
B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
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As shown in the following figure, a G_floating point complex number (real, imaginary) is composed of two G_floating point numbers: the first is the real part of the complex number; the second is the imaginary part.

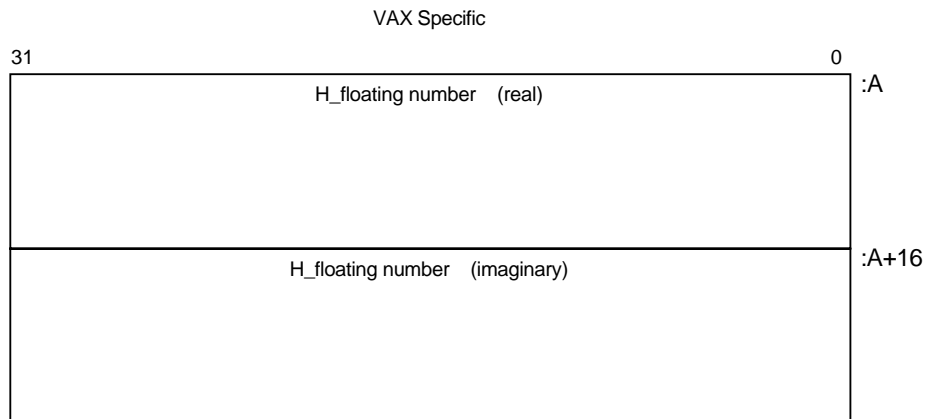
For more structure detail, see *floating_point* described later in this table.



ZK-4728A-GE

On VAX systems¹, as shown in the following figure, an H_floating complex number (real, imaginary) is composed of two H_floating point numbers: the first is the real part of the complex number; the second is the imaginary part. Note that H_float numbers apply to VAX environments only.

For more structure detail, see *floating_point* described later in this table.



ZK-4729A-GE

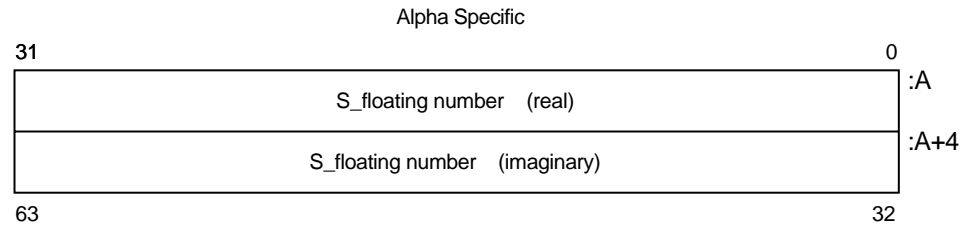
¹VAX specific.

(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

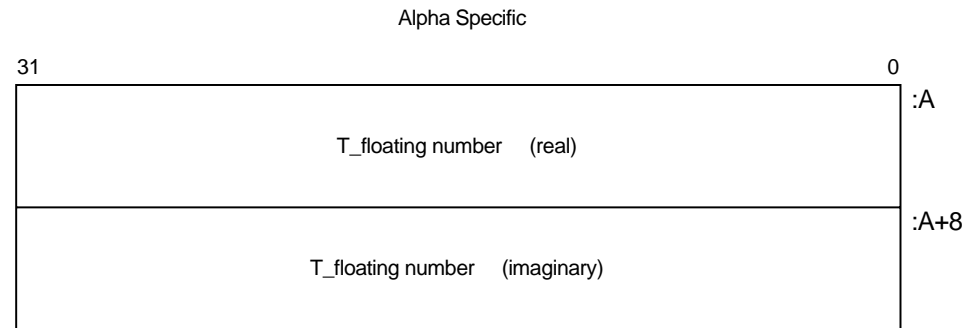
Data Type	Definition
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On Alpha systems², as shown in the following figure, an S_floating point complex number (real, imaginary) is composed of two S_floating point numbers: the first is the real part of the complex number; the second is the imaginary part.
For more structure detail, see *floating_point* described later in this table.



ZK-5189A-GE

On Alpha systems², as shown in the following figure, a T_floating complex number (real, imaginary) is composed of two T_floating point numbers: the first is the real part of the complex number; the second is the imaginary part.
For more structure detail, see *floating_point* described later in this table.



ZK-5190A-GE

²Alpha specific.

(continued on next page)

OpenVMS Data Types

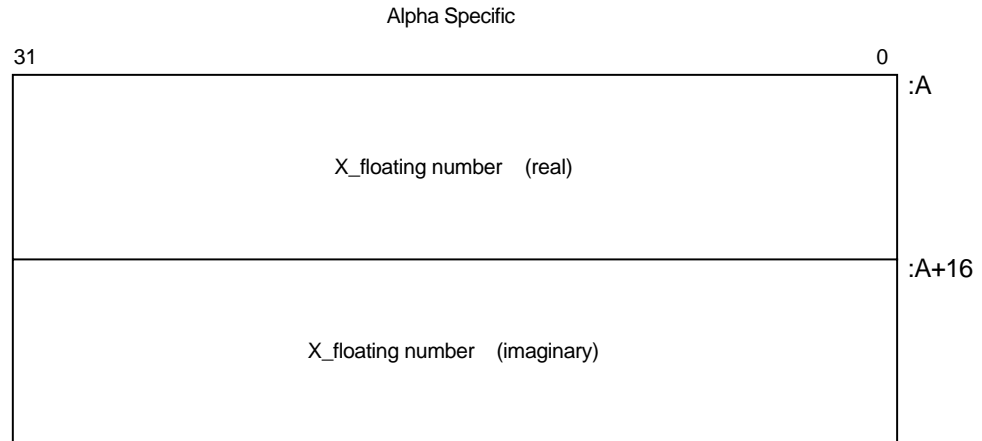
B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
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On Alpha systems², as shown in the following figure, an X_floating complex number (real, imaginary) is composed of two X_floating point numbers: the first is the real part of the complex number; the second is the imaginary part.

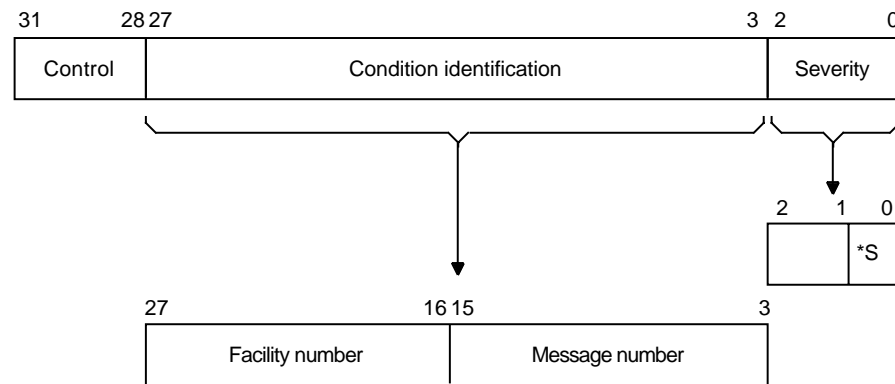
For more structure detail, see *floating_point* described later in this table.



ZK-6512A-GE

cond_value

Longword integer for VAX or quadword sign-extended integer for Alpha denoting a condition value (a return status or system condition code) that is typically returned by a procedure in R0. Each numeric condition value has a unique symbolic name in the following format, where the severity condition code is a mnemonic describing the return condition:



*S = Success

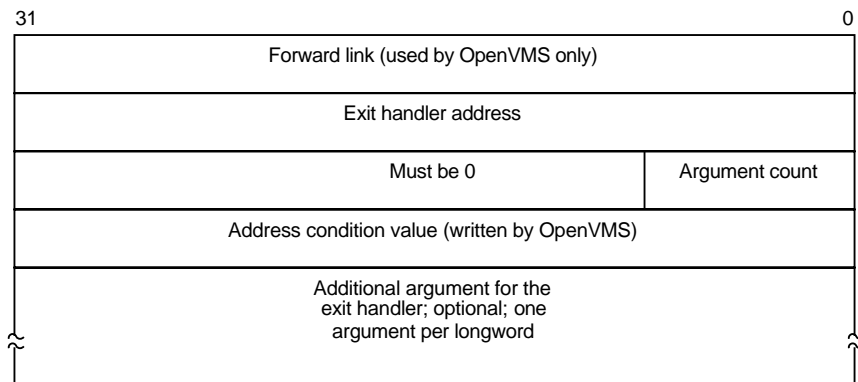
ZK-1795-GE

²Alpha specific.

(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
	<p>Depending on your specific needs, you can test just the low-order bit, the low-order three bits, or the entire value.</p> <ul style="list-style-type: none"> • The low-order bit indicates successful (1) or unsuccessful (0) completion of the service. • The low-order 3 bits taken together represent the severity of the error. • The remaining bits <31:3> classify the particular return condition and the operating system component that issued the condition value.
context	Unsigned longword used by a called procedure to maintain position over an iterative sequence of calls. The data type is usually initialized by the caller but thereafter is manipulated by the called procedure.
date_time	Unsigned 64-bit binary integer denoting a date and time as the number of elapsed 100-nanosecond units since 00:00 o'clock, November 17, 1858. This OpenVMS data type is the same as the data type absolute date and time in Table 17-3.
device_name	Character string denoting the 1- to 15-character name of a device. This string can be a logical name, but if it is, it must translate to a valid device name. If the device name contains a colon (:), the colon and the characters following it are ignored. An underscore (_) preceding the device name string indicates that the string is a physical device name.
ef_cluster_name	Character string denoting the 1- to 15-character name of an event flag cluster. This string can be a logical name, but if it is, it must translate to a valid event-flag cluster name.
ef_number	Unsigned longword integer denoting the number of an event flag. Local event flags numbered 32 to 63 are available to your programs.
exit_handler_block	Variable-length structure denoting an exit-handler control block. This control block, which describes the exit handler, is depicted in the following diagram:



ZK-1714-GE

fab Structure denoting an RMS file access block.

(continued on next page)

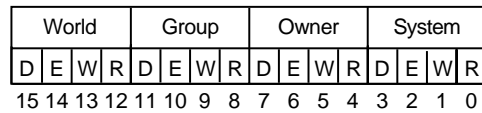
OpenVMS Data Types

B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

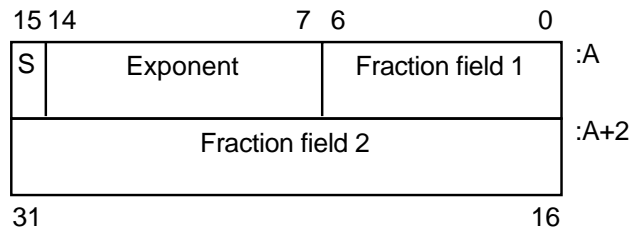
Data Type	Definition
file_protection	Unsigned word that is a 16-bit mask that specifies file protection. The mask contains four 4-bit fields, each of which specifies the protection (access protected when a bit is 1) to be applied to file access attempts by one of the four categories of users, from rightmost field to leftmost field: (1) system users, (2) file owner, (3) users in the same UIC group as the owner, and (4) all other users (the world). Each field specifies, from rightmost bit to leftmost bit: (1) read access, (2) write access, (3) execute access, (4) delete access. Set bits indicate that access is denied.

The following diagram depicts the 16-bit file-protection mask:



ZK-1706-GE

floating_point	<p>One of the Alpha or VAX standard floating-point data types. VAX systems support F_floating, D_floating, G_floating, or H_floating data types. In addition, Alpha systems support S_floating, T_floating, or X_floating types. The following paragraphs briefly describe these data types:</p> <p>The structure of an F_floating datum follows. It contains two fraction fields. Note that the field 2 extension holds the least significant portion of the fractional number.</p>
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ZK-4722A-GE

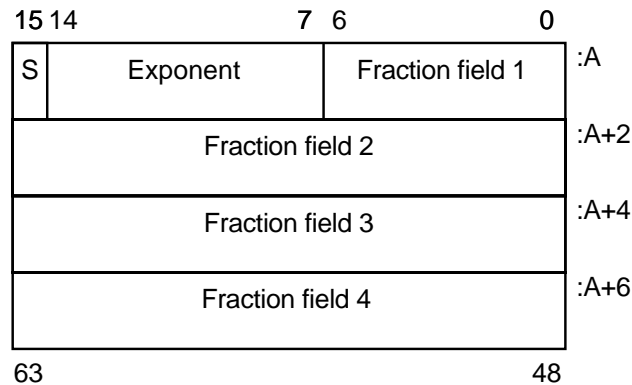
(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
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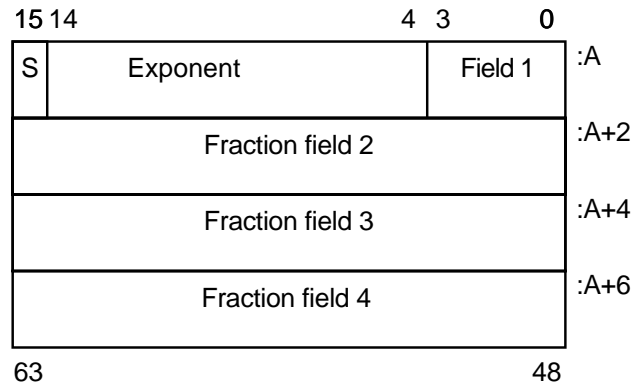
The structure of a D_floating datum follows. It contains four fraction fields. Note that the field 4 extension holds the least significant portion of the fractional number.

While OpenVMS Alpha ² supports the manipulation of D_floating and D_floating complex data, compiled-code support invokes conversion from D_floating to G_floating for Alpha arithmetic operations. Also, the conversion of G_floating intermediate results are converted back to D_floating when needed either for stores to memory or for passing parameters. However, use of D_floating data in arithmetic operations on Alpha processors produces results that are limited to G_float precision.



ZK-4723A-GE

The structure of a G_floating datum follows. It contains four fraction fields. Note that the field 4 extension holds the least significant portion of the fractional number.



ZK-4724A-GE

²Alpha specific.

(continued on next page)

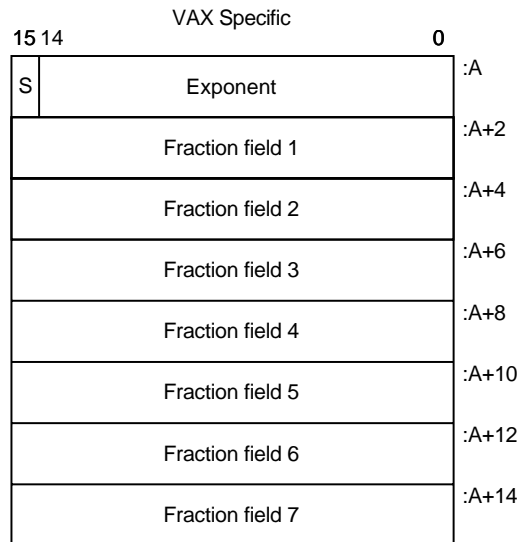
OpenVMS Data Types

B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

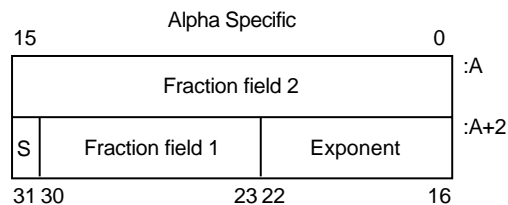
Data Type	Definition
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The structure of an H_floating datum follows (VAX ¹systems only). It contains seven fraction fields. Note that the field 7 extension holds the least significant portion of the fractional number.



ZK-4725A-GE

The structure of an S_floating datum follows (Alpha ² systems only). It contains two fraction fields. Note that the field 2 extension holds the least significant portion of the fractional number.



ZK-4726A-GE

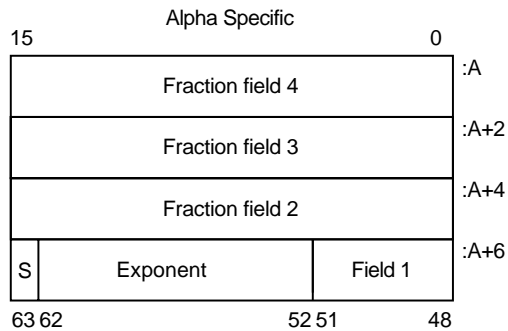
¹VAX specific.
²Alpha specific.

(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

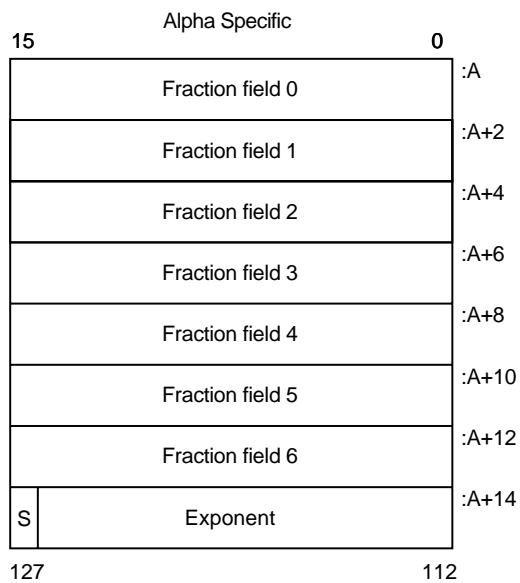
Data Type	Definition
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The structure of a T_floating datum follows (Alpha² systems only). It contains four fraction fields. Note that fraction field 1 holds the most significant bits, and the field 4 extension holds the least significant portion of the fractional number.



ZK-4727A-GE

The structure of an X_floating datum follows (Alpha² systems only). An X_floating datum occupies 16 contiguous bytes in memory or two consecutive floating-point registers. It contains seven fraction fields (0-6). Note that fraction field 6 holds the most significant bits and the field 0 extension holds the least significant portion of the fractional number.



ZK-6511A-GE

function_code Unsigned longword specifying the exact operations a procedure is to perform. This longword has two word-length fields: the first field is a number specifying the major operation; the second field is a mask or bit vector specifying various suboperations within the major operation.

identifier Unsigned longword that identifies an object returned by the system.

²Alpha specific.

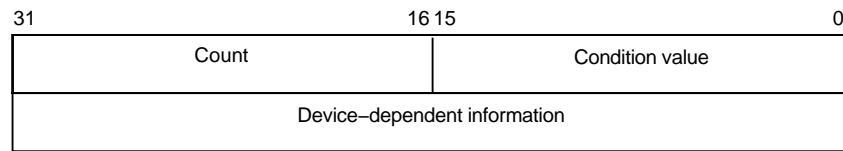
(continued on next page)

OpenVMS Data Types

B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
invo_context_blk ²	Structure that contains the context information of a specific procedure invocation in a call chain. For information describing the invocation context block, see the <i>OpenVMS Calling Standard</i> .
invo_handle ²	Unsigned longword that refers to a specific procedure invocation at run time. The invo_handle longword defines the invocation handle of a procedure in a call chain.
io_status_block	Quadword structure containing information returned by a procedure that completes asynchronously. The information returned varies depending on the procedure. The following figure illustrates the format of the information written in the IOSB for SYSSQIO:



ZK-0856-GE

The first word contains a condition value indicating the success or failure of the operation. The condition values used are the same as for all returns from system services; for example, SSS_NORMAL indicates successful completion.

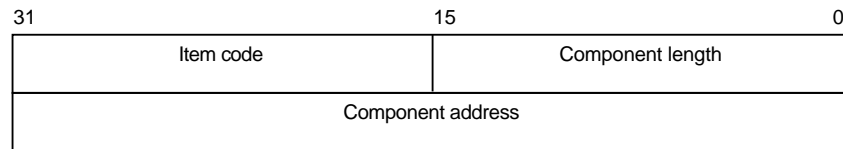
The second word contains the number of bytes actually transferred in the I/O operation. Note that for some devices this word contains only the low-order word of the count.

The second longword contains device-dependent return information.

To ensure successful I/O completion and the integrity of data transfers, you should check the IOSB following I/O requests, particularly for device-dependent I/O functions.

item_list_2	Structure that consists of one or more item descriptors and is terminated by a longword containing 0. Each item descriptor is a 2-longword structure that contains three fields.
-------------	--

The following diagram depicts a single-item descriptor:



ZK-1709-GE

The first field is a word in which the service writes the length (in characters) of the requested component. If the service does not locate the component, it returns the value 0 in this field and in the component address field.

The second field contains a user-supplied, word-length symbolic code that specifies the component desired. The item codes are defined by the macros specific to the service.

The third field is a longword in which the service writes the starting address of the component. This address is within the input string itself.

²Alpha specific.

(continued on next page)

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition												
item_list_3	<p>Structure that consists of one or more item descriptors and is terminated by a longword containing 0. Each item descriptor is a 3-longword structure that contains four fields.</p> <p>The following diagram depicts the format of a single-item descriptor:</p> <div style="text-align: center; margin: 10px 0;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%; text-align: center;">31</td> <td style="width: 33%; text-align: center;">15</td> <td style="width: 33%; text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">Item code</td> <td style="text-align: center;">Buffer length</td> <td></td> </tr> <tr> <td colspan="3" style="text-align: center;">Buffer address</td> </tr> <tr> <td colspan="3" style="text-align: center;">Return length address</td> </tr> </table> </div> <p style="text-align: right; margin-right: 20px;">ZK-1705-GE</p> <p>The first field is a word containing a user-supplied integer specifying the length (in bytes) of the buffer in which the service writes the information. The length of the buffer needed depends on the item code specified in the item code field of the item descriptor. If the value of buffer length is too small, the service truncates the data.</p> <p>The second field is a word containing a user-supplied symbolic code specifying the item of information that the service is to return. These codes are defined by macros specific to the service.</p> <p>The third field is a longword containing the user-supplied address of the buffer in which the service writes the information.</p> <p>The fourth field is a longword containing the user-supplied address of a word in which the service writes the length in bytes of the information it actually returned.</p>	31	15	0	Item code	Buffer length		Buffer address			Return length address		
31	15	0											
Item code	Buffer length												
Buffer address													
Return length address													
item_list_pair	Structure that consists of one or more longword pairs, or doublets , and is terminated by a longword containing 0. Typically, the first longword contains an integer value such as a code. The second longword can contain a real or integer value.												
item_quota_list	Structure that consists of one or more quota descriptors and is terminated by a byte containing a value defined by the symbolic name PQLS_LISTEND. Each quota descriptor consists of a 1-byte quota name followed by an unsigned longword containing the value for that quota.												
lock_id	Unsigned longword integer denoting a lock identifier. This lock identifier is assigned to a lock by the lock manager when the lock is granted.												
lock_status_block	<p>Structure into which the lock manager writes status information about a lock. A lock status block always contains at least two longwords: the first word of the first longword contains a condition value; the second word of the first longword is reserved by Compaq. The second longword contains the lock identifier.</p> <p>The lock status block receives the final condition value plus the lock identification, and optionally contains a lock value block. When a request is queued, the lock identification is stored in the lock status block even if the lock has not been granted. This allows a procedure to dequeue locks that have not been granted.</p> <p>The condition value is placed in the lock status block only when the lock is granted (or when errors occur in granting the lock).</p>												

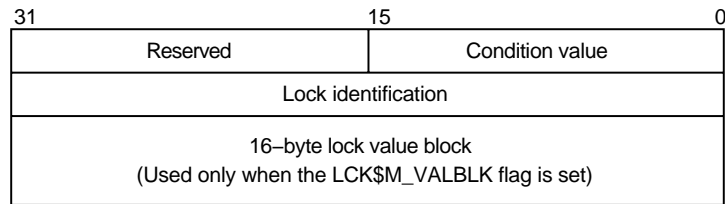
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OpenVMS Data Types

B.1 OpenVMS Data Types

Table B–1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
	The following diagram depicts a lock status block that includes the optional 16-byte lock value block:



ZK–1708–GE

lock_value_block	A 16-byte block that the lock manager includes in a lock status block if the user requests it. The contents of the lock value block are user-defined and are not interpreted by the lock manager.
logical_name	Character string of from 1 to 255 characters that identifies a logical name or equivalence name to be manipulated by OpenVMS logical name system services. Logical names that denote specific OpenVMS objects have their own OpenVMS types; for example, a logical name identifying a device has the OpenVMS type device_name .
longword_signed	Same as the data type longword integer (signed) in Table 17–3.
longword_unsigned	Same as the data type longword (unsigned) in Table 17–3.
mask_byte	Unsigned byte in which each bit is interpreted by the called procedure. A mask is also referred to as a set of flags or as a bit mask.
mask_longword	Unsigned longword in which each bit is interpreted by the called procedure. A mask is also referred to as a set of flags or as a bit mask.
mask_quadword	Unsigned quadword in which each bit is interpreted by the called procedure. A mask is also referred to as a set of flags or as a bit mask.
mask_word	Unsigned word in which each bit is interpreted by the called procedure. A mask is also referred to as a set of flags or as a bit mask.
mechanism_args	Structure (array) of mechanism argument vectors that contain information about the machine state when an exception occurs or when a condition is signaled. For more information concerning mechanism argument vectors, see the <i>OpenVMS Calling Standard</i> .
null_arg	Unsigned longword denoting a null argument. (A null argument is one whose only purpose is to hold a place in the argument list.)
octaword_signed	Same as the data type octaword integer (signed) in Table 17–3.
octaword_unsigned	Same as the data type octaword (unsigned) in Table 17–3.

(continued on next page)

Table B–1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition																																
page_protection	<p>Unsigned longword specifying page protection to be applied by the Alpha or VAX hardware. Protection values are specified using bits <3:0>; bits <31:4> are ignored. If you specify the protection as 0, the protection defaults to kernel read only. The \$PRTDEF macro defines the following symbolic names for the protection codes:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Symbol</th> <th style="text-align: left;">Description</th> </tr> </thead> <tbody> <tr><td>PRT\$C_NA</td><td>No access</td></tr> <tr><td>PRT\$C_KR</td><td>Kernel read only</td></tr> <tr><td>PRT\$C_KW</td><td>Kernel write</td></tr> <tr><td>PRT\$C_ER</td><td>Executive read only</td></tr> <tr><td>PRT\$C_EW</td><td>Executive write</td></tr> <tr><td>PRT\$C_SR</td><td>Supervisor read only</td></tr> <tr><td>PRT\$C_SW</td><td>Supervisor write</td></tr> <tr><td>PRT\$C_UR</td><td>User read only</td></tr> <tr><td>PRT\$C_UW</td><td>User write</td></tr> <tr><td>PRT\$C_ERKW</td><td>Executive read; kernel write</td></tr> <tr><td>PRT\$C_SRKW</td><td>Supervisor read; kernel write</td></tr> <tr><td>PRT\$C_SREW</td><td>Supervisor read; executive write</td></tr> <tr><td>PRT\$C_URKW</td><td>User read; kernel write</td></tr> <tr><td>PRT\$C_UREW</td><td>User read; executive write</td></tr> <tr><td>PRT\$C_URSW</td><td>User read; supervisor write</td></tr> </tbody> </table>	Symbol	Description	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
Symbol	Description																																
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																																
procedure	<p>Procedure value of a procedure that is not to be called at AST level. (Arguments specifying procedures to be called at AST level have the OpenVMS type ast_procedure.)</p> <p>A procedure value is an address that represents a procedure. On VAX systems, a procedure value is the address of the procedure entry mask. On Alpha systems, a procedure value is the address of the procedure descriptor for the procedure. For more information, see the <i>OpenVMS Calling Standard</i>.</p>																																
process_id	<p>Unsigned longword integer denoting a process identification (PID). This process identification is assigned to a process by the operating system when the process is created.</p>																																
process_name	<p>Character string containing 1 to 15 characters that specifies the name of a process.</p>																																
quadword_signed	<p>Same as the data type quadword integer (signed) in Table 17–3.</p>																																
quadword_unsigned	<p>Same as the data type quadword (unsigned) in Table 17–3.</p>																																

(continued on next page)

OpenVMS Data Types

B.1 OpenVMS Data Types

Table B-1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition
rights_holder	<p>Unsigned quadword specifying a user's access rights to a system object. This quadword consists of two fields: the first is an unsigned longword identifier (OpenVMS type rights_id), and the second is a longword bit mask in which each bit specifies an access right. The following diagram depicts the format of a rights holder:</p> <div style="text-align: center;"> <pre> 31 0 +-----+-----+ UIC identifier of holder +-----+-----+ 0 +-----+-----+ </pre> </div> <p style="text-align: right;">ZK-1903-GE</p>
rights_id	<p>Unsigned longword denoting a rights identifier, which identifies an interest group in the context of the OpenVMS security environment. This rights environment might consist of all or part of a user's user identification code (UIC).</p> <p>Identifiers have two formats in the rights database: UIC format (OpenVMS type uic) and ID format. The high-order bits of the identifier value specify the format of the identifier. Two high-order zero bits identify a UIC format identifier; bit <31>, set to 1, identifies an ID format identifier. Bits <30:28> are reserved by Compaq. The remaining bits specify the identifier value. The following diagram depicts the ID format of a rights identifier:</p> <div style="text-align: center;"> <pre> 31 27 0 +-----+-----+-----+ 1000 Identifier +-----+-----+-----+ </pre> </div> <p style="text-align: right;">ZK-1906-GE</p> <p>To the system, an identifier is a binary value; however, to make identifiers easy to use, the system translates the binary identifier value into an identifier name. The binary value and the identifier name are associated in the rights database.</p> <p>An identifier name consists of 1 to 31 alphanumeric characters and contains at least one nonnumeric character. An identifier name cannot consist entirely of numeric characters. It can include the characters A through Z, dollar signs (\$), and underscores (_), as well as the numbers 0 through 9. Any lowercase characters are automatically converted to uppercase.</p>
rab	Structure denoting an RMS record access block.
section_id	Unsigned quadword denoting a global section identifier. This identifier specifies the version of a global section and the criteria to be used in matching that global section.
section_name	Character string denoting a 1- to 43-character global-section name. This character string can be a logical name, but it must translate to a valid global section name.
system_access_id	Unsigned quadword that denotes a system identification value to be associated with a rights database.
time_name	Character string specifying a time value in an OpenVMS format.
transaction_id	Unsigned octaword that denotes a unique transaction identifier.

(continued on next page)

Table B–1 (Cont.) OpenVMS Usage Data Type Entries

Data Type	Definition			
uic	Unsigned longword denoting a user identification code (UIC). Each UIC is unique and represents a system user. The UIC identifier contains two high-order bits that designate format, a member field, and a group field. Member numbers range from 0 to 65534; group numbers range from 1 to 16382. The following diagram depicts the UIC format:			
	<div style="display: flex; justify-content: space-between; align-items: center;"> 31 0 </div> <table border="1" style="margin: 0 auto; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;">00</td> <td style="width: 50%; text-align: center;">Group</td> <td style="width: 40%; text-align: center;">Member</td> </tr> </table>	00	Group	Member
00	Group	Member		
	ZK–1905–GE			
user_arg	On VAX systems, an unsigned longword, and on Alpha systems, an unsigned quadword denoting a user-defined argument. The longword (VAX) or quadword (Alpha) is passed to a procedure as an argument, but the contents of the longword or quadword are defined and interpreted by the user.			
varying_arg	On VAX systems, an unsigned longword, and on Alpha systems, an unsigned quadword denoting a varying argument. A variable argument can have variable types, depending on specifications made for other arguments in the call.			
vector_byte_signed	Homogeneous array whose elements are all signed bytes.			
vector_byte_unsigned	Homogeneous array whose elements are all unsigned bytes.			
vector_longword_signed	Homogeneous array whose elements are all signed longwords.			
vector_longword_unsigned	Homogeneous array whose elements are all unsigned longwords.			
vector_quadword_signed	Homogeneous array whose elements are all signed quadwords.			
vector_quadword_unsigned	Homogeneous array whose elements are all unsigned quadwords.			
vector_word_signed	Homogeneous array whose elements are all signed words.			
vector_word_unsigned	Homogeneous array whose elements are all unsigned words.			
word_signed	Same as the data type word integer (signed) in Table 17–3.			
word_unsigned	Same as the data type word (unsigned) in Table 17–3.			

B.2 Ada Implementations

Table B–2 lists the OpenVMS data types and their corresponding Ada data type declarations.

Table B–2 Ada Implementations

OpenVMS Data Types	Ada Declarations
access_bit_names	STARLET.ACCESS_BIT_NAMES_TYPE
access_mode	STARLET.ACCESS_MODE_TYPE
address	SYSTEM.ADDRESS

(continued on next page)

OpenVMS Data Types

B.2 Ada Implementations

Table B–2 (Cont.) Ada Implementations

OpenVMS Data Types	Ada Declarations
address_range	STARLET.ADDRESS_RANGE_TYPE
arg_list	STARLET.ARG_LIST_TYPE
ast_procedure	SYSTEM.AST_HANDLER
boolean	STANDARD.BOOLEAN
byte_signed	STANDARD.SHORT_SHORT_INTEGER
byte_unsigned	SYSTEM.UNSIGNED_BYTE
channel	STARLET.CHANNEL_TYPE
char_string	STANDARD.STRING
complex_number	User-defined record
cond_value	CONDITION_HANDLING.COND_VALUE_TYPE
context	STARLET.CONTEXT_TYPE
date_time	STARLET.DATE_TIME_TYPE
device_name	STARLET.DEVICE_NAME_TYPE
ef_cluster_name	STARLET.EF_CLUSTER_NAME_TYPE
ef_number	STARLET.EF_NUMBER_TYPE
exit_handler_block	STARLET.EXIT_HANDLER_BLOCK_TYPE
fab	STARLET.FAB_TYPE
file_protection	STARLET.FILE_PROTECTION_TYPE
floating_point	STANDARD.FLOAT STANDARD.LONG_FLOAT STANDARD.LONG_LONG_FLOAT SYSTEM.F_FLOAT SYSTEM.D_FLOAT SYSTEM.G_FLOAT SYSTEM.H_FLOAT SYSTEM.IEEE_SINGLE_FLOAT ¹ SYSTEM.IEEE_DOUBLE_FLOAT ¹
function_code	STARLET.FUNCTION_CODE_TYPE
identifier	SYSTEM.UNSIGNED_LONGWORD
invo_context_blk ¹	User-defined record
invo_handle ¹	SYSTEM.UNSIGNED_LONGWORD
io_status_block	STARLET.IOSB_TYPE
item_list_pair	SYSTEM.UNSIGNED_LONGWORD
item_list_2	STARLET.ITEM_LIST_2_TYPE
item_list_3	STARLET.ITEM_LIST_3_TYPE
item_quota_list	User-defined record
lock_id	STARLET.LOCK_ID_TYPE
lock_status_block	STARLET.LOCK_STATUS_BLOCK_TYPE
lock_value_block	STARLET.LOCK_VALUE_BLOCK_TYPE
logical_name	STARLET.LOGICAL_NAME_TYPE

¹Alpha specific.

(continued on next page)

Table B–2 (Cont.) Ada Implementations

OpenVMS Data Types	Ada Declarations
longword_signed	STANDARD.INTEGER
longword_unsigned	SYSTEM.UNSIGNED_LONGWORD
mask_byte	SYSTEM.UNSIGNED_BYTE
mask_longword	SYSTEM.UNSIGNED_LONGWORD
mask_quadword	SYSTEM.UNSIGNED_QUADWORD
mask_word	SYSTEM.UNSIGNED_WORD
mechanism_args	STARLET.CHFDEF2_TYPE
null_arg	SYSTEM.UNSIGNED_LONGWORD
octaword_signed	array(1..4) of SYSTEM.UNSIGNED_LONGWORD
octaword_unsigned	array(1..4) of SYSTEM.UNSIGNED_LONGWORD
page_protection	STARLET.PAGE_PROTECTION_TYPE
procedure	SYSTEM.ADDRESS
process_id	STARLET.PROCESS_ID_TYPE
process_name	STARLET.PROCESS_NAME_TYPE
quadword_signed	SYSTEM.UNSIGNED_QUADWORD
quadword_unsigned	SYSTEM.UNSIGNED_QUADWORD
rights_holder	STARLET.RIGHTS HOLDER_TYPE
rights_id	STARLET.RIGHTS_ID_TYPE
rab	STARLET.RAB_TYPE
section_id	STARLET.SECTION_ID_TYPE
section_name	STARLET.SECTION_NAME_TYPE
system_access_id	STARLET.SYSTEM_ACCESS_ID_TYPE
time_name	STARLET.TIME_NAME_TYPE
transaction_id	array(1..n) of SYSTEM.UNSIGNED_LONGWORD
uic	STARLET.UIC_TYPE
user_arg	STARLET.USER_ARG_TYPE
varying_arg	SYSTEM.UNSIGNED_LONGWORD
vector_byte_signed	array(1..n) of STANDARD.SHORT_SHORT_INTEGER
vector_byte_unsigned	array(1..n) of SYSTEM.UNSIGNED_BYTE
vector_longword_signed	array(1..n) of STANDARD.INTEGER
vector_longword_unsigned	array(1..n) of SYSTEM.UNSIGNED_LONGWORD
vector_quadword_signed	array(1..n) of SYSTEM.UNSIGNED_QUADWORD
vector_quadword_unsigned	array(1..n) of SYSTEM.UNSIGNED_QUADWORD
vector_word_signed	array(1..n) of STANDARD.SHORT_INTEGER
vector_word_unsigned	array(1..n) of SYSTEM.UNSIGNED_WORD
word_signed	STANDARD.SHORT_INTEGER
word_unsigned	SYSTEM.UNSIGNED_WORD

OpenVMS Data Types

B.3 Application Programming Language (APL) Implementations

B.3 Application Programming Language (APL) Implementations

Table B-3 lists the OpenVMS data types and their corresponding APL data type declarations.

Table B-3 APL Implementations

OpenVMS Data Types	APL Declarations
access_bit_names	na
access_mode	/TYPE=BU
address	na
address_range	na
arg_list	na
ast_procedure	na
boolean	/TYPE=V
byte_signed	/TYPE=B
byte_unsigned	/TYPE=BU
channel	/TYPE=WU
char_string	/TYPE=T
complex_number	/TYPE=FC /TYPE=DC /TYPE=GC /TYPE=HC
cond_value	/TYPE=LU
context	na
date_time	na
device_name	/TYPE=T
ef_cluster_name	/TYPE=T
ef_number	/TYPE=LU
exit_handler_block	na
fab	na
file_protection	/TYPE=WU
floating_point	/TYPE=F /TYPE=D /TYPE=G /TYPE=H
function_code	na
identifier	na
io_status_block	na
item_list_2	na
item_list_3	na
item_list_pair	na
item_quota_list	na
lock_id	/TYPE=LU

(continued on next page)

OpenVMS Data Types

B.3 Application Programming Language (APL) Implementations

Table B-3 (Cont.) APL Implementations

OpenVMS Data Types	APL Declarations
lock_status_block	na
lock_value_block	na
logical_name	/TYPE=T
longword_signed	/TYPE=L
longword_unsigned	/TYPE=LU
mask_byte	/TYPE=BU
mask_longword	/TYPE=LU
mask_quadword	na
mask_word	/TYPE=WU
null_arg	/TYPE=LU
octaword_signed	na
octaword_unsigned	na
page_protection	/TYPE=LU
procedure	na
process_id	/TYPE=LU
process_name	/TYPE=T
quadword_signed	na
quadword_unsigned	na
rights_holder	na
rights_id	/TYPE=LU
rab	na
section_id	na
section_name	/TYPE=T
system_access_id	na
time_name	/TYPE=T
transaction_id	na
uic	/TYPE=LU
user_arg	/TYPE=LU
varying_arg	na
vector_byte_signed	/TYPE=B
vector_byte_unsigned	/TYPE=BU
vector_longword_signed	/TYPE=L
vector_longword_unsigned	/TYPE=LU
vector_quadword_signed	na
vector_quadword_unsigned	na
vector_word_signed	/TYPE=W

(continued on next page)

OpenVMS Data Types

B.3 Application Programming Language (APL) Implementations

Table B-3 (Cont.) APL Implementations

OpenVMS Data Types	APL Declarations
vector_word_unsigned	/TYPE=WU
word_signed	/TYPE=W
word_unsigned	/TYPE=WU

B.4 BASIC Implementations

Table B-4 lists the OpenVMS data types and their corresponding BASIC data type declarations.

Table B-4 BASIC Implementations

OpenVMS Data Type	BASIC Declarations
access_bit_names	na
access_mode	BYTE (signed)
address	LONG
address_range	LONG address_range (1) or RECORD address_range LONG beginning_address LONG ending_address END RECORD
arg_list	na
ast_procedure	EXTERNAL LONG ast_proc
boolean	LONG
byte_signed	BYTE
byte_unsigned	BYTE ¹
channel	WORD
char_string	STRING
complex_number	RECORD complex REAL real_part REAL imaginary_part END RECORD
cond_value	LONG
context	LONG
date_time	RECORD date_time LONG FILL (2) END RECORD
device_name	STRING
ef_cluster_name	STRING
ef_number	LONG

¹Although unsigned data types are not directly supported in BASIC, you may substitute the signed equivalent provided you do not exceed the range of the signed data type.

(continued on next page)

OpenVMS Data Types B.4 BASIC Implementations

Table B-4 (Cont.) BASIC Implementations

OpenVMS Data Type	BASIC Declarations
exit_handler_block	RECORD EHCB LONG flink LONG handler_addr BYTE arg_count BYTE FILL (3) LONG status_value_addr END RECORD
fab	na
file_protection	LONG
floating_point	SINGLE DOUBLE GFLOAT HFLOAT
function_code	RECORD function-code WORD major-function WORD subfunction END RECORD
identifier	LONG
io_status_block	RECORD iosb WORD iosb-field (3) END RECORD
item_list_2	RECORD item_list_two GROUP item(15) VARIANT CASE WORD comp_length WORD code LONG comp_address CASE LONG terminator END VARIANT END GROUP END RECORD
item_list_3	RECORD item_list_3 GROUP item (15) VARIANT CASE WORD buf_len WORD code LONG buffer_address LONG length_address CASE LONG terminator END VARIANT END GROUP END RECORD

(continued on next page)

OpenVMS Data Types

B.4 BASIC Implementations

Table B-4 (Cont.) BASIC Implementations

OpenVMS Data Type	BASIC Declarations
item_list_pair	<pre> RECORD item_list_pair GROUP item (15) VARIANT CASE LONG code LONG value CASE LONG terminator END VARIANT END GROUP END RECORD item_list_pair </pre>
item_quota_list	<pre> RECORD item_quota_list GROUP quota (<i>n</i>) VARIANT CASE BYTE quota_name LONG value CASE BYTE list_end END VARIANT END GROUP END RECORD </pre>
lock_id	LONG
lock_status_block	na
lock_value_block	na
logical_name	STRING
longword_signed	LONG
longword_unsigned	LONG ¹
mask_byte	BYTE
mask_longword	LONG
mask_quadword	<pre> RECORD quadword LONG FILL (2) END RECORD¹ </pre>
mask_word	WORD
null_arg	A null argument is indicated by a comma used as a placeholder in the argument list.
octaword_signed	na
octaword_unsigned	na
page_protection	LONG
procedure	EXTERNAL LONG proc
process_id	LONG
process_name	STRING
quadword_signed	<pre> RECORD quadword LONG FILL (2) END RECORD </pre>

¹Although unsigned data types are not directly supported in BASIC, you may substitute the signed equivalent provided you do not exceed the range of the signed data type.

(continued on next page)

Table B–4 (Cont.) BASIC Implementations

OpenVMS Data Type	BASIC Declarations
quadword_unsigned	RECORD quadword LONG FILL (2) END RECORD ¹
rights_holder	RECORD quadword LONG FILL (2) END RECORD ¹
rights_id	LONG
rab	na
section_id	RECORD quadword LONG FILL (2) END RECORD ¹
section_name	STRING
system_access_id	RECORD quadword LONG FILL (2) END RECORD ¹
time_name	STRING
transaction_id	na
uic	LONG
user_arg	LONG
varying_arg	Depends on the application.
vector_byte_signed	BYTE array <i>n</i>
vector_byte_unsigned	BYTE array <i>n</i> ¹
vector_longword_signed	LONG array <i>n</i>
vector_longword_unsigned	LONG array <i>n</i> ¹
vector_quadword_signed	na
vector_quadword_unsigned	na
vector_word_signed	WORD array <i>n</i>
vector_word_unsigned	WORD array <i>n</i> ¹
word_signed	WORD
word_unsigned	WORD ¹

¹Although unsigned data types are not directly supported in BASIC, you may substitute the signed equivalent provided you do not exceed the range of the signed data type.

B.5 BLISS Implementations

Table B–5 lists the OpenVMS data types and their corresponding BLISS data type declarations.

Table B–5 BLISS Implementations

OpenVMS Data Types	BLISS Declarations
access_bit_names	BLOCKVECTOR[32,8,BYTE]

(continued on next page)

OpenVMS Data Types

B.5 BLISS Implementations

Table B–5 (Cont.) BLISS Implementations

OpenVMS Data Types	BLISS Declarations
access_mode	UNSIGNED BYTE
address	UNSIGNED LONG
address_range	VECTOR[2, LONG, UNSIGNED]
arg_list	VECTOR[<i>n</i> , LONG, UNSIGNED] where <i>n</i> is the number of arguments + 1.
ast_procedure	UNSIGNED LONG
boolean	UNSIGNED LONG
byte_signed	SIGNED BYTE
byte_unsigned	UNSIGNED BYTE
channel	UNSIGNED WORD
char_string	VECTOR[65536, BYTE, UNSIGNED]
complex_number	F_Complex: VECTOR[2, LONG] D_Complex: VECTOR[4, LONG] G_Complex: VECTOR[4, LONG] H_Complex: VECTOR[8, LONG]
cond_value	UNSIGNED LONG
context	UNSIGNED LONG
date_time	VECTOR[2, LONG, UNSIGNED]
device_name	VECTOR[<i>n</i> , BYTE, UNSIGNED] where <i>n</i> is the length of the device name.
ef_cluster_name	VECTOR[<i>n</i> , BYTE, UNSIGNED] where <i>n</i> is the length of the event-flag cluster name.
ef_number	UNSIGNED LONG
exit_handler_block	BLOCK[<i>n</i> , BYTE] where <i>n</i> is the size of the exit-handler control block.
fab	\$FAB_DECL (from STARLET.REQ)
file_protection	BLOCK[2, BYTE]
floating_point	F_Floating: VECTOR[1, LONG] D_Floating: VECTOR[2, LONG] G_Floating: VECTOR[2, LONG] H_Floating: VECTOR[4, LONG]
function_code	BLOCK[2, WORD]
identifier	UNSIGNED LONG
io_status_block	BLOCK[8, BYTE]
item_list_2	BLOCKVECTOR[<i>n</i> , 8, BYTE] where <i>n</i> is the number of the item descriptors + 1.
item_list_3	BLOCKVECTOR[<i>n</i> , 12, BYTE] where <i>n</i> is the number of the item descriptors + 1. \$ITMLST_DECL/\$ITMLST_INIT from STARLET.REQ
item_list_pair	BLOCKVECTOR[<i>n</i> , 2, LONG] where <i>n</i> is the number of the item descriptors + 1.

(continued on next page)

Table B-5 (Cont.) BLISS Implementations

OpenVMS Data Types	BLISS Declarations
item_quota_list	BLOCKVECTOR[<i>n</i> ,5,BYTE] where <i>n</i> is the number of the quota descriptors + 1.
lock_id	UNSIGNED_LONG
lock_status_block	BLOCK[<i>n</i> ,BYTE] where <i>n</i> is the size of the lock_status_block minus at least 8.
lock_value_block	BLOCK[16,BYTE]
logical_name	VECTOR[255,BYTE,UNSIGNED]
longword_signed	SIGNED LONG
longword_unsigned	UNSIGNED LONG
mask_byte	BITVECTOR[8]
mask_longword	BITVECTOR[32]
mask_quadword	BITVECTOR[64]
mask_word	BITVECTOR[16]
null_arg	UNSIGNED LONG
octaword_signed	VECTOR[4,LONG,UNSIGNED]
octaword_unsigned	VECTOR[4,LONG,UNSIGNED]
page_protection	UNSIGNED LONG
procedure	UNSIGNED LONG
process_id	UNSIGNED LONG
process_name	VECTOR[<i>n</i> ,BYTE,UNSIGNED] where <i>n</i> is the length of the process name.
quadword_signed	VECTOR[2,LONG,UNSIGNED]
quadword_unsigned	VECTOR[2,LONG,UNSIGNED]
rights_holder	BLOCK[8,BYTE]
rights_id	UNSIGNED LONG
rab	\$RAB_DECL from STARLET.REQ
section_id	VECTOR[2,LONG,UNSIGNED]
section_name	VECTOR[<i>n</i> ,BYTE,UNSIGNED] where <i>n</i> is the length of the global section name.
system_access_id	VECTOR[2,LONG,UNSIGNED]
time_name	VECTOR[<i>n</i> ,BYTE,UNSIGNED] where <i>n</i> is the length of the time value in OpenVMS format.
transaction_id	VECTOR[4,LONG,UNSIGNED]
uic	UNSIGNED LONG
user_arg	UNSIGNED LONG
varying_arg	UNSIGNED LONG
vector_byte_signed	VECTOR[<i>n</i> ,BYTE,SIGNED] where <i>n</i> is the size of the array.

(continued on next page)

OpenVMS Data Types

B.5 BLISS Implementations

Table B–5 (Cont.) BLISS Implementations

OpenVMS Data Types	BLISS Declarations
vector_byte_unsigned	VECTOR[<i>n</i> ,BYTE,UNSIGNED] where <i>n</i> is the size of the array.
vector_longword_signed	VECTOR[<i>n</i> ,LONG,SIGNED] where <i>n</i> is the size of the array.
vector_longword_unsigned	VECTOR[<i>n</i> ,LONG,UNSIGNED] where <i>n</i> is the size of the array.
vector_quadword_signed	BLOCKVECTOR[<i>n</i> ,2,LONG] where <i>n</i> is the size of the array.
vector_quadword_unsigned	BLOCKVECTOR[<i>n</i> ,2,LONG] where <i>n</i> is the size of the array.
vector_word_signed	VECTOR[<i>n</i> ,BYTE,SIGNED] where <i>n</i> is the size of the array.
vector_word_unsigned	VECTOR[<i>n</i> ,BYTE,UNSIGNED] where <i>n</i> is the size of the array.
word_signed	SIGNED WORD
word_unsigned	UNSIGNED WORD

B.6 C and C++ Implementations

Table B–6 lists the OpenVMS data types and their corresponding C and C++ data type declarations.

Table B–6 C and C++ Implementations

OpenVMS Data Types	C and C++ Declarations
access_bit_names	User defined ¹
access_mode	unsigned char
address	User defined ¹ *pointer ^{2,4}
address_range	int *array [2] ^{2,3,4}
arg_list	User defined ¹
ast_procedure	Pointer to function ²
boolean	unsigned long int
byte_signed	char
byte_unsigned	unsigned char
channel	unsigned short int
char_string	char array[<i>n</i>] ^{3,5}
complex_number	User defined ¹

¹The declaration of a user-defined data structure depends on how the data will be used. Such data structures can be declared in a variety of ways, each of which is suitable only to specific applications.

²C and C++ pointers are declared with special syntax and are associated with the data type of the object being pointed to. This object is often user defined.

³The term array denotes the syntax of a C or C++ array declaration.

⁴The data type specified can be changed to any valid C or C++ data type.

⁵The size of the array must be substituted for *n*.

(continued on next page)

Table B–6 (Cont.) C and C++ Implementations

OpenVMS Data Types	C and C++ Declarations
cond_value	unsigned long int
context	unsigned long int
date_time	User defined ¹
device_name	char array[n] ^{3,5}
ef_cluster_name	char array[n] ^{3,5}
ef_number	unsigned long int
exit_handler_block	User defined ¹
fab	#include <fab.h> struct FAB
file_protection	unsigned short int or user defined ¹
floating_point	float, double, or long double
function_code	unsigned long int or user defined ¹
identifier	unsigned long int *pointer ^{2,4}
invo_context_blk ⁶	#include <libich.h> struct invo_context_blk
invo_handle ⁶	unsigned long int
io_status_block	User defined ¹
item_list_2	User defined ¹
item_list_3	User defined ¹
item_list_pair	User defined ¹
item_quota_list	User defined ¹
lock_id	unsigned long int
lock_status_block	User defined ¹
lock_value_block	User defined ¹
logical_name	char array[n] ^{3,5}
longword_signed	long int
longword_unsigned	unsigned long int
mask_byte	unsigned char
mask_longword	unsigned long int
mask_quadword	User defined ¹
mask_word	unsigned short int
mechanism_args	#include <chfdef.h> struct chf\$mech_array
null_arg	unsigned long int

¹The declaration of a user-defined data structure depends on how the data will be used. Such data structures can be declared in a variety of ways, each of which is suitable only to specific applications.

²C and C++ pointers are declared with special syntax and are associated with the data type of the object being pointed to. This object is often user defined.

³The term array denotes the syntax of a C or C++ array declaration.

⁴The data type specified can be changed to any valid C or C++ data type.

⁵The size of the array must be substituted for *n*.

⁶Alpha specific.

(continued on next page)

OpenVMS Data Types

B.6 C and C++ Implementations

Table B–6 (Cont.) C and C++ Implementations

OpenVMS Data Types	C and C++ Declarations
octaword_signed	User defined ¹
octaword_unsigned	User defined ¹
page_protection	unsigned long int
procedure	Pointer to function ²
process_id	unsigned long int
process_name	char array[n] ^{3,5}
quadword_signed	User defined ¹
quadword_unsigned	User defined ¹
rights_holder	User defined ¹
rights_id	unsigned long int
rab	#include <rab.h> struct RAB
section_id	User defined ¹
section_name	char array[n] ^{3,5}
system_access_id	User defined ¹
time_name	char array[n] ^{3,5}
transaction_id	User defined ¹
uic	unsigned long int
user_arg	User defined ¹
varying_arg	User defined ¹
vector_byte_signed	char array[n] ^{3,5}
vector_byte_unsigned	unsigned char array[n] ^{3,5}
vector_longword_signed	long int array[n] ^{3,5}
vector_longword_unsigned	unsigned long int array[n] ^{3,5}
vector_quadword_signed	User defined ¹
vector_quadword_unsigned	User defined ¹
vector_word_signed	short int array[n] ^{3,5}
vector_word_unsigned	unsigned short int array[n] ^{3,5}
word_signed	short int
word_unsigned	unsigned short int

¹The declaration of a user-defined data structure depends on how the data will be used. Such data structures can be declared in a variety of ways, each of which is suitable only to specific applications.

²C and C++ pointers are declared with special syntax and are associated with the data type of the object being pointed to. This object is often user defined.

³The term array denotes the syntax of a C or C++ array declaration.

⁵The size of the array must be substituted for *n*.

B.7 COBOL Implementations

Table B–7 lists the OpenVMS data types and their corresponding COBOL data type declarations.

OpenVMS Data Types B.7 COBOL Implementations

Table B-7 COBOL Implementations

OpenVMS Data Types	COBOL Declarations
access_bit_names	na . . . PIC X(128) ¹
access_mode	na . . . PIC X ¹ The access_mode data type is usually passed BY VALUE as PIC 9(5) COMP.
address	USAGE POINTER
address_range	01 ADDRESS-RANGE 02 BEGINNING-ADDRESS USAGE POINTER 02 ENDING-ADDRESS USAGE POINTER
arg_list	na . . . Constructed by the compiler as a result of using the COBOL CALL statement. An argument list may be created as follows, but cannot be referenced by the COBOL CALL statement. 01 ARG-LIST 02 ARG-COUNT PIC S9(5) COMP 02 ARG-BY-VALUE PIC S9(5) COMP 02 ARG-BY-REFERENCE USAGE POINTER 02 VALUE REFERENCE ARG-NAME . . . continue as needed
ast_procedure	01 AST-PROC PIC 9(5) COMP ²
boolean	01 BOOLEAN-VALUE PIC 9(5) COMP ²
byte_signed	na . . . PIC X ¹
byte_unsigned	na . . . PIC X ¹
channel	01 CHANNEL PIC 9(4) COMP ²
char_string	01 CHAR-STRING PIC X to PIC X(65535)
complex_number	na . . . PIC X(<i>n</i>), where <i>n</i> is the length. ¹
cond_value	01 COND-VALUE PIC 9(5) COMP ²
context	01 CONTEXT PIC 9(5) COMP ²
date_time	na . . . PIC X(16) ¹
device_name	01 DEVICE-NAME PIC X(<i>n</i>), where <i>n</i> is the length.
ef_cluster_name	01 CLUSTER-NAME PIC X(<i>n</i>), where <i>n</i> is the length.
ef_number	01 EF-NO PIC 9(5) COMP ²
exit_handler_block	na . . . PIC X(<i>n</i>), where <i>n</i> is the length. ¹
fab	na . . . Too complex for general COBOL use. Most of a FAB structure can be described by a lengthy COBOL record description, but such a FAB cannot then be referenced by a COBOL I-O statement. It is much simpler to do the I-O completely within COBOL, and let the COBOL compiler generate the FAB structure or do the I-O in another language.
file_protection	01 FILE-PROT PIC 9(4) COMP ²

¹Most OpenVMS data types not directly supported in COBOL can be represented as an alphanumeric data item of a certain number of bytes. While COBOL does not interpret the data type, you can use it to pass objects from one language to another.

²Although unsigned computational data structures are not directly supported in COBOL, you may substitute the signed equivalent provided you do not exceed the range of the signed data structure.

(continued on next page)

OpenVMS Data Types

B.7 COBOL Implementations

Table B–7 (Cont.) COBOL Implementations

OpenVMS Data Types	COBOL Declarations
floating_point	01 F-FLOAT USAGE COMP-1 01 D-FLOAT USAGE COMP-2 The G-float and H-float data types are not supported in COBOL.
function_code	01 FUNCTION-CODE 02 MAJOR-FUNCTION PIC 9(4) COMP ² 02 SUB-FUNCTION PIC 9(4) COMP ²
identifier	01 ID PIC 9(5) COMP ²
invo_context_blk ³	na
invo_handle ³	na
io_status_block	01 IOSB 02 COND-VAL PIC 9(4) COMP ² 02 BYTE-CNT PIC 9(4) COMP ² 02 DEV-INFO PIC 9(5) COMP ²
item_list_2	01 ITEM-LIST-TWO 02 ITEM-LIST OCCURS <i>n</i> TIMES 04 COMP-LENGTH PIC S9(4) COMP 04 ITEM-CODE PIC S9(4) COMP 04 COMP-ADDRESS PIC S9(5) COMP 02 TERMINATOR PIC S9(5) COMP VALUE 0
item_list_3	01 ITEM-LIST-3 02 ITEM-LIST OCCURS <i>n</i> TIMES 04 BUF-LEN PIC S9(4) COMP 04 ITEM-CODE PIC S9(4) COMP 04 BUFFER-ADDRESS PIC S9(5) COMP 04 LENGTH-ADDRESS PIC S9(5) COMP 02 TERMINATOR PIC S9(5) COMP VALUE 0
item_list_pair	01 ITEM-LIST-PAIR 02 ITEM-LIST OCCURS <i>n</i> TIMES 04 ITEM-CODE PIC S9(5) COMP 04 ITEM-VALUE PIC S9(5) COMP 02 TERMINATOR PIC S9(5) COMP VALUE 0
item_quota_list	na
lock_id	01 LOCK-ID PIC 9(5) COMP ²
lock_status_block	na
lock_value_block	na
logical_name	01 LOG-NAME PIC X TO X(255)
longword_signed	01 LWS PIC S9(5) COMP
longword_unsigned	01 LWU PIC 9(5) COMP ²
mask_byte	na . . . PIC X ¹
mask_longword	01 MLW PIC 9(5) COMP ²
mask_quadword	01 MQW PIC 9(18) COMP ²

¹Most OpenVMS data types not directly supported in COBOL can be represented as an alphanumeric data item of a certain number of bytes. While COBOL does not interpret the data type, you can use it to pass objects from one language to another.

²Although unsigned computational data structures are not directly supported in COBOL, you may substitute the signed equivalent provided you do not exceed the range of the signed data structure.

³Alpha specific.

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Table B-7 (Cont.) COBOL Implementations

OpenVMS Data Types	COBOL Declarations
mask_word	01 MW PIC 9(4) COMP ²
mechanism_args	na
null_arg	CALL . . . USING OMITTED or PIC S9(5) COMP VALUE 0 passed USING BY VALUE
octaword_signed	na
octaword_unsigned	na
page_protection	01 PAGE-PROT PIC 9(5) COMP ²
procedure	01 ENTRY-MASK PIC 9(5) COMP ²
process_id	01 PID PIC 9(5) COMP ²
process_name	01 PROCESS-NAME PIC X TO X(15)
quadword_signed	01 QWS PIC S9(18) COMP
quadword_unsigned	01 QWU PIC 9(18) COMP ²
rights_holder	01 RIGHTS-HOLDER 02 RIGHTS-ID PIC 9(5) COMP ² 02 ACCESS-RIGHTS PIC 9(5) COMP ²
rights_id	01 RIGHTS-ID PIC 9(5) COMP ²
rab	na . . . Too complex for general COBOL use. Most of a RAB structure can be described by a lengthy COBOL record description, but such a RAB cannot then be referenced by a COBOL I-O statement. It is much simpler to do the I-O completely within COBOL, and let the COBOL compiler generate the RAB structure, or do the I-O in another language.
section_id	01 SECTION-ID PIC 9(18) COMP ²
section_name	01 SECTION-NAME PIC X to X(43)
system_access_id	01 SECTION-ACCESS-ID PIC 9(18) COMP ²
time_name	01 TIME-NAME PIC X(<i>n</i>), where <i>n</i> is the length.
transaction_id	na
uic	01 UIC PIC 9(5) COMP ²
user_arg	01 USER-ARG PIC 9(5) COMP ²
varying_arg	Depends on the application.
vector_byte_signed	na . . . ³
vector_byte_unsigned	na . . . ³
vector_longword_signed	na . . . ³
vector_longword_unsigned	na . . . ³
vector_quadword_signed	na . . . ³
vector_quadword_unsigned	na . . . ³
vector_word_signed	na . . . ³

²Although unsigned computational data structures are not directly supported in COBOL, you may substitute the signed equivalent provided you do not exceed the range of the signed data structure.

³Alpha specific.

(continued on next page)

OpenVMS Data Types

B.7 COBOL Implementations

Table B-7 (Cont.) COBOL Implementations

OpenVMS Data Types	COBOL Declarations
vector_word_unsigned	na . . . ⁴
word_signed	01 WS PIC S9(4) COMP
word_unsigned	01 WS PIC 9(4) COMP ²

²Although unsigned computational data structures are not directly supported in COBOL, you may substitute the signed equivalent provided you do not exceed the range of the signed data structure.

⁴COBOL does not permit the passing of variable-length data structures.

B.8 FORTRAN Implementations

Table B-8 lists the OpenVMS data types and their corresponding FORTRAN data type declarations.

Table B-8 FORTRAN Implementations

OpenVMS Data Types	FORTRAN Declarations
access_bit_names	INTEGER*4(2,32) or STRUCTURE /access_bit_names/ INTEGER*4 access_name_len INTEGER*4 access_name_buf END STRUCTURE !access_bit_names RECORD /access_bit_names/ my_names(32)
access_mode	BYTE or INTEGER*1 ¹
address	INTEGER*4
address_range	INTEGER*4(2) or INTEGER*8 ¹ or STRUCTURE /address_range/ INTEGER*4 low_address INTEGER*4 high_address END STRUCTURE
arg_list	INTEGER*4(<i>n</i>) or INTEGER*8 ¹ (<i>n</i>)
ast_procedure	EXTERNAL
boolean	LOGICAL*4
byte_signed	BYTE or INTEGER*1

¹Alpha specific.

(continued on next page)

Table B–8 (Cont.) FORTRAN Implementations

OpenVMS Data Types	FORTRAN Declarations
byte_unsigned	BYTE ² or INTEGER*1 ^{1, 2}
channel	INTEGER*2
char_string	CHARACTER*n
complex_number	COMPLEX*8 COMPLEX*16
cond_value	INTEGER*4
context	INTEGER*4
date_time	INTEGER*4(2) or INTEGER*8 ¹
device_name	CHARACTER*n
ef_cluster_name	CHARACTER*n
ef_number	INTEGER*4
exit_handler_block	STRUCTURE /exhblock/ INTEGER*4 flink INTEGER*4 exit_handler_addr BYTE(3) /0/ BYTE arg_count INTEGER*4 cond_value ! ! .(optional arguments . . . one argument ! . per longword) ! END STRUCTURE !cntrlblk RECORD /exhblock/ myexh_block
fab	INCLUDE '\$FABDEF' RECORD /fabdef/ myfab
file_protection	INTEGER*4
floating_point	REAL*4 ³ REAL*8 ³ DOUBLE PRECISION ³ REAL*16 ⁴
function_code	INTEGER*4
identifier	INTEGER*4
invo_context_blk ¹	INCLUDE ('LIBICB') RECORD /INVO_CONTEXT_BLK/ invo_context_blk
invo_handle ¹	INTEGER*4

¹Alpha specific.

²Unsigned data types are not directly supported by FORTRAN. However, in most cases you can substitute the signed equivalent as long as you do not exceed the range of the signed data structure.

³The format used by floating-point data in memory is determined by the FORTRAN command qualifier /FLOAT.

⁴The REAL*16 type is used for both H_floating on VAX systems and X_floating on Alpha systems.

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OpenVMS Data Types

B.8 FORTRAN Implementations

Table B–8 (Cont.) FORTRAN Implementations

OpenVMS Data Types	FORTTRAN Declarations
io_status_block	<pre> STRUCTURE /iosb/ INTEGER*2 iostat, !return status 2 term_offset, !location of line terminator 2 terminator, !value of terminator 2 term_size !size of terminator END STRUCTURE RECORD /iosb/ my_iosb </pre>
item_list_2	<pre> STRUCTURE /itmlst/ UNION MAP INTEGER*2 buflen,code INTEGER*4 bufadr END MAP MAP INTEGER*4 end_list /0/ END MAP END UNION END STRUCTURE !itmlst RECORD /itmlst/ my_itmlst_2(<i>n</i>) (Allocate <i>n</i> records, where <i>n</i> is the number of item codes plus an extra element for the end-of-list item.) </pre>
item_list_3	<pre> STRUCTURE /itmlst/ UNION MAP INTEGER*2 buflen,code INTEGER*4 bufadr,retlenadr END MAP MAP INTEGER*4 end_list /0/ END MAP END UNION END STRUCTURE !itmlst RECORD /itmlst/ my_itmlst_2(<i>n</i>) (Allocate <i>n</i> records, where <i>n</i> is the number of item codes plus an extra element for the end-of-list item.) </pre>
item_list_pair	<pre> STRUCTURE /itmlst_pair/ UNION MAP INTEGER*4 code INTEGER*4 value END MAP MAP INTEGER*4 end_list /0/ END MAP END UNION END STRUCTURE !itmlst_pair RECORD /itmlst_pair/ my_itmlst_pair(<i>n</i>) (Allocate <i>n</i> records, where <i>n</i> is the number of item codes plus an extra element for the end-of-list item.) </pre>

(continued on next page)

OpenVMS Data Types B.8 FORTRAN Implementations

Table B–8 (Cont.) FORTRAN Implementations

OpenVMS Data Types	FORTRAN Declarations
item_quota_list	STRUCTURE /item_quota_list/ MAP BYTE quota_name INTEGER*4 quota_value END MAP MAP BYTE end_quota_list END MAP END STRUCTURE !item_quota_list
lock_id	INTEGER*4
lock_status_block	STRUCTURE/lksb/ INTEGER*2 cond_value INTEGER*2 unused INTEGER*4 lock_id BYTE(16) END STRUCTURE !lock_status_lock
lock_value_block	BYTE(16)
logical_name	CHARACTER*n
longword_signed	INTEGER*4
longword_unsigned	INTEGER*4 ²
mask_byte	BYTE or INTEGER*1
mask_longword	INTEGER*4
mask_quadword	INTEGER*4(2) or INTEGER*8 ¹
mask_word	INTEGER*2
mechanism_args	INCLUDE '(\$CHFDEF)' RECORD /CHFDEF2/ mechargs
null_arg	%VAL(0)
octaword_signed	INTEGER*4(4)
octaword_unsigned	INTEGER*4(4) ²
page_protection	INTEGER*4
procedure	INTEGER*4
process_id	INTEGER*4
process_name	CHARACTER*n
quadword_signed	INTEGER*4(2) or INTEGER*8 ¹
quadword_unsigned	INTEGER*4(2) ² or INTEGER*8 ¹

¹Alpha specific.

²Unsigned data types are not directly supported by FORTRAN. However, in most cases you can substitute the signed equivalent as long as you do not exceed the range of the signed data structure.

(continued on next page)

OpenVMS Data Types

B.8 FORTRAN Implementations

Table B–8 (Cont.) FORTRAN Implementations

OpenVMS Data Types	FORTRAN Declarations
rights_holder	INTEGER*4(2) or STRUCTURE /rights_holder/ INTEGER*4 rights_id INTEGER*4 rights_mask END STRUCTURE !rights_holder
rights_id	INTEGER*4
rab	INCLUDE '\$RABDEF' RECORD /rabdef/ myrab
section_id	INTEGER*4(2) or INTEGER*8 ¹
section_name	CHARACTER*n
system_access_id	INTEGER*4(2) or INTEGER*8 ¹
time_name	CHARACTER*23
transaction_id	INTEGER*4(4) ²
uic	INTEGER*4
user_arg	Any longword quantity
varying_arg	INTEGER*4
vector_byte_signed	BYTE(<i>n</i>)
vector_byte_unsigned	BYTE(<i>n</i>) ²
vector_longword_signed	INTEGER*4(<i>n</i>)
vector_longword_unsigned	INTEGER*4(<i>n</i>) ²
vector_quadword_signed	INTEGER*4(2, <i>n</i>) or INTEGER*8(<i>n</i> ¹)
vector_quadword_unsigned	INTEGER*4(2, <i>n</i>) ² or INTEGER*8(<i>n</i>) ^{1, 2}
vector_word_signed	INTEGER*2(<i>n</i>)
vector_word_unsigned	INTEGER*2(<i>n</i>) ²
word_signed	INTEGER*2(<i>n</i>)
word_unsigned	INTEGER*2(<i>n</i>) ²

¹Alpha specific.

²Unsigned data types are not directly supported by FORTRAN. However, in most cases you can substitute the signed equivalent as long as you do not exceed the range of the signed data structure.

B.9 Pascal Implementations

Table B–9 lists the OpenVMS data types and their corresponding Pascal data type declarations.

Table B–9 Pascal Implementations

OpenVMS Data Types	Pascal Declarations
access_bit_names	PACKED ARRAY [1..32] OF [QUAD] RECORD END; ^{1,2}
access_mode	[BYTE] 0..3; ²
address	UNSIGNED;
address_range	PACKED ARRAY [1..2] OF UNSIGNED; ²
arg_list	PACKED ARRAY [1..n] OF UNSIGNED; ²
ast_procedure	UNSIGNED;
boolean	BOOLEAN; ³
byte_signed	[BYTE] –128..127; ²
byte_unsigned	[BYTE] 0..255; ²
channel	[WORD] 0..65535; ²
char_string	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
complex_number	[LONG(2)] RECORD END; * F_Floating Complex * ^{1,2} [QUAD(2)] RECORD END; * D/G_Floating Complex * [OCTA(2)] RECORD END; * H_Floating Complex *
cond_value	UNSIGNED;
context	UNSIGNED;
date_time	[QUAD] RECORD END; ^{1,2}
device_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
ef_cluster_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
ef_number	UNSIGNED;
exit_handler_block	PACKED ARRAY [1..n] OF UNSIGNED; ²
fab	FAB\$TYPE; ⁵
file_protection	[WORD] RECORD END; ^{1,2}
floating_point	REAL; { F_Floating } SINGLE; { F_Floating } DOUBLE; { D_Floating/G_Floating } ⁶ QUADRUPLE; { H_Floating }
function_code	UNSIGNED;
identifier	UNSIGNED;

¹This type is not available in Pascal when an empty record has been inserted. To manipulate the contents, declare with explicit field components. If you pass an empty record as a parameter to a Pascal routine, you must use the VAR keyword.

²Pascal expects either a type identifier or conformant schema. Declare this under the TYPE declaration and use the type identifier in the formal parameter declaration.

³Pascal allocates a byte for a BOOLEAN variable. Use the [LONG] attribute when passing to routines that expect a longword.

⁴This parameter declaration accepts VARYING OF CHAR or PACKED ARRAY OF CHAR and produces the CLASS_S descriptor required by system services.

⁵The program must inherit the STARLET environment file located in SYSSLIBRARY:STARLET.PEN.

⁶If the {G_Floating} attribute is used in compiling, double-precision variables and expressions are represented in G_floating format. You can also use the /G_FLOATING command line qualifier. Both methods default to no G_floating.

(continued on next page)

OpenVMS Data Types

B.9 Pascal Implementations

Table B-9 (Cont.) Pascal Implementations

OpenVMS Data Types	Pascal Declarations
invo_context_blk ⁷	LIBICB\$INFO_CONTEXT_BLK ⁵
invo_handle ⁷	[UNSAFE]INTEGER;
io_status_block	[QUAD] RECORD END; ^{1,2}
item_list_2	PACKED ARRAY [1..n] OF PACKED RECORD ² CASE INTEGER OF 1: (FIELD1 : [WORD] 0..65535; FIELD2 : [WORD] 0..65535; FIELD3 : UNSIGNED); 2: (TERMINATOR : UNSIGNED); END;
item_list_3	PACKED ARRAY [1..n] OF PACKED RECORD ² CASE INTEGER OF 1: (FIELD1 : [WORD] 0..65535; FIELD2 : [WORD] 0..65535; FIELD3 : UNSIGNED; FIELD4 : UNSIGNED); 2: (TERMINATOR : UNSIGNED); END;
item_list_pair	PACKED ARRAY [1..n] OF PACKED RECORD ² CASE INTEGER OF 1: (FIELD1 : INTEGER; FIELD2 : INTEGER); 2: (TERMINATOR : UNSIGNED); END;
item_quota_list	PACKED ARRAY [1..n] OF PACKED RECORD ² CASE INTEGER OF 1: (QUOTA_NAME : [BYTE] 0..255; QUOTA_VALUE: UNSIGNED); 2: (QUOTA_TERM : [BYTE] 0..255); END;
lock_id	UNSIGNED;
lock_status_block	[BYTE(24)] RECORD END; ^{1,2}
lock_value_block	[BYTE(16)] RECORD END; ^{1,2}
logical_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴

¹This type is not available in Pascal when an empty record has been inserted. To manipulate the contents, declare with explicit field components. If you pass an empty record as a parameter to a Pascal routine, you must use the VAR keyword.

²Pascal expects either a type identifier or conformant schema. Declare this under the TYPE declaration and use the type identifier in the formal parameter declaration.

⁴This parameter declaration accepts VARYING OF CHAR or PACKED ARRAY OF CHAR and produces the CLASS_S descriptor required by system services.

⁵The program must inherit the STARLET environment file located in SYSSLIBRARY:STARLET.PEN.

⁷Alpha specific.

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Table B–9 (Cont.) Pascal Implementations

OpenVMS Data Types	Pascal Declarations
longword_signed	INTEGER;
longword_unsigned	UNSIGNED;
mask_byte	[BYTE,UNSAFE] PACKED ARRAY [1..8] OF BOOLEAN; ²
mask_longword	[LONG,UNSAFE] PACKED ARRAY [1..32] OF BOOLEAN; ²
mask_quadword	[QUAD,UNSAFE] PACKED ARRAY [1..64] OF BOOLEAN; ²
mask_word	[WORD,UNSAFE] PACKED ARRAY [1..16] OF BOOLEAN; ²
mechanism_args	CHF\$TYPE; ⁵
null_arg	UNSIGNED;
octaword_signed	[OCTA] RECORD END; ^{1,2}
octaword_unsigned	[OCTA] RECORD END; ^{1,2}
page_protection	[LONG] 0..7; ²
procedure	UNSIGNED;
process_id	UNSIGNED;
process_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
quadword_signed	[QUAD] RECORD END; ^{1,2}
quadword_unsigned	[QUAD] RECORD END; ^{1,2}
rights_holder	[QUAD] RECORD END; ^{1,2}
rights_id	UNSIGNED;
rab	RAB\$TYPE; ⁵
section_id	[QUAD] RECORD END; ^{1,2}
section_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
system_access_id	[QUAD] RECORD END; ^{1,2}
time_name	[CLASS_S] PACKED ARRAY [L..U:INTEGER] OF CHAR; ⁴
transaction_id	[OCTA] RECORD END; ^{1,2}
uic	UNSIGNED;
user_arg	[UNSAFE] UNSIGNED;
varying_arg	[UNSAFE,REFERENCE] PACKED ARRAY [L..U:INTEGER] OF [BYTE] 0..255;
vector_byte_signed	PACKED ARRAY [1..n] OF [BYTE] –128..127; ²
vector_byte_unsigned	PACKED ARRAY [1..n] OF [BYTE] 0..255; ²

¹This type is not available in Pascal when an empty record has been inserted. To manipulate the contents, declare with explicit field components. If you pass an empty record as a parameter to a Pascal routine, you must use the VAR keyword.

²Pascal expects either a type identifier or conformant schema. Declare this under the TYPE declaration and use the type identifier in the formal parameter declaration.

⁴This parameter declaration accepts VARYING OF CHAR or PACKED ARRAY OF CHAR and produces the CLASS_S descriptor required by system services.

⁵The program must inherit the STARLET environment file located in SYSSLIBRARY:STARLET.PEN.

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OpenVMS Data Types

B.9 Pascal Implementations

Table B–9 (Cont.) Pascal Implementations

OpenVMS Data Types	Pascal Declarations
vector_longword_signed	PACKED ARRAY [1..n] OF INTEGER; ²
vector_longword_unsigned	PACKED ARRAY [1..n] OF UNSIGNED; ²
vector_quadword_signed	PACKED ARRAY [1..n] OF [QUAD] RECORD END; ^{1,2}
vector_quadword_unsigned	PACKED ARRAY [1..n] OF [QUAD] RECORD END; ^{1,2}
vector_word_signed	PACKED ARRAY [1..n] OF [WORD] –32768..32767; ²
vector_word_unsigned	PACKED ARRAY [1..n] OF [WORD] 0..65535; ²
word_signed	[WORD] –32768..32767; ²
word_unsigned	[WORD] 0..65535; ²

¹This type is not available in Pascal when an empty record has been inserted. To manipulate the contents, declare with explicit field components. If you pass an empty record as a parameter to a Pascal routine, you must use the VAR keyword.

²Pascal expects either a type identifier or conformant schema. Declare this under the TYPE declaration and use the type identifier in the formal parameter declaration.

B.10 PL/I Implementations

Table B–10 lists the OpenVMS data types and their corresponding PL/I data type declarations.

Table B–10 PL/I Implementations

OpenVMS Data Types	PL/I Declarations
access_bit_names	1 ACCESS_BIT_NAMES(32), 2 LENGTH FIXED BINARY(15), 2 DTYPE FIXED BINARY(7) INITIAL((32)DSC\$K_DTYPE_T), 2 CLASS FIXED BINARY(7) INITIAL((32)DSC\$K_CLASS_S), 2 CHAR_PTR POINTER; ¹ The length of the LENGTH field in each element of the array should correspond to the length of a string of characters pointed to by the CHAR_PTR field. The constants DSC\$K_CLASS_S and DSC\$K_DTYPE_T can be used by including the module \$DSCDEF from PLISSTARLET.
access_mode	FIXED BINARY(7) (The constants for this type—PSL\$C_KERNEL, PSL\$C_EXEC, PSL\$C_SUPER, PSL\$C_USER—are declared in module \$PSLDEF in PLISSTARLET.)
address	POINTER
address_range	(2) POINTER ¹

¹System routines are often written so the parameter passed occupies more storage than the object requires. For example, some system services have parameters that return a bit value as a longword. These variables must be declared BIT(32) ALIGNED (not BIT(n) ALIGNED) so that adjacent storage is not overwritten by return values or used incorrectly as input. (Longword parameters are always declared BIT(32) ALIGNED.)

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Table B–10 (Cont.) PL/I Implementations

OpenVMS Data Types	PL/I Declarations
arg_list	1 ARG_LIST BASED, 2 ARGCOUNT FIXED BINARY(31), 2 ARGUMENT (X REFER (ARGCOUNT)) POINTER; ¹ If the arguments are passed by value, you may need to change the type of the ARGUMENT field of the structure. Alternatively, you can use the POSINT, INT, or UNSPEC built-in functions and pseudovariables to access the data. X should be an expression with a value in the range 0 to 255 when the structure is allocated.
ast_procedure	PROCEDURE or ENTRY ²
boolean	BIT ALIGNED ¹
byte_signed	FIXED BINARY(7)
byte_unsigned	FIXED BINARY(7) ³
channel	FIXED BINARY(15)
char_string	CHARACTER(<i>n</i>) ⁴
complex_number	(2) FLOAT BINARY(<i>n</i>) (See floating_point for values of <i>n</i> .)
cond_value	See STSSVALUE in module \$STSDEF in PLISSTARLET. ¹
context	FIXED BINARY(31)
date_time	BIT(64) ALIGNED ^{5,6}
device_name	CHARACTER(<i>n</i>) ⁴
ef_cluster_name	CHARACTER(<i>n</i>) ⁴
ef_number	FIXED BINARY(31)

¹System routines are often written so the parameter passed occupies more storage than the object requires. For example, some system services have parameters that return a bit value as a longword. These variables must be declared BIT(32) ALIGNED (not BIT(*n*) ALIGNED) so that adjacent storage is not overwritten by return values or used incorrectly as input. (Longword parameters are always declared BIT(32) ALIGNED.)

²AST procedures and those passed as parameters of type ENTRY VALUE or ANY VALUE must be external procedures. This applies to all system routines that take procedure parameters.

³This is actually an unsigned integer. This declaration is interpreted as a signed number; use the POSINT function to determine the actual value.

⁴System services require CHARACTER string representation for parameters. Most other system routines allow either CHARACTER or CHARACTER VARYING. For parameter declarations, *n* should be an asterisk (*).

⁵PL/I does not support FIXED BINARY numbers with precisions greater than 31. To use larger values, declare variables to be BIT variables of the appropriate size and use the POSINT and SUBSTR bits as necessary to access the values, or declare the item as a structure. The RTL routines LIB\$ADDX and LIB\$SUBX may be useful if you need to perform arithmetic on these types.

⁶Routines declared in PLISSTARLET often use ANY, so you are free to declare the data structure in the most convenient way for the application. ANY may be necessary in some cases because PL/I does not allow parameter declarations for some data types used by OpenVMS. (In particular, PL/I parameters with arrays passed by reference cannot be declared to have nonconstant bounds.)

(continued on next page)

OpenVMS Data Types

B.10 PL/I Implementations

Table B–10 (Cont.) PL/I Implementations

OpenVMS Data Types	PL/I Declarations
exit_handler_block	1 EXIT_HANDLER_BLOCK BASED, 2 FORWARD_LINK POINTER, 2 HANDLER POINTER, 2 ARGCOUNT FIXED BINARY(31), 2 ARGUMENT (<i>n</i> REFER (ARGCOUNT)) POINTER; ¹ (Replace <i>n</i> with an expression that yields a value between 0 and 255 when the structure is allocated.)
fab	See module \$FABDEF in PLISSTARLET.
file_protection	BIT(16) ALIGNED ¹
floating_point	FLOAT BINARY(<i>n</i>) The values for <i>n</i> are as follows: 1 <= <i>n</i> <= 24 — F_floating 25 <= <i>n</i> <= 53 — D_floating 25 <= <i>n</i> <= 53 — G_floating (with /G_FLOAT) 54 <= <i>n</i> <= 113 — H_floating
function_code	BIT(32) ALIGNED
identifier	POINTER
invo_context_blk ⁷	%INCLUDE LIBICB
invo_handle ⁷	FIXED BINARY(31)
io_status_block	Because the format for I/O status blocks differs with the system service, you can vary the definitions accordingly. Some of the common formats are as follows: 1 IOSB_SYSSGETSYL, 2 STATUS FIXED BINARY(31), 2 RESERVED FIXED BINARY(31); 1 IOSB_TTDRIIVER_A, 2 STATUS FIXED BINARY(15), 2 BYTE_COUNT FIXED BINARY(15), 2 MBZ FIXED BINARY(31) INITIAL(0); 1 IOSB_TTDRIIVER_B, 2 STATUS FIXED BINARY(15), 2 TRANSMIT_SPEED FIXED BINARY(7), 2 RECEIVE_SPEED FIXED BINARY(7), 2 CR_FILL FIXED BINARY(7), 2 LF_FILL FIXED BINARY(7), 2 PARITY_FLAGS FIXED BINARY(7), 2 MBZ FIXED BINARY(7) INITIAL(0);

¹System routines are often written so the parameter passed occupies more storage than the object requires. For example, some system services have parameters that return a bit value as a longword. These variables must be declared BIT(32) ALIGNED (not BIT(*n*) ALIGNED) so that adjacent storage is not overwritten by return values or used incorrectly as input. (Longword parameters are always declared BIT(32) ALIGNED.)

⁷Alpha specific.

(continued on next page)

Table B–10 (Cont.) PL/I Implementations

OpenVMS Data Types	PL/I Declarations
item_list_2	<pre> 1 ITEM_LIST_2, 2 ITEM(SIZE), 3 COMPONENT_LENGTH FIXED BINARY(15), 3 ITEM_CODE FIXED BINARY(15), 3 COMPONENT_ADDRESS POINTER, 2 TERMINATOR FIXED BINARY(31) INITIAL(0);¹ </pre> <p>(Replace SIZE with the number of items you want.)</p>
item_list_3	<pre> 1 ITEM_LIST_3, 2 ITEM(SIZE), 3 BUFFER_LENGTH FIXED BINARY(15), 3 ITEM_CODE FIXED BINARY(15), 3 BUFFER_ADDRESS POINTER, 3 RETURN_LENGTH POINTER, 2 TERMINATOR FIXED BINARY(31) INITIAL(0);¹ </pre> <p>(Replace SIZE with the number of items you want.)</p>
item_list_pair	<pre> 1 ITEM_LIST_PAIR, 2 ITEM(SIZE), 3 ITEM_CODE FIXED BINARY(31), 3 ITEM UNION, 4 INTEGER FIXED BINARY(31), 4 REAL FLOAT BINARY(24), 2 TERMINATOR FIXED BINARY(31) INITIAL(0);¹ </pre> <p>(Replace SIZE with the number of items you want.)</p>
item_quota_list	<pre> 1 ITEM_QUOTA_LIST, 2 QUOTA(SIZE), 3 NAME FIXED BINARY(7), 3 VALUE FIXED BINARY(31), 2 TERMINATOR FIXED BINARY(7) INITIAL(PQLS_LISTEND);¹ </pre> <p>(Replace SIZE with the number of quota entries you want to use. The constant PQLS_LISTEND can be used by including the module SPQLDEF from PLISSTARLET or by declaring it GLOBALREF FIXED BINARY(31) VALUE.)</p>
lock_id	FIXED BINARY(31)
lock_status_block	<pre> 1 LOCK_STATUS_BLOCK, 2 STATUS_CODE FIXED BINARY(15), 2 RESERVED FIXED BINARY(15), 2 LOCK_ID FIXED BINARY(31);¹ </pre>

¹System routines are often written so the parameter passed occupies more storage than the object requires. For example, some system services have parameters that return a bit value as a longword. These variables must be declared BIT(32) ALIGNED (not BIT(*n*) ALIGNED) so that adjacent storage is not overwritten by return values or used incorrectly as input. (Longword parameters are always declared BIT(32) ALIGNED.)

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OpenVMS Data Types

B.10 PL/I Implementations

Table B–10 (Cont.) PL/I Implementations

OpenVMS Data Types	PL/I Declarations
lock_value_block	The declaration of an item of this structure depends on the use of the structure because the OpenVMS operating system does not interpret the value. ¹
logical_name	CHARACTER(<i>n</i>) ⁴
longword_signed	FIXED BINARY(31)
longword_unsigned	FIXED BINARY(31) ³
mask_byte	BIT(8) ALIGNED
mask_longword	BIT(32) ALIGNED
mask_quadword	BIT(64) ALIGNED
mask_word	BIT(16) ALIGNED
mechanism_args	INCLUDE \$SCHFDEF Declare mechanism_args like CHF\$MECH_ARRAY
null_arg	Omit the corresponding parameter in the call. For example, FOO(A,,B) would omit the second parameter.
octaword_signed	BIT(128) ALIGNED ^{5,6}
octaword_unsigned	BIT(128) ALIGNED ^{5,6}
page_protection	FIXED BINARY(31) (The constants for this type are declared in module \$PRTDEF in PLISSTARLET.)
procedure	PROCEDURE or ENTRY ²
process_id	FIXED BINARY(31)
process_name	CHARACTER(<i>n</i>) ⁴
quadword_signed	BIT(64) ALIGNED ^{5,6}
quadword_unsigned	BIT(64) ALIGNED ^{5,6}
rights_holder	1 RIGHTS HOLDER, 2 RIGHTS_ID FIXED BINARY(31), 2 ACCESS_RIGHTS BIT(32) ALIGNED; ¹
rights_id	FIXED BINARY(31)
rab	See module \$RABDEF in PLISSTARLET. ¹

¹System routines are often written so the parameter passed occupies more storage than the object requires. For example, some system services have parameters that return a bit value as a longword. These variables must be declared BIT(32) ALIGNED (not BIT(*n*) ALIGNED) so that adjacent storage is not overwritten by return values or used incorrectly as input. (Longword parameters are always declared BIT(32) ALIGNED.)

²AST procedures and those passed as parameters of type ENTRY VALUE or ANY VALUE must be external procedures. This applies to all system routines that take procedure parameters.

³This is actually an unsigned integer. This declaration is interpreted as a signed number; use the POSINT function to determine the actual value.

⁴System services require CHARACTER string representation for parameters. Most other system routines allow either CHARACTER or CHARACTER VARYING. For parameter declarations, *n* should be an asterisk (*).

⁵PL/I does not support FIXED BINARY numbers with precisions greater than 31. To use larger values, declare variables to be BIT variables of the appropriate size and use the POSINT and SUBSTR bits as necessary to access the values, or declare the item as a structure. The RTL routines LIB\$ADDDX and LIB\$SUBX may be useful if you need to perform arithmetic on these types.

⁶Routines declared in PLISSTARLET often use ANY, so you are free to declare the data structure in the most convenient way for the application. ANY may be necessary in some cases because PL/I does not allow parameter declarations for some data types used by OpenVMS. (In particular, PL/I parameters with arrays passed by reference cannot be declared to have nonconstant bounds.)

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Table B–10 (Cont.) PL/I Implementations

OpenVMS Data Types	PL/I Declarations
section_id	BIT(64) ALIGNED
section_name	CHARACTER(<i>n</i>) ⁴
system_access_id	BIT(64) ALIGNED
time_name	CHARACTER(<i>n</i>) ⁴
transaction_id	BIT(128) ALIGNED ^{5,6}
uic	FIXED BINARY(31)
user_arg	ANY
varying_arg	ANY with OPTIONS(VARIABLE) on the routine declaration or with OPTIONAL on the parameter declaration.
vector_byte_signed	(<i>n</i>) FIXED BINARY(7) ⁸
vector_byte_unsigned	(<i>n</i>) FIXED BINARY(7) ^{3,8}
vector_longword_signed	(<i>n</i>) FIXED BINARY(31) ⁸
vector_longword_unsigned	(<i>n</i>) FIXED BINARY(31) ^{3,8}
vector_quadword_signed	(<i>n</i>) BIT(64) ALIGNED ^{5,6,8}
vector_quadword_unsigned	(<i>n</i>) BIT(64) ALIGNED ^{3,5,6,8}
vector_word_signed	(<i>n</i>) FIXED BINARY(15) ⁸
vector_word_unsigned	(<i>n</i>) FIXED BINARY(15) ^{3,8}
word_signed	FIXED BINARY(15)
word_unsigned	FIXED BINARY(15) ⁵

³This is actually an unsigned integer. This declaration is interpreted as a signed number; use the POSINT function to determine the actual value.

⁴System services require CHARACTER string representation for parameters. Most other system routines allow either CHARACTER or CHARACTER VARYING. For parameter declarations, *n* should be an asterisk (*).

⁵PL/I does not support FIXED BINARY numbers with precisions greater than 31. To use larger values, declare variables to be BIT variables of the appropriate size and use the POSINT and SUBSTR bits as necessary to access the values, or declare the item as a structure. The RTL routines LIB\$ADDDX and LIB\$SUBX may be useful if you need to perform arithmetic on these types.

⁶Routines declared in PLISSTARLET often use ANY, so you are free to declare the data structure in the most convenient way for the application. ANY may be necessary in some cases because PL/I does not allow parameter declarations for some data types used by OpenVMS. (In particular, PL/I parameters with arrays passed by reference cannot be declared to have nonconstant bounds.)

⁸For parameter declarations, the bounds must be constant for arrays passed by reference. For arrays passed by descriptor, *s should be used for the array extent instead. (OpenVMS system routines almost always take arrays by reference.)

Note

All system services and many system constants and data structures are declared in PLISSTARLET.TLB.

While the current version of PL/I does not support unsigned fixed binary numbers or fixed binary numbers with a precision greater than 31, future versions may support these features. If PL/I is extended to support these types, declarations in PLISTARLET may change to use the new data types where appropriate.

OpenVMS Data Types

B.11 VAX MACRO Implementations

B.11 VAX MACRO Implementations

Table B–11 lists the OpenVMS data types and their corresponding VAX MACRO data type declarations.

Table B–11 VAX MACRO Implementations

OpenVMS Data Type	VAX MACRO Declarations
access_bit_names	.ASCID /name_for_bit0/ .ASCID /name_for_bit1/ASCID /name_for_bit31/
access_mode	.BYTE PSL\$C_xxx
address	.ADDRESSSS virtual_address
address_range	.ADDRESS start_address,end_address
arg_list	.LONG n_args, arg1, arg2, . . .
ast_procedure	.ADDRESS ast_procedure
boolean	.LONG 1 or .LONG 0
byte_signed	.SIGNED_BYTE byte_value
byte_unsigned	.BYTE byte_value
channel	.WORD channel_number
char_string	.ASCID /string/
complex_number	na
cond_value	.LONG cond_value
context	.LONG 0
date_time	.QUAD date_time
device_name	.ASCID /ddcu/
ef_cluster_name	.ASCID /ef_cluster_name/
ef_number	.LONG ef_number
exit_handler_block	.LONG 0 .ADDRESS exit_handler_routine .LONG 1 .ADDRESS status STATUS: .BLKL 1
fab	MYFAB: \$FAB
file_protection	.WORD prot_value
floating_point	.FLOAT, .G_FLOAT, or .H_FLOAT
function_code	.LONG code_mask
identifier	.ADDRESSSS virtual_address
invo_context_blk ¹	\$LIBICBDEF
invo_handle ¹	.LONG
io_status_block	.QUAD 0
item_list_2	.WORD component_length .WORD item_code .ADDRESS component_address

¹Alpha specific.

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Table B–11 (Cont.) VAX MACRO Implementations

OpenVMS Data Type	VAX MACRO Declarations
item_list_3	.WORD buffer_length .WORD item_code .ADDRESS buffer_address .ADDRESS return_length_address
item_list_pair	.LONG item_code .LONG data
item_quota_list	.BYTE PQL\$_xxx .LONG value_for_quota .BYTE pql\$_listend
lock_id	.LONG lock_id
lock_status_block	.QUAD 0
lock_value_block	.BLKB 16
logical_name	.ASCID /logical_name/
longword_signed	.LONG value
longword_unsigned	.LONG value
mask_byte	.BYTE mask_byte
mask_longword	.LONG mask_longword
mask_quadword	.QUAD mask_quadword
mask_word	.WORD mask_word
mechanism_args	MECH_ARGS: \$SCHFDEF
null_arg	.LONG 0
octaword_signed	na
octaword_unsigned	.OCTA value
page_protection	.LONG page_protection
procedure	.ADDRESS procedure
process_id	.LONG process_id
process_name	.ASCID /process_name/
quadword_signed	na
quadword_unsigned	.QUAD value
rights_holder	.LONG identifier, access_rights_bitmask
rights_id	.LONG rights_id
rab	MYRAB: \$RAB
section_id	.LONG sec\$_k_matxxx, version_number
section_name	.ASCID /section_name/
system_access_id	.QUAD system_access_id
time_name	.ASCID /dd-mmm-yyyy:hh:mm:ss.cc/
transaction_id	.OCTA value
uic	.LONG uic
user_arg	.LONG data
varying_arg	Depends on the application.

(continued on next page)

OpenVMS Data Types

B.11 VAX MACRO Implementations

Table B–11 (Cont.) VAX MACRO Implementations

OpenVMS Data Type	VAX MACRO Declarations
vector_byte_signed	.SIGNED_BYTE val1,val2, . . . valn
vector_byte_unsigned	.BYTE val1,val2, . . . valn
vector_longword_signed	.LONG val1,val2, . . . valn
vector_longword_unsigned	.LONG val1,val2, . . . valn
vector_quadword_signed	na
vector_quadword_unsigned	.QUAD val1, val2, . . . valn
vector_word_signed	.SIGNED_WORD val1,val2, . . . valn
vector_word_unsigned	.WORD val1,val2, . . . valn
word_signed	.SIGNED_WORD value
word_unsigned	.WORD value

B.12 RPG II Implementations

Table B–12 lists the OpenVMS data types and their corresponding RPG II data type declarations.

Table B–12 RPG II Implementations

OpenVMS Data Type	RPG II Declarations
access_bit_names	na
access_mode	Declare as text string of 1 byte. When using this data structure, you must interpret the ASCII contents of the string to determine access_mode.
address	L ¹
address_range	Q ¹
arg_list	na
ast_procedure	L ¹
boolean	na
byte_signed	Declare as text string of 1 byte. When using this data structure, you must interpret the ASCII contents of the string.
byte_unsigned	Same as for byte_signed . ¹
channel	W ¹
char_string	TEXT STRING
complex_number	DATA STRUCTURE
cond_value	cond_value GIVNG OPCODE
context	L ¹
date_time	Q ¹
device_name	TEXT STRING

¹Technically, RPG II does not support unsigned data structures. However, unsigned information may be passed using the signed equivalent, provided the contents do not exceed the range of the signed data structure.

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Table B–12 (Cont.) RPG II Implementations

OpenVMS Data Type	RPG II Declarations
ef_cluster_name	TEXT STRING
ef_number	L ¹
exit_handler_block	DATA STRUCTURE
fab	Implicitly generated by the compiler on your behalf. You cannot access the fab data structure from an RPG II program.
file_protection	W ¹
floating_point	F D
function_code	F
identifier	L ¹
io_status_block	Q
item_list_pair	DATA STRUCTURE
item_list_2	DATA STRUCTURE
item_list_3	DATA STRUCTURE
item_quota_list	na
lock_id	L ¹
lock_status_block	DATA STRUCTURE
lock_value_block	DATA STRUCTURE
logical_name	TEXT STRING
longword_signed	L
longword_unsigned	L ¹
mask_byte	Same as for byte_signed ¹
mask_longword	L ¹
mask_quadword	Q ¹
mask_word	W ¹
null_arg	na
octaword_signed	DATA STRUCTURE
octaword_unsigned	DATA STRUCTURE
page_protection	L ¹
procedure	L ¹
process_id	L ¹
process_name	TEXT STRING
quadword_signed	Q
quadword_unsigned	Q ¹
rights_holder	Q ¹
rights_id	L ¹

¹Technically, RPG II does not support unsigned data structures. However, unsigned information may be passed using the signed equivalent, provided the contents do not exceed the range of the signed data structure.

(continued on next page)

OpenVMS Data Types

B.12 RPG II Implementations

Table B–12 (Cont.) RPG II Implementations

OpenVMS Data Type	RPG II Declarations
rab	Implicitly generated by the compiler on your behalf. You cannot access the rab data structure from an RPG II program.
section_id	Q ¹
section_name	TEXT STRING
system_access_id	Q ¹
time_name	TEXT STRING
transaction_id	DATA STRUCTURE
uic	L ¹
user_arg	L ¹
varying_arg	Depends on the application.
vector_byte_signed	ARRAY OF TEXT STRING
vector_byte_unsigned	ARRAY OF TEXT STRING ¹
vector_longword_signed	ARRAY OF LONGWORD INTEGER (SIGNED) L
vector_longword_unsigned	RAY OF LONGWORD INTEGER L ¹
vector_quadword_signed	na
vector_quadword_unsigned	na
vector_word_signed	ARRAY OF WORD INTEGER (SIGNED) W
vector_word_unsigned	ARRAY OF WORD INTEGER W ¹
word_signed	W
word_unsigned	W ¹

¹Technically, RPG II does not support unsigned data structures. However, unsigned information may be passed using the signed equivalent, provided the contents do not exceed the range of the signed data structure.

B.13 SCAN Implementations

Table B–13 lists the OpenVMS data types and their corresponding SCAN data type declarations.

Table B–13 SCAN Implementations

OpenVMS Data Type	SCAN Declarations
access_bit_name	FILL(8*32) ¹
access_mode	FILL(1) ¹
address	POINTER

¹FILL is a data type that can always be used. A FILL is an object between 0 and 65K bytes in length. SCAN does not interpret the contents of an object. Thus, it can be used to pass or return the object to another language that does understand the type.

(continued on next page)

Table B–13 (Cont.) SCAN Implementations

OpenVMS Data Type	SCAN Declarations
address_range	RECORD start: POINTER, end: POINTER, END RECORD
arg_list	RECORD count: INTEGER, arg1: POINTER, ! if by reference arg2: INTEGER, ! if by value ... ! depending on needs END RECORD
ast_procedure	POINTER
boolean	BOOLEAN ²
byte_signed	FILL(1) ¹
byte_unsigned	FILL(1) ¹
channel	FILL(2) ¹
char_string	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
complex_number	FILL(<i>x</i>), where <i>x</i> is the length. ¹
cond_value	INTEGER
context	INTEGER
date_time	FILL(8) ¹
device_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
ef_cluster_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
ef_number	INTEGER
exit_handler_block	FILL(<i>x</i>), where <i>x</i> is the length. ¹
fab	A FAB data type is too large a structure to include in this table (see the <i>OpenVMS Record Management Services Reference Manual</i>); most of the fields can be described with a SCAN record. However, fab data structures are simpler to use with less coding errors when accessed from other languages that have the record predefined.
file_protection	FILL(2) ¹
floating_point	FILL(<i>x</i>), where <i>x</i> is the length. ¹
function_code	INTEGER
identifier	POINTER
io_status_block	FILL(8) ¹

¹FILL is a data type that can always be used. A FILL is an object between 0 and 65K bytes in length. SCAN does not interpret the contents of an object. Thus, it can be used to pass or return the object to another language that does understand the type.

²SCAN Boolean is just 1 byte.

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OpenVMS Data Types

B.13 SCAN Implementations

Table B–13 (Cont.) SCAN Implementations

OpenVMS Data Type	SCAN Declarations
item_list_2	RECORD item1: FILL(8), item2: FILL(8), ... terminator: INTEGER, END RECORD ¹
item_list_3	RECORD item1: FILL(12), item2: FILL(12), ... terminator: INTEGER, END RECORD ¹
item_list_pair	RECORD pair_1: RECORD ! 2 integer pair long1: INTEGER, long2: INTEGER, END RECORD, pair_2: RECORD ! integer-real pair long1: INTEGER, long2: FILL(4), END RECORD, ... ! depending on need terminator: INTEGER, END RECORD
item_quota_list	RECORD item1: RECORD type: FILL(1), value: INTEGER, END RECORD item2: RECORD type: FILL(1), value: INTEGER, END RECORD, ... terminator: FILL(1), END RECORD ¹
lock_id	INTEGER

¹FILL is a data type that can always be used. A FILL is an object between 0 and 65K bytes in length. SCAN does not interpret the contents of an object. Thus, it can be used to pass or return the object to another language that does understand the type.

(continued on next page)

Table B–13 (Cont.) SCAN Implementations

OpenVMS Data Type	SCAN Declarations
lock_status_block	RECORD status: FILL(2), reserved: FILL(2), lock_id: INTEGER, END RECORD ¹
lock_value_block	FILL(16) ¹
logical_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
longword_signed	INTEGER
longword_unsigned	INTEGER
mask_byte	FILL(1) ¹
mask_longword	INTEGER
mask_quadword	RECORD first_half: INTEGER, second_half: INTEGER, END RECORD
mask_word	FILL(2) ¹
null_arg	Use asterisk (*) for argument.
octaword_signed	FILL(16) ¹
octaword_unsigned	FILL(16) ¹
page_protection	INTEGER
procedure	POINTER
process_id	INTEGER
process_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
quadword_signed	FILL(8) ¹
quadword_unsigned	FILL(8) ¹
rights_holder	RECORD rights_id: INTEGER, bitmask: INTEGER, END RECORD
rights_id	INTEGER
rab	A rab data type is too large a structure to include in this table (see the <i>OpenVMS Record Management Services Reference Manual</i>); most of the fields can be described with a SCAN record. However, RAB data structures are simpler to use with less coding errors when accessed from other languages that have the record predefined.
second_name	FILL(8) ¹
section_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.

¹FILL is a data type that can always be used. A FILL is an object between 0 and 65K bytes in length. SCAN does not interpret the contents of an object. Thus, it can be used to pass or return the object to another language that does understand the type.

(continued on next page)

OpenVMS Data Types

B.13 SCAN Implementations

Table B–13 (Cont.) SCAN Implementations

OpenVMS Data Type	SCAN Declarations
system_access_id	FILL(8) ¹
time_name	FIXED STRING(<i>x</i>), where <i>x</i> is the length.
transaction_id	FILL(16) ¹
uic	INTEGER
user_arg	INTEGER
varying_arg	INTEGER
vector_byte_signed	FILL(<i>x</i>), where <i>x</i> is the length. ¹
vector_byte_unsigned	FILL(<i>x</i>), where <i>x</i> is the length. ¹
vector_longword_signed	FILL(4* <i>x</i>), where <i>x</i> is the length. ¹
vector_longword_unsigned	FILL(4* <i>x</i>), where <i>x</i> is the length. ¹
vector_quadword_signed	FILL(8* <i>x</i>), where <i>x</i> is the length. ¹
vector_quadword_unsigned	FILL(8* <i>x</i>), where <i>x</i> is the length. ¹
vector_word_signed	FILL(2* <i>x</i>), where <i>x</i> is the length. ¹
vector_word_unsigned	FILL(2* <i>x</i>), where <i>x</i> is the length. ¹
word_signed	FILL(2) ¹
word_unsigned	FILL(2) ¹

¹FILL is a data type that can always be used. A FILL is an object between 0 and 65K bytes in length. SCAN does not interpret the contents of an object. Thus, it can be used to pass or return the object to another language that does understand the type.

Distributed Name Service (VAX Only)

This chapter describes the Digital Distributed Name Service (DECdns) Clerk by introducing the functions of the DECdns (SYSSDNS) system service and various run-time library routines. It is divided into the following sections:

Section C.1 describes how to use the portable application programming interface and the operating system's system service and run-time library interface.

Section C.2 describes how to use the SYSSDNS system service.

Section C.3 describes how to use the DCL command DEFINE.

C.1 DECdns Clerk System Service

The DECdns Clerk (SYSSDNS) system service provides applications with a means of assigning networkwide names to system resources. Applications can use DECdns to name such resources as printers, files, disks, nodes, servers, and application databases. Once an application has named a resource using DECdns, the name is available for all users of the application.

The SYSSDNS system service supports two programming interfaces:

- Portable application programming interface
- System service and run-time library (RTL)

Portable Application Interface

Application designers should select an interface for their application based on programming language, application base, and the specific requirements of their application.

The portable interface provides support for applications written in the C programming language, and it provides a high-level interface with easy-to-use methods of creating and maintaining DECdns names. Use the portable interface for applications that must be portable between VAX systems and the Compaq Tru64 UNIX operating system.

The portable interface is documented in the *Guide to Programming with DECdns*.

VAX System Services and RTL Routines

The VAX system services and run-time library routines can be used by applications written in the high-level and midlevel languages listed in the preface of this document. However, applications that use these interfaces are limited to the VAX system environment. Use the system service when an application meets any of the following requirements:

- The application needs the full capabilities, flexibility, and functions of asynchronous support.
- The application will run as part of a privileged shareable image on the operating system.

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- The application is not written in the C programming language.

The SYSSDNS system service is documented in the *OpenVMS System Services Reference Manual*. Before using this system service, familiarize yourself with the basic operating principles, terms, and definitions used by DECDns. You can gain a working knowledge of DECDns by reading about the following topics in the *Guide to Programming with DECDns*:

- DECDns component operation
- Namespace directories, objects, soft links, groups, and clearinghouses
- DECDns name syntax
- Attributes
- Clerk caching
- Setting confidence and timeouts
- Recommendations for DECDns application programmers

By understanding these topics, you can proceed more easily with this chapter, which provides an introduction to the DECDns system service and run-time library routines and discusses the following topics:

- Functions provided by the service and routines
- How to use the SYSSDNS system service

C.1.1 Using the DECDns System Service and Run-Time Library Routines

You can use the SYSSDNS system service and run-time library routines together to assign, maintain, and retrieve DECDns names. This section describes the capabilities of each interface.

C.1.1.1 Using the SYSSDNS System Service

DECDns provides a single system service call (SYSSDNS) to create, delete, modify, and retrieve DECDns names from a namespace. The SYSSDNS system service completes asynchronously; that is, it returns to the client immediately after making a name service call. The status returned to the client indicates whether a request was queued successfully to the name service.

The SYSSDNSW system service is the synchronous equivalent of SYSSDNS. The SYSSDNSW call is identical to SYSSDNS in every way except that SYSSDNSW returns to the caller after the operation completes.

The SYSSDNS call has two main parameters:

- A function code that identifies the particular service to perform
- An item list that specifies all the parameters for the required function

The system service provides the following functions:

- Create and delete DECDns names in the namespace
- Enumerate DECDns names in a particular directory
- Add, read, remove, and test attributes and attribute values
- Add, create, remove, restore, and update directories
- Create, remove, and resolve soft links
- Create and remove groups

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- Add, remove, and test members in a group
- Parse names to convert string format names to DECDns opaque format names and back to string

You specify item codes as either input or output parameters in the item list. Input parameters modify functions, set context, or describe the information to be returned. Output parameters return the requested information.

You can specify the following in input item codes:

- An attribute name and type
- The class of a DECDns name and, optionally, a class filter
- The class version of a DECDns name
- A confidence setting to indicate whether the request should be serviced from the clerk's cache or from a server
- An indication that the application will repeat a read call, which forces caching of recently read data
- A name or timestamp that sets the context from which to begin or restart enumerating or reading
- The name and type of an object, directory, group, member, clearinghouse, or soft link, and the ability to suppress the namespace nickname from the full name
- A simple or full name in opaque or string format
- A request to search subgroups for a member
- An operation, either adding or deleting an attribute
- A value for an attribute
- A pointer to the address of the next character in a full or simple name
- A timeout period to wait for a call to complete
- An expiration time and extension time for soft links

The output item codes return the following information:

- A creation timestamp for an object
- A set of child directories, soft links, attribute names, attribute values, or object names
- An opaque simple or full name
- A string name and length
- A resolved soft link
- A name or timestamp context variable that indicates the last directory, object, soft link, or attribute that was enumerated or read

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C.1.1.2 Using the Run-Time Library Routines

You can use the DECDNS run-time library routines to manipulate output from the SYSSDNS system service. The routines provide the following functions:

- Remove a value from a set returned by an enumeration or read system service function
- Compare, append, concatenate, and count opaque names that were created with the system service
- Convert addresses

To read a single attribute value using the system service and run-time library routines, use the following routines:

- DNSS\$ENUMERATE_OBJECTS function code to enumerate objects
- DNSS\$REMOVE_FIRST_SET_VALUE run-time library routine to remove the first set value
- DNSS\$READ_ATTRIBUTE function code to read the first set value

You can also use the system service and run-time library routines together to add an opaque simple name to a full name by performing the following steps:

1. Obtain a string full name from a user.
2. Use the system service DNSS\$PARSE_FULLNAME_STRING function code to convert the string name to opaque format.
3. Use the DNSS\$APPEND_SIMPLE_TO_RIGHT run-time library routine to add an opaque simple name to the end of the full name.

C.2 Using the SYSSDNS System Service Call

The following sections describe how to create and modify an object, and then how to read attributes and enumerate names and attributes in the namespace.

Each section contains a code example. These code examples are all contained in the sample program that resides on your distribution medium under the file name SYS\$EXAMPLES:SYSSDNS_SAMPLE.C.

C.2.1 Creating Objects

Applications that use DECDNS can create an object in the namespace for each resource used by the application. You can create objects using either the SYSSDNS or the SYSSDNSW system service.

A DECDNS object consists of a name and its associated attributes. When you create the object, you must assign a class and a class version. You can modify the object to hold additional attributes, such as class-specific attributes, on an as-needed basis.

Note that applications can use objects that are created by other applications.

To create an object in the namespace with SYSSDNS:

1. Prompt the user for a name.

The name that an application assigns to an object should come from a user, a configuration file, a system logical name, or some other source. The application never assigns an object's name because the namespace structure is uncertain. The name the application receives from the user is in string format.

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2. Use the SYS\$DNS parse function to convert the full name string into an opaque format. Specify the DNSS_NEXTCHAR_PTR item code to obtain the length of the opaque name.
3. Optionally, reserve an event flag so you can check for completion of the service.
4. Build an item list that contains the following elements:
 - The opaque name for the object (resulting from the translation in step 2)
 - The class name given by the application, which should contain the facility code
 - The class version assigned by the application
 - An optional timeout value that specifies when the call expires
5. Optionally, provide the address of the DECdns status block to receive status information from the name service.
6. Optionally, provide the address of the asynchronous system trap (AST) service routine. AST routines allow a program to continue execution while waiting for parts of the program to complete.
7. Optionally, supply a parameter to pass to the AST routine.
8. Call the create object function and provide all the parameters supplied in steps 1 through 7.

If a clerk call is not complete when timeout occurs, then the call completes with an error. The error is returned in the DECdns status block.

An application should check for errors that are returned; it is not enough to check the return of the SYS\$DNS call itself. You need to check the DECdns status block to be sure no errors are returned by the DECdns server.

The following routine, written in C, shows how to create an object in the namespace with the synchronous service SYS\$DNSW. The routine demonstrates how to construct an item list.

```
#include <dnsdef.h>
#include <dnsmsg.h>
/*
 * Parameters:
 *   class_name = address of the opaque simple name of the class
 *               to assign to the object
 *   class_len  = length (in bytes) of the class opaque simple name
 *   object_name= address of opaque full name of the object
 *               to create in the namespace.
 *   object_len = length (in bytes) of the opaque full name of the
 *               object to create
 */
create_object(class_name, class_len, object_name, object_len)
unsigned char *class_name; /*Format is a DECdns opaque simple name*\
unsigned short class_len;
unsigned char *object_name; /*Format is a DECdns opaque simple name*\
unsigned short object_len;
{
    struct $dnsitndef createitem[4]; /* Item list used by system service */
    struct $dnscversdef version; /* Version assigned to the object */
    struct $dnspb iosb; /* Used to determine DECdns server status */
    int status; /* Status return from system service */
```

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C.2 Using the SYS\$DNS System Service Call

```
/*
 * Construct the item list that creates the object:
 */
createitem[0].dns$w_itm_size = class_len; ❶
createitem[0].dns$w_itm_code = dns$class;
createitem[0].dns$a_itm_address = class_name;

createitem[1].dns$w_itm_size = object_len; ❷
createitem[1].dns$w_itm_code = dns$objectname;
createitem[1].dns$a_itm_address = object_name;

version.dns$b_c_major = 1; ❸
version.dns$b_c_minor = 0;

createitem[2].dns$w_itm_size = sizeof(struct $dnscversdef); ❹
createitem[2].dns$w_itm_code = dns$version;
createitem[2].dns$a_itm_address = &version;

*((int *)&createitem[3]) = 0; ❺

status = sys$dns(0, dns$create_object, &createitem, &iosb, 0, 0); ❻

if(status == SS$NORMAL)
{
    status = iosb.dns$l_dnsb_status; ❼
}

return(status);
}
```

- ❶ The first entry in the item list is the address of the opaque simple name that represents the class of the object.
- ❷ The second entry is the address of the opaque full name for the object.
- ❸ The next step is to build a version structure that indicates the version of the object. In this case, the object is version 1.0.
- ❹ The third entry is the address of the version structure that was just built.
- ❺ A value of 0 terminates the item list.
- ❻ The next step is to call the system service to create the object.
- ❼ Check to see that both the system service and DECdns were able to perform the operation without error.

C.2.2 Modifying Objects and Their Attributes

After you create objects that identify resources, you can add or modify attributes that describe properties of the object. There is no limit imposed on the number of attributes an object can have.

You modify an object whenever you need to add an attribute or attribute value, change an attribute value, or delete an attribute or attribute value. When you modify an attribute, DECdns updates the timestamp contained in the DNS\$UTS attribute for that attribute.

To modify an attribute or attribute value, use the DNS\$MODIFY_ATTRIBUTE function code. Specify the attribute name in the input item code along with the following required input item codes:

- DNS\$ATTRIBUTETYPE to specify a set-valued (DNS\$K_SET) or single-valued (DNS\$K_SINGLE) attribute
- DNS\$MODOPERATION to specify that the value is being added (DNS\$K_PRESENT) or deleted (DNS\$K_ABSENT)

Distributed Name Service (VAX Only) C.2 Using the SYS\$DNS System Service Call

Use the `DNS$_MODVALUE` item code to specify the value of the attribute. Note that the `DNS$_MODVALUE` item code must be specified to add a single-valued attribute. You can specify a null value for a set-valued attribute. `DECdns` modifies attribute values in the following way:

- If the attribute exists and you specify an attribute value, the attribute value is removed from a set-valued attribute. All other values are unaffected. For a single-valued attribute, `DECdns` removes the attribute and its value from the name.
- If you do not specify an attribute value, `DECdns` removes the attribute and all values of the attribute for both set-valued and single-valued attributes.

To delete an attribute, use the `DNS$_MODOPERATION` item code.

The following is an example of how to use the `DNS$_MODIFY_ATTRIBUTE` function code to add a new member to a group object. To do this, you add the new member to the `DNS$Members` attribute of the group object. Use the following function codes:

- Specify the group object (`DNS$_ENTRY`) and type (`DNS$_LOOKINGFOR`). The type should be specified as object (`DNS$_K_OBJECT`).
- Use `DNS$_MODOPERATION` to add a member to the `DNS$Members` attribute (`DNS$_ATTRIBUTENAME`), which is a set-valued attribute (`DNS$_ATTRIBUTETYPE`).
- Specify the new member object name in `DNS$_MODVALUE`.
- Use another `DNS$_MODIFY_ATTRIBUTE` call to assign access rights for the new member to the `DNS$ACS` attribute of the member object.

Perform the following steps to modify an object with `SYS$DNSW`:

1. Build an item list that contains the following elements:
 - Opaque name of the object you are modifying
 - Type of object
 - Operation to perform
 - Type of attribute you are modifying
 - Attribute name
 - Value being added to the attribute
2. Supply any of the optional parameters described in Section C.2.1.
3. Call the modify attribute function, supplying the parameters established in steps 1 and 2.

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C.2 Using the SYS\$DNS System Service Call

The following example, written in C, shows how to add a set-valued attribute and a value to an object:

```
#include <dnsdef.h>
#include <dnsmsg.h>
/*
 * Parameters:
 *   obj_name = address of opaque full name of object
 *   obj_len  = length of opaque full name of object
 *   att_name = address of opaque simple name of attribute to create
 *   att_len  = length of opaque simple name of attribute
 *   att_value= value to associate with the attribute
 *   val_len  = length of added value (in bytes)
 */

add_attribute(obj_name, obj_len, att_name, att_len, att_value, val_len)
unsigned char *obj_name;
unsigned short obj_len;
unsigned char *att_name;
unsigned short att_len;
unsigned char *att_value;
unsigned short val_len;

main() {
    struct $dnsitmdf moditem[7];          /* Item list for $DNSW */
    unsigned char objtype = dns$k_object; /* Using objects */
    unsigned char opertype = dns$k_present; /* Adding an object */
    unsigned char attype = dns$k_set;     /* Attribute will be type set */
    struct $dnsb iosb;                   /* Used to determine DECdns status */
    int status;                          /* Status of system service */

    /*
     * Construct the item list to add an attribute to an object.
     */
    moditem[0].dns$w_itm_size = obj_len;
    moditem[0].dns$w_itm_code = dns$_entry;
    moditem[0].dns$a_itm_address = obj_name; ❶

    moditem[1].dns$w_itm_size = sizeof(char);
    moditem[1].dns$w_itm_code = dns$_lookingfor;
    moditem[1].dns$a_itm_address = &objtype; ❷

    moditem[2].dns$w_itm_size = sizeof(char);
    moditem[2].dns$w_itm_code = dns$_modoperation;
    moditem[2].dns$a_itm_address = &opertype; ❸

    moditem[3].dns$w_itm_size = sizeof(char);
    moditem[3].dns$w_itm_code = dns$_attributetype;
    moditem[3].dns$a_itm_address = &attype; ❹

    moditem[4].dns$w_itm_size = att_len;
    moditem[4].dns$w_itm_code = dns$_attributename;
    moditem[4].dns$a_itm_address = att_name; ❺

    moditem[5].dns$w_itm_size = val_len;
    moditem[5].dns$w_itm_code = dns$_modvalue;
    moditem[5].dns$a_itm_address = att_value; ❻

    *((int *)&moditem[6]) = 0; ❼

    /*
     * Call $DNSW to add the attribute to the object.
     */
    status = sys$dns(0, dns$_modify_attribute, &moditem, &iosb, 0, 0);❽
}
```


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C.2 Using the SYS\$DNS System Service Call

```
if(status == SS$NORMAL)
{
status = iosb.dns$l_dnsb_status; ❸
}

return(status);
}
```

- ❶ The first entry in the item list is the address of the opaque full name of the object.
- ❷ The second entry shows that this is an object, not a soft link or child directory pointer.
- ❸ The third entry is the operation to perform. The program adds an attribute with its value to the object.
- ❹ The fourth entry is the attribute type. The attribute has a set of values rather than a single value.
- ❺ The fifth entry is the opaque simple name of the attribute being added.
- ❻ The sixth entry is the value associated with the attribute.
- ❼ A value of 0 terminates the item list.
- ❽ A call is made to the SYS\$DNSW system service to perform the operation.
- ❾ A check is made to see that both the system service and DECdns performed the operation without error.

C.2.3 Requesting Information from DECdns

Once an application adds its objects to the namespace and modifies the names to contain all necessary attributes, the application is ready to use the namespace. An application can request that the DECdns Clerk either read attribute information stored with an object or list all the application's objects that are stored in a particular directory. An application might also need to resolve all soft links in a name in order to identify a target.

To request information from DECdns, use the read or enumerate function codes, as follows:

- The DNS\$READ_ATTRIBUTE function reads and returns a set whose members are the values of the specified attribute.
- The DNS\$ENUMERATE functions return a list of names for attributes, child directories, objects, and soft links.

C.2.3.1 Using the Distributed File Service (DFS)

The VAX Distributed File Service (DFS) uses DECdns for resource naming. This section gives an example of the DNS\$READ_ATTRIBUTE call as used by DFS. The DFS application uses DECdns to give the operating system's users the ability to use remote operating system disks as if the disks were attached to their local VAX system. The DFS application creates DECdns names for the operating system's directory structures (a directory and all of its subdirectories). Each DFS object in the namespace references a particular file access point. DFS creates each object with a class attribute of DF\$ACCESSPOINT and modifies the address attribute (DNS\$Address) of each object to hold the DECnet node address where the directory structures reside. As a final step in registering its resources, DFS creates a database that maps DECdns names to the appropriate operating system directory structures.

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C.2 Using the SYS\$DNS System Service Call

Whenever the DFS application receives the following mount request, DFS sends a request for information to the DECdns Clerk:

```
MOUNT ACCESS_POINT dns-name vms-logical-name
```

To read the address attribute of the access point object, the DFS application performs the following steps:

1. Translates the DECdns name that is supplied through the user to opaque format using the SYS\$DNS parse function
2. Reads the class attribute of the object with the \$DNS read attribute function, indicating that there is a second call to read other attributes of the object
3. Makes a second call to the SYS\$DNS read attribute function to read the address attribute of the object
4. Sends the DECdns name to the DFS server, which looks up the disk on which the access point is located
5. Verifies that the DECdns name is valid on the DFS server

The DFS client and DFS server now can communicate to complete the mount function.

C.2.3.2 Reading Attributes from DNS

When requesting information from DNS, an application always takes an object name from the user, translates the name into opaque format, and passes it in an item list to the DECdns Clerk.

Each read request returns a set of attribute values. The DNS\$READ_ATTRIBUTE service uses a context item code called DNS\$CONTEXTVARTIME to maintain context when reading the attribute values. The context item code saves the last member that is read from the set. When the next read call is issued, the item code sets the context to the next member in the set, reads it, and returns it. The context item code treats single-valued attributes as though they were a set of one.

If an enumeration call returns DNS\$MOREDATA, not all matching names or attributes have been enumerated. If you receive this message, you should make further calls, setting DNS\$CONTEXTVARTIME to the last value returned until the procedure returns SSS\$NORMAL.

The following program, written in C, shows how an application reads an object attribute. The SYS\$DNSW service uses an item list to return a set of objects. Then the application calls a run-time library routine to read each value in the set.

```
#include <dnsdef.h>
#include <dnsmsg.h>
/*
 * Parameters:
 *   opaque_objname = address of opaque full name for the object
 *                   containing the attribute to be read
 *   obj_len       = length of opaque full name of the object
 *   opaque_attname = address of the opaque simple name of the
 *                   attribute to be read
 *   attname_len   = length of opaque simple name of attribute
 */
```

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```

read_attribute(opaque_objname, obj_len, opaque_attname, attname_len)
unsigned char *opaque_objname;
unsigned short obj_len;
unsigned char *opaque_attname;
unsigned short attname_len;
{
    struct $dnsb iosb;          /* Used to determine DECDns status */
    char objtype = dns$k_object; /* Using objects */

    struct $dnsitmdef readitem[6]; /* Item list for system service */
    struct dsc$dscdescriptor set_dsc, value_dsc, newset_dsc, cts_dsc;

    unsigned char attvalbuf[dns$k_maxattribute]; /* To hold the attribute */
                                                /* values returned from extraction routine. */
    unsigned char attsetbuf[dns$k_maxattribute]; /* To hold the set of */
                                                /* attribute values after the return from $DNSW. */
    unsigned char ctsbuf[dns$k_cts_length]; /* Needed for context of multiple reads */

    int read_status;          /* Status of read attribute routine */
    int set_status;          /* Status of remove value routine */
    int xx;                  /* General variable used by print routine */

    unsigned short setlen; /* Contains current length of set structure */
    unsigned short val_len; /* Contains length of value extracted from set */
    unsigned short cts_len; /* Contains length of CTS extracted from set */

    /* Construct an item list to read values of the attribute. */ ❶
    readitem[0].dns$w_itm_code = dns$_entry;
    readitem[0].dns$w_itm_size = obj_len;
    readitem[0].dns$a_itm_address = opaque_objname;

    readitem[1].dns$w_itm_code = dns$_lookingfor;
    readitem[1].dns$w_itm_size = sizeof(char);
    readitem[1].dns$a_itm_address = &objtype;

    readitem[2].dns$w_itm_code = dns$_attributename;
    readitem[2].dns$a_itm_address = opaque_attname;
    readitem[2].dns$w_itm_size = attname_len;

    readitem[3].dns$w_itm_code = dns$_outvalset;
    readitem[3].dns$a_itm_ret_length = &setlen;
    readitem[3].dns$w_itm_size = dns$k_maxattribute;
    readitem[3].dns$a_itm_address = attsetbuf;

    *((int *)&readitem[4]) = 0;

    do ❷
    {
        read_status = sys$dns(0, dns$_read_attribute, &readitem, &iosb, 0, 0);

        if(read_status == SS$_NORMAL)
        {
            read_status = iosb.dns$l_dnsb_status;
        }

        if((read_status == SS$_NORMAL) || (read_status == DNS$_MOREDATA))
        {
            do
            {
                set_dsc.dsc$w_length = setlen;
                set_dsc.dsc$a_pointer = attsetbuf; /* Address of set */

                value_dsc.dsc$w_length = dns$k_simplenamemax;
                value_dsc.dsc$a_pointer = attvalbuf; /* Buffer to hold */
                                                    /* attribute value */

                cts_dsc.dsc$w_length = dns$k_cts_length;
                cts_dsc.dsc$a_pointer = ctsbuf; /* Buffer to hold value's CTS*/
            }
        }
    }
}

```

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C.2 Using the SYS\$DNS System Service Call

```
newset_dsc.dsc$w_length = dns$k_maxattribute;
newset_dsc.dsc$a_pointer = attsetbuf; /* Same buffer for */
                                   /* each call      */

set_status = dns$remove_first_set_value(&set_dsc, &value_dsc,
    ❸                                     &val_len, &cts_dsc,
                                       &cts_len, &newset_dsc,
                                       &setlen);

if(set_status == SS$NORMAL)
{
    ❹
    readitem[4].dns$w_itm_code = dns$contextvartime;
    readitem[4].dns$w_itm_size = cts_len;
    readitem[4].dns$a_itm_address = ctsbuf;

    *((int *)&readitem[5]) = 0;

    printf("\tValue: ");
    ❺
    for(xx = 0; xx < val_len; xx++)
        printf("%x ", attvalbuf[xx]);
    printf("\n");
}
else if (set_status != 0)
{
    printf("Error %d returned when removing value from set\n",
        set_status);
    exit(set_status);
}
} while(set_status == SS$NORMAL);
}
else
{
    printf("Error reading attribute = %d\n", read_status);
    exit(read_status);
}
} while(read_status == DNS$MOREDATA);
}
```

- ❶ The item list contains five entries:
 - Opaque full name of the object with the attribute the program wants to read
 - Type of object to access
 - Opaque simple name of the attribute to read
 - Address of the buffer containing the set of values returned by the read operation
 - A value of 0 to terminate the item list
- ❷ The loop repeatedly calls the SYS\$DNSW service to read the values of the attribute because the first call might not return all the values. The loop executes until \$DNSW returns something other than DNS\$MOREDATA.
- ❸ The DNS\$REMOVE_FIRST_SET_VALUE routine extracts a value from the set.
- ❹ This attribute name may be the context the routine uses to read additional attributes. The attribute's creation timestamp (CTS), not its value, provides the context.
- ❺ Finally, display the value in hexadecimal format. (You could also take the attribute name and convert it to a printable format before displaying the result.)

Distributed Name Service (VAX Only) C.2 Using the SYS\$DNS System Service Call

See the discussion about setting confidence in the *Guide to Programming with DECdns* for information about obtaining up-to-date data on read requests.

C.2.3.3 Enumerating DECdns Names and Attributes

The enumerate functions return DECdns names for objects, child directories, soft links, groups, or attributes in a specific directory. Use either the asterisk (*) or question mark (?) wildcard to screen enumerated items. DECdns matches any single character against the specified wildcard.

Enumeration calls return a set of simple names or attributes. If an enumeration call returns DNSS_MOREDATA, not all matching names or attributes have been enumerated. If you receive this message, use the context-setting conventions that are described for the DNSS_READ_ATTRIBUTE call. You should make further calls, setting DNSS_CONTEXTVARNAME to the last value returned until the procedure returns SSS_NORMAL. For more information, see the SYS\$DNS system service in the *OpenVMS System Services Reference Manual: A-GETUAI*.

The following program, written in C, shows how an application can read the objects in a directory with the SYS\$DNS system service. The values that DECdns returns from read and enumerate functions are in different structures. For example, an enumeration of objects returns different structures than an enumeration of child directories. To clarify how to use this data, the sample program demonstrates how to parse any set that the enumerate objects function returns with a run-time library routine in order to remove the first value from the set. The example also demonstrates how the program takes each value from the set.

```
#include <dnsdef.h>
#include <dnsmsg.h>
/*
 * Parameters:
 *   fname_p   : opaque full name of the directory to enumerate
 *   fname_len : length of full name of the directory
 */

struct $dnsitmdef enumitem[4];          /* Item list for enumeration */
unsigned char setbuf[100];             /* Values from enumeration */
struct $dnspb enum_iosb;               /* DECdns status information */
int synch_event;                      /* Used for synchronous AST threads */
unsigned short setlen;                 /* Length of output in setbuf */

enumerate_objects(fname_p, fname_len)
unsigned char *fname_p;
unsigned short fname_len;
{
    int enumerate_objects_ast();

    int status;                        /* General routine status */
    int enum_status;                   /* Status of enumeration routine */

    /* Set up item list */

    enumitem[0].dns$w_itm_code = dns$_directory; /* Opaque directory name */
    enumitem[0].dns$w_itm_size = fname_len;
    enumitem[0].dns$a_itm_address = fname_p;

    enumitem[1].dns$w_itm_code = dns$_outobjects; /* output buffer */
    enumitem[1].dns$a_itm_ret_length = &setlen;
    enumitem[1].dns$w_itm_size = 100;
    enumitem[1].dns$a_itm_address = setbuf;

    *((int *)&enumitem[2]) = 0; /* Zero terminate item list */
    status = lib$get_ef(&synch_event); ❶
}
```

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C.2 Using the SYS\$DNS System Service Call

```

if(status != SS$NORMAL)
{
    printf("Could not get event flag to synch AST threads\n");
    exit(status);
}

enum_status = sys$dns(0, dns$enumerate_objects, &enumitem,
    ❷ &enum_iosb, enumerate_objects_ast, setbuf);

if(enum_status != SS$NORMAL) ❸
{
    printf("Error enumerating objects = %d\n", enum_status);
    exit(enum_status);
}

status = sys$synch(synch_event, &enum_iosb); ❹

if(status != SS$NORMAL)
{
    printf("Synchronization with AST threads failed\n");
    exit(status);
}
}

/* AST routine parameter: */
/*   outbuf : address of buffer that contains enumerated names. */
    ❺
unsigned char objnamebuf[dns$k_simplenamemax]; /* Opaque object name */
enumerate_objects_ast(outbuf)
unsigned char *outbuf;
{
    struct $dnsitndef cvtitem[3];          /* Item list for class name */
    struct $dnsb iosb;                    /* Used for name service status information */
    struct dsc$dscdescriptor set_dsc, value_dsc, newset_dsc;

    unsigned char simplebuf[dns$k_simplestrmax]; /* Object name string */

    int enum_status; /* The status of the enumeration itself */
    int status;      /* Used for checking immediate status returns */
    int set_status;  /* Status of remove value routine */

    unsigned short val_len; /* Length of set value */
    unsigned short sname_len; /* Length of object name */

    enum_status = enum_iosb.dns$l_dnsb_status; /* Check status */
    if((enum_status != SS$NORMAL) && (enum_status != DNS$MOREDATA))
    {
        printf("Error enumerating objects = %d\n", enum_status);
        sys$setef(synch_event);
        exit(enum_status);
    }
}

do
{
    /*
     * Extract object names from output buffer one
     * value at a time. Set up descriptors for the extraction.
     */
    set_dsc.dsc$w_length = setlen; /* Contains address of */
    set_dsc.dsc$a_pointer = setbuf; /* the set whose values */
                                    /* are to be extracted */

    value_dsc.dsc$w_length = dns$k_simplenamemax;
    value_dsc.dsc$a_pointer = objnamebuf; /* To contain the */
                                            /* name of an object */
                                            /* after the extraction */

    newset_dsc.dsc$w_length = 100; /* To contain a new */
    newset_dsc.dsc$a_pointer = setbuf; /* set structure after */
                                        /* the extraction. */
}

```

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C.2 Using the SYS\$DNS System Service Call

```

/* Call yRTL routine to extract the value from the set */
set_status = dns$remove_first_set_value(&set_dsc, &value_dsc, &val_len,
                                       0, 0, &newset_dsc, &setlen);

if(set_status == SS$NORMAL)
{
    cvtitem[0].dns$w_itm_code = dns$_fromsimpname;
    cvtitem[0].dns$w_itm_size = val_len;
    cvtitem[0].dns$a_itm_address = objnamebuf;

    cvtitem[1].dns$w_itm_code = dns$_tostringname;
    cvtitem[1].dns$w_itm_size = dns$_k_simplestrmax;
    cvtitem[1].dns$a_itm_address = simplebuf;
    cvtitem[1].dns$a_itm_ret_length = &sname_len;

    *((int *)&cvtitem[2]) = 0;

    status = sys$dns(0, dns$_simple_opaque_to_string, &cvtitem,
                   &iosb, 0, 0);

    if(status == SS$NORMAL)
        status = iosb.dns$l_dnsb_status; /* Check for errors */
    if(status != SS$NORMAL) /* If error, terminate processing */
    {
        printf("Converting object name to string returned %d\n",
              status);
        exit(status);
    }
    else
    {
        printf("%.s\n", sname_len, simplebuf);
    }

    enumitem[2].dns$w_itm_code = dns$_contextvarname;
    enumitem[2].dns$w_itm_size = val_len;
    enumitem[2].dns$a_itm_address = objnamebuf;

    *((int *)&enumitem[3]) = 0;
}
else if (set_status != 0)
{
    printf("Error %d returned when removing value from set\n",
          set_status);
    exit(set_status);
}
} while(set_status == SS$NORMAL);

if(enum_status == DNS$_MOREDATA)
{
    enum_status = sys$dns(0, dns$_enumerate_objects, &enumitem,
                        &enum_iosb, enumerate_objects_ast, setbuf);

    if(enum_status != SS$NORMAL) /* Check status of $DNS */
    {
        printf("Error enumerating objects = %d\n", enum_status);
        sys$setef(synch_event);
    }
}
else
{
    sys$setef(synch_event);
}
}

```

- ❶ Get an event flag to synchronize the execution of AST threads.
- ❷ Use the system service to enumerate the object names.
- ❸ Check the status of the system service itself before waiting for threads.

Distributed Name Service (VAX Only)

C.2 Using the SYS\$DNS System Service Call

- ④ Use the SYSSYNCH call to make sure the DECdns Clerk has completed and that all threads have finished executing.
- ⑤ After enumerating objects, SYS\$DNS calls an AST routine. The routine shows how DNS\$REMOVE_FIRST_SET_VALUE extracts object names from the set returned by the DNS\$_ENUMERATE_OBJECTS function.
- ⑥ Use an item list to convert the opaque simple name to a string name so you can display it to the user. The item list contains the following entries:
 - Address of the opaque simple name to be converted
 - Address of the buffer that will hold the string name
 - A value of 0 to terminate the item list
- ⑦ This object name may provide the context for continuing the enumeration. Append the context variable to the item list so the enumeration can continue from this name if there is more data.
- ⑧ Use the system service to enumerate the object names as long as there is more data.
- ⑨ Set the event flag to indicate that all AST threads have completed and that the program can terminate.

C.3 Using the DCL Command DEFINE with DECdns Logical Names

When the DECdns Clerk is started on the operating system, the VAX system creates a unique logical name table for DECdns to use in translating full names. This logical name table, called DNS\$SYSTEM, prevents unintended interaction with other system logical names.

To define systemwide logical names for DECdns objects, you must have the appropriate privileges to use the DCL command DEFINE. Use the DEFINE command to create the logical RESEARCH.PROJECT_DISK, for example, by entering the following DCL command:

```
$ DEFINE /TABLE=DNS$SYSTEM RESEARCH "ENG.RESEARCH"
```

When parsing a name, the SYS\$DNS service specifies the logical name DNS\$LOGICAL as the table it uses to translate a simple name into a full name. This name translates to DNS\$SYSTEM (by default) to access the systemwide DECdns logical name table.

To define process or job logical names for SYS\$DNS, you must create a process or job table and redefine DNS\$LOGICAL as a search list, as in the following example (note that elevated privileges are required to create a job table):

```
$ CREATE /NAME_TABLE DNS_PROCESS_TABLE
$ DEFINE /TABLE=LNMS$PROCESS_DIRECTORY DNS$LOGICAL -
_$DNS_PROCESS_TABLE, DNS$SYSTEM
```

Once you have created the process or job table and redefined DNS\$LOGICAL, you can create job-specific logical names for DECdns by using the DCL command DEFINE, as follows:

```
$ DEFINE /TABLE=DNS_PROCESS_TABLE RESEARCH "ENG.RESEARCH.MYGROUP"
```


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