VMS Software

VSI TCP/IP Services for OpenVMS Sockets API and System Services Programming

Operating System and Version: VSI OpenVMS IA-64 Version 8.4-1H1 or higher
VSI OpenVMS Alpha Version 8.4-2L1 or higher

Software Version: VSI TCP/IP Services Version 5.7

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Legal Notice

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Preface

The TCP/IP Services product is the VSI implementation of the TCP/IP networking protocol suite and internet services for OpenVMS Alpha, OpenVMS I64, and OpenVMS VAX systems.

A layered software product, TCP/IP Services provides a comprehensive suite of functions and applications that support industry-standard protocols for heterogeneous network communications and resource sharing.

This manual describes how to use TCP/IP Services to develop network applications using Berkeley Sockets or OpenVMS system services.

1. About VSI

VMS Software, Inc. (VSI) is an independent software company licensed by Hewlett Packard Enterprise to develop and support the OpenVMS operating system.

2. Intended Audience

This manual is intended for experienced programmers who want to write network application programs that run in the TCP/IP Services environment. Readers should be familiar with the C programming language, TCP/IP protocols, and networking concepts.

3. Document Structure

This manual contains the following chapters and appendixes:

- *Chapter 1, "Application Programming Interfaces"* describes the application programming interfaces that TCP/IP Services supports.
- *Chapter 2, "Writing Network Applications"* describes the typical function calls for developing network applications using the TCP and UDP protocols.
- *Chapter 3, "Using the Sockets API"* discusses information to consider when writing portable network applications using the Sockets API for IPv4 and IPv6.
- *Chapter 4, "Sockets API Reference"* contains Sockets API reference information.
- *Chapter 5, "Using the $QIO System Service"* describes how to use $QIO system services and data structures to write network applications using OpenVMS system services.
- *Chapter 6, "OpenVMS System Services Reference"* contains OpenVMS system services and I/O function reference information pertinent to TCP/IP Services. This information supplements the OpenVMS system services programming information contained in the *VSI OpenVMS System Services Reference Manual* manual.
- *Appendix A, "Socket Options"* lists socket options supported by both programming interfaces.
- *Appendix B, "IOCTL Requests"* lists IOCTL requests.

- *Appendix C, "Data Types"* describes TCP/IP Services data types.
- *Appendix D, "Error Codes"* lists Sockets API error codes and equivalent OpenVMS system services status codes.
- *Appendix E, "Porting Applications to IPv6"* describes how to modify a network application so that it can operate in an IPv6 networking environment.

4. Related Documentation

Table 1, "TCP/IP Services Documentation" lists the documents available with this version of TCP/IP Services.

Table 1. TCP/IP Services Documentation

Manual	Contents
VSI TCP/IP Services for OpenVMS Concepts and Planning	This manual provides conceptual information about TCP/IP networking on OpenVMS systems, including general planning issues to consider before configuring your system to use the TCP/IP Services software. This manual also describes the manuals in the TCP/IP Services documentation set and provides a glossary of terms and acronyms for the TCP/IP Services software product.
VSI TCP/IP Services for OpenVMS Installation and Configuration	This manual explains how to install and configure the TCP/IP Services product.
VSI TCP/IP Services for OpenVMS User's Guide	This manual describes how to use the applications available with TCP/IP Services such as remote file operations, email, TELNET, TN3270, and network printing. This manual explains how to use these services to communicate with systems on private internets or on the worldwide Internet.
VSI TCP/IP Services for OpenVMS Management	This manual describes how to configure and manage the TCP/IP Services product. Use this manual with the *VSI TCP/IP Services for OpenVMS Management Command Reference* manual.
VSI TCP/IP Services for OpenVMS Management Command Reference	This manual describes the TCP/IP Services management commands. Use this manual with the *VSI TCP/IP Services for OpenVMS Management* manual.
VSI TCP/IP Services for OpenVMS ONC RPC Programming	This manual presents an overview of high-level programming using open network computing remote procedure calls (ONC RPC). This manual also describes the RPC programming interface and how to use the RPCGEN protocol compiler to create applications.

Manual	Contents
VSI TCP/IP Services for OpenVMS Sockets API and System Services Programming	This manual describes how to use the Berkeley Sockets API and OpenVMS system services to develop network applications.
VSI TCP/IP Services for OpenVMS SNMP Programming and Reference	This manual describes the Simple Network Management Protocol (SNMP) and the SNMP application programming interface (eSNMP). It describes the subagents provided with TCP/IP Services, utilities provided for managing subagents, and how to build your own subagents.
VSI TCP/IP Services for OpenVMS Guide to IPv6	This manual describes the IPv6 environment, the roles of systems in this environment, the types and function of the different IPv6 addresses, and how to configure TCP/IP Services to access the IPv6 network.

5. OpenVMS Documentation

The full VSI OpenVMS documentation set can be found on the VMS Software Documentation webpage at https://docs.vmssoftware.com.

6. VSI Encourages Your Comments

You may send comments or suggestions regarding this manual or any VSI document by sending electronic mail to the following Internet address: <docinfo@vmssoftware.com>. Users who have VSI OpenVMS support contracts through VSI can contact <support@vmssoftware.com> for help with this product.

7. Typographical Conventions

The following conventions may be used in this manual:

Ctrl/*x*	A sequence such as Ctrl/*x* indicates that you must hold down the key labeled Ctrl while you press another key or a pointing device button.
PF1 *x*	A sequence such as PF1 *x* indicates that you must first press and release the key labeled PF1, then press and release another key or a pointing device button.
. . .	In examples, a horizontal ellipsis indicates one of the following possibilities: • 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 format descriptions, parentheses indicate that, if you choose more than one option, you must enclose the choices in parentheses.

[]	In format descriptions, brackets indicate that whatever is enclosed within the brackets is optional; you can select none, one, or all of the choices. (Brackets are not, however, optional in the syntax of a directory name in a file specification or in the syntax of a substring specification in an assignment statement.)
{ }	In format descriptions, braces surround a required choice of options; you must choose one of the options listed.
red ink	Red ink indicates information that you must enter from the keyboard or a screen object that you must choose or click on. For online versions of the book, user input is shown in **bold**.
boldface text	Boldface text represents the introduction of a new term or the name of an argument, an attribute, or a reason. Boldface text is also used to show user input in online versions of the book.
italic text	Italic text represents information that can vary in system messages (for example, Internal error *number*).
UPPERCASE TEXT	Uppercase letters indicate that you must enter a command (for example, enter OPEN/READ), or they indicate the name of a routine, the name of a file, the name of a file protection code, or the abbreviation for a system privilege.
–	Hyphens in coding examples indicate that additional arguments to the request are provided on the line that follows.
numbers	Unless otherwise noted, all numbers in the text are assumed to be decimal. Nondecimal radixes—binary, octal, or hexadecimal—are explicitly indicated.

Chapter 1. Application Programming Interfaces

The application programming interfaces available with TCP/IP Services allow programmers to write network applications that are independent of the underlying communication facilities. This means that the system can support communications networks that use different sets of protocols, naming conventions, and hardware platforms.

The TCP/IP Services product supports two network communication application programming interfaces (APIs):

- Berkeley Software Distribution (BSD) Sockets
- OpenVMS system services

1.1. BSD Sockets

The Sockets application programming interface (API) supports only the C programming language. The benefits of using this API include:

- Ease of use.
- Portability — you can create common code for use on UNIX, OpenVMS, and many other platforms.
- 64-bit addressing capability on OpenVMS Alpha and OpenVMS I64 systems.

See *Chapter 4, "Sockets API Reference"* for a detailed description of Sockets API functions.

1.2. OpenVMS System Services

Each step in the Sockets communications process has a corresponding OpenVMS system service routine. The benefits of using OpenVMS system services include:

- Improved application performance
- 64-bit addressing capability on OpenVMS Alpha and OpenVMS I64 systems
- Finer granularity of control
- Easier asynchronous programming
- Support for the following programming languages:
  - MACRO-32
  - BLISS-32
  - Ada
  - BASIC

- C
- C++
- COBOL
- Fortran
- Pascal

See *Chapter 6, "OpenVMS System Services Reference"* for a detailed description of OpenVMS system service calls.

1.3. Application Development Files

TCP/IP Services provides definition files and function libraries for use in developing network applications, and programming example files to assist in learning how to develop network applications.

1.3.1. Definition Files

Table 1.1, "Network Definition Files" lists the definition files that are included with TCP/IP Services in the SYS$LIBRARY directory. Specific languages may also supply additional files that define structures related to network programming. Check the documentation for the language you are using.

Table 1.1. Network Definition Files

File	Description
TCPIP$INETDEF.ADA	Ada definition file
TCPIP$INETDEF.BAS	BASIC definition file
TCPIP$INETDEF.FOR	Fortran definition file
TCPIP$INETDEF.H	C and C++ definition file
TCPIP$INETDEF.MAR	MACRO-32 definition file
TCPIP$INETDEF.PAS	Pascal definition file
TCPIP$INETDEF.PLI	PL/I definition file
TCPIP$INETDEF.R32	BLISS-32 definition file

TCP/IP Services provides header files, data types, and support functions to facilitate OpenVMS system services programming. The header files provide definitions for constants. *Table 1.2, "C Language Definition Files"* lists the header files.

Table 1.2. C Language Definition Files

Header File	Description
Common Industry Standard	
IN.H	Internet system. Constants, functions, and structures
INET.H	Network address information

Header File	Description
NETDB.H	Network database library information
SIGNAL.H	UNIX style signal value definitions
SOCKET.H	BSD Sockets API
TCP/IP Services Related	
BITYPES.H	Basic integral types
IF.H	Structures providing a basic transport mechanism
IF_ARP.H	Structures for the Address Resolution Protocol
IF_TYPES.H	IANA types
IN.H	Internet protocol family
IN6.H	Internet V6 protocol family
IN6_MACHTYPES.H	Machine-specific internet V6 protocol family
INET.H	Internet access
IOCTL.H	I/O controls for special files
IP.H	Definitions for IPv4
IP6.H	Definitions for IPv6
NAMESER.H	Definition for maximum domain name size
NETDB.H	Network database library information
RESOLV.H	Resolver configuration file
SOCKET.H	TCP/IP socket definitions
STROPTS.H	Streams interface definitions
TCP.H	TCP descriptions
__DECC_INCLUDE_PROLOGUE.H	TCP/IP Services internal transliterations for IPv6 functions (directed to TCPIP$LIB.OLB)
OpenVMS Related	
DESCRIP.H	OpenVMS descriptor
IOCTL.H	I/O control
IODEF.H	I/O function codes
LIB$FUNCTIONS.H	Run-time library function signatures
SSDEF.H	System service status codes
STARLET.H	System service calls
TCPIP$INETDEF.H	TCP/IP network constants, functions, and structures
Standard UNIX	
STDIO.H	Standard UNIX I/O functions
STDLIB.H	Standard UNIX library functions
STRING.H	String-handling functions

The header files NAMESER.H and RESOLV.H contain transliterations that intercept calls made to name server and resolver API functions and redirect them to TCPIP$LIB.OLB. To use an implementation of these functions other than the one provided by TCP/IP Services, define the following symbols:

- For the name server API routines, use _TCPIP_NO_NS_TRANSLITERATIONS.
- For the resolver API routines, use _TCPIP_NO_RES_TRANSLITERATIONS.

1.3.2. Libraries

Table 1.3, "Sockets API Libraries" lists the function libraries included with TCP/IP Services.

Table 1.3. Sockets API Libraries

File	Location	Description
TCPIP$IPC_SHR.EXE	SYS$LIBRARY	Sockets API Run-Time Library
TCPIP$LIB.OLB	TCPIP$LIBRARY	BSD Version 4.4 Sockets object library

1.3.3. Programming Examples

Table 1.4, "TCP Programming Examples" and *Table 1.5, "UDP Programming Examples"* summarize the programming examples included with TCP/IP Services in the TCPIP$EXAMPLES directory. Most of these examples consist of a client and a corresponding server.

Table 1.4. TCP Programming Examples

File	Description
TCPIP$TCP_SERVER_SOCK.C TCPIP$TCP_CLIENT_SOCK.C	Example TCP client and server using the Sockets API.
TCPIP$TCP_SERVER_SOCK_AUXS.C	Example TCP server using the Sockets API that accepts connections from the auxiliary server.
TCPIP$TCP_SERVER_QIO.C TCPIP$TCP_CLIENT_QIO.C	Example TCP client and server using QIO system services.
TCPIP$TCP_SERVER_QIO_AUXS.C	Example TCP server using QIO system services that accepts connections from the auxiliary server.
TCPIP$TCP_CLIENT_QIO.MAR TCPIP$TCP_SERVER_QIO.MAR	Example TCP client and server using QIO system services and the MACRO-32 programming language.

Table 1.5. UDP Programming Examples

File	Description
TCPIP$UDP_SERVER_SOCK.C TCPIP$UDP_CLIENT_SOCK.C	Example UDP client and server using the Sockets API.
TCPIP$UDP_SERVER_QIO.C TCPIP$UDP_CLIENT_QIO.C	Example UDP client and server using QIO system services.
TCPIP$UDP_CLIENT_QIO.MAR TCPIP$UDP_SERVER_QIO.MAR	Example UDP client and server using QIO system services and the MACRO-32 programming language.

1.4. Compiling and Linking C Language Programs

To compile and link a C program called MAIN.C, enter the following commands:

```
$ CC MAIN.C
$ LINK MAIN.OBJ
```

1.4.1. Compiling and Linking Programs Using BSD Version 4.4

To compile and link MAIN.C using BSD Version 4.4, enter the following commands:

```
$ CC/DEFINE=(_SOCKADDR_LEN) MAIN.C
$ LINK MAIN.OBJ
```

Instead of using the /DEFINE=(_SOCKADDR_LEN) option to the compile command, you can change your code to include the following #DEFINE preprocessor directive:

```
#define   _SOCKADDR_LEN    1
```

This statement must appear before you include any of the following header files:

```
#include <in.h>
#include <netdb.h>
#include <inet.h>
```

1.4.2. VSI C Compilation Warnings

Certain parameters to the TCP/IP Services Sockets API functions require typecasting to avoid VSI C compilation warnings. Typecasting is required because of parameter prototyping, which the VSI C header (*filename*.H) files have in order to comply with ANSI standards.

1.5. Using 64-Bit Addresses (Alpha and I64 Only)

For applications that run on OpenVMS Alpha and I64 systems, input and output (I/O) operations can be performed directly to and from the P2 or S2 addressable space by means of the 64-bit friendly $QIO and $QIOW system services.

To write data to a remote host, use the $QIO(IO$_WRITEVBLK) function with either the **p1** (input buffer) or **p5** (input buffer list) parameter. The address you specify for the parameter can be a 64-bit value.

To read data from a remote host, use the $QIO(IO$_READVBLK) function with either the **p1** (output buffer) or **p6** (output buffer list) parameter. The address you specify for the parameter can be a 64-bit value.

MACRO-32 does not provide 64-bit macros for system services. For more information about MACRO-32 programming support and for 64-bit addressing in general, see the *OpenVMS Alpha Guide to 64-Bit Addressing and VLM Features*.

For more information about using the $QIO and $QIOW system services for 64-bit addressing, see *Chapter 5, "Using the $QIO System Service"* and *Chapter 6, "OpenVMS System Services Reference"*.

Chapter 2. Writing Network Applications

You can use either the Sockets API or OpenVMS system services to write TCP/IP applications that run on your corporate network. These applications consist of a series of system calls that perform tasks, such as creating a socket, performing host and IP address lookups, accepting and closing connections, and setting socket options. These system calls are direct entry points that client and server processes use to obtain services from the TCP/IP kernel software. System calls look and behave exactly like other procedural calls in that they take arguments and return one or more results, including a status value. These arguments can contain values or pointers to objects in the application program.

This chapter describes the communication process followed by client and server applications. This process reflects the sequence of system calls within the client and server programs (see Tables *Table 2.1, "TCP Server Tasks and Related Functions"* through *Table 2.4, "UDP Client Tasks and Related Functions"*). The chapter also includes Sockets API and OpenVMS system services examples for each step in the communication process.

2.1. The Client/Server Communication Process

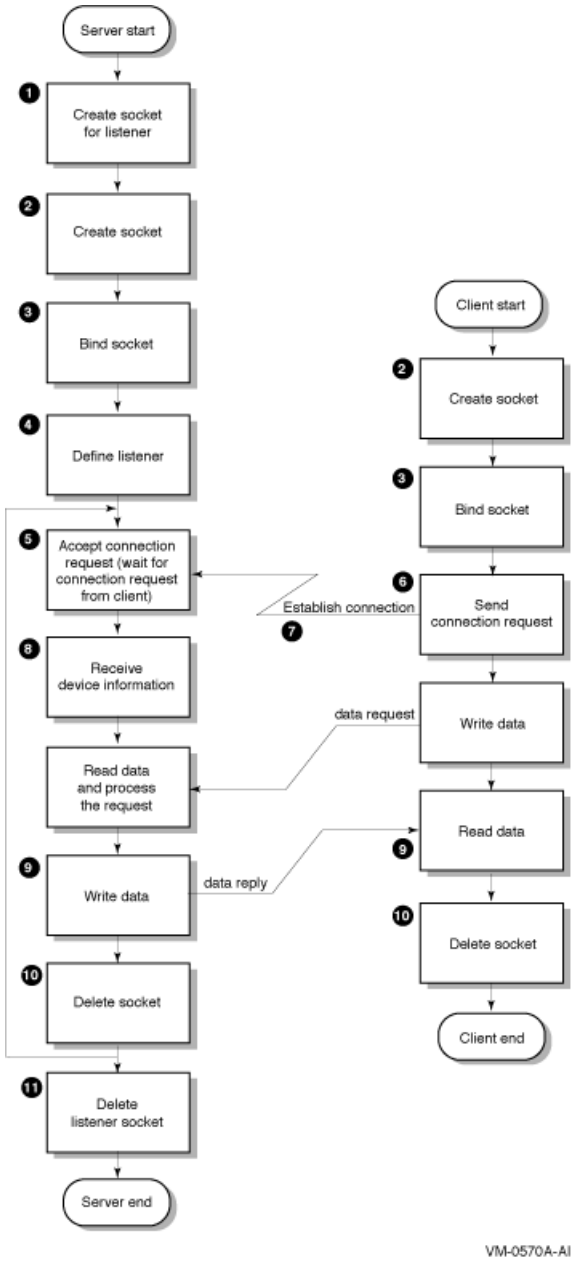
The most commonly used paradigm in constructing distributed applications is the client/server model. The requester, known as the client, sends a request to a server and waits for a response. The server is an application-level program that offers a service that can be reached over the network. Servers accept requests that arrive over the network, perform their service, and return the result to the client.

A network connection also has a mode of communication: either connection-oriented or connectionless. When writing network applications, the developer uses the mode of communication required by the application-level service. If the application-level service uses the connection-oriented mode of communication, the developer uses the Transmission Control Protocol (TCP). If the application-level service uses the connectionless mode of communication, then the developer uses the the User Datagram Protocol (UDP). The following sections describe how to use TCP and UDP.

2.1.1. Using the TCP Protocol

Figure 2.1, "Client/Server Communication Process Using TCP" shows the communication process for a TCP client/server application.

Figure 2.1. Client/Server Communication Process Using TCP



In this figure:

1. Server issues a call to create a listening socket.
2. Server and client create a socket.
3. Server and client bind socket. (This step is optional for a client.)
4. Server converts an unconnected socket into a passive socket (LISTEN state).
5. Server issues an `accept()` and process blocks waiting for a connection request.
6. Client sends a connection request.
7. Server accepts the connection; a new socket is created for communication with this client.

8. Server receives device information from the local host.

9. Data exchange takes place.

10. Client and server delete the socket.

11. Server deletes the listener socket when the service to the client is terminated.

For server applications that use the TCP protocol, *Table 2.1, "TCP Server Tasks and Related Functions"* identifies the typical communication tasks, the applicable Sockets API function, and the equivalent OpenVMS system service.

Table 2.1. TCP Server Tasks and Related Functions

Task	Sockets API Function	OpenVMS System Services
Create a socket	`socket()`	$ASSIGN $QIO(IO$_SETMODE)[1]
Bind socket name	`bind()`	$QIO(IO$_SETMODE)[1]
Define listener socket	`listen()`	$QIO(IO$_SETMODE)[1]
Accept connection request	`accept()`	$QIO(IO$_ACCESS|IO $M_ACCEPT)

Exchange data	`read()`
	`recv()`
	`recvmsg()`
		$QIO(IO$_READVBLK)

	`write()`
	`send()`
	`sendmsg()`
		$QIO(IO$_WRITEVBLK)

Shut down the socket (optional)	`shutdown()`	$QIO(IO$_DEACCESS|IO $M_SHUTDOWN)
Close and delete the socket	`close()`	$QIO(IO$_DEACCESS) $DASSGN

[1]The $QIO system service calls for creating a socket, binding a socket name, and defining a network pseudo device as a listener are listed as three separate calls in this table. You can perform all three steps with one $QIO(IO$_SETMODE) call.

For a client application using the TCP protocol, *Table 2.2, "TCP Client Tasks and Related Functions"* shows the tasks in the communication process, the applicable Sockets API functions, and the equivalent OpenVMS system services.

Table 2.2. TCP Client Tasks and Related Functions

Task	Sockets API Function	OpenVMS System Services
Create a socket	socket()	$ASSIGN $QIO(IO$_SETMODE)[1]
Bind socket name	`bind()`	$QIO(IO$_SETMODE)[1]

Task	Sockets API Function	OpenVMS System Services
Connect to server	`connect()`	$QIO(IO$_ACCESS)

Exchange data	`read()`
	`recv()`
	`recvmsg()`
		$QIO(IO$_READVBLK)

	`write()`
	`send()`
	`sendmsg()`
		$QIO(IO$_WRITEVBLK)

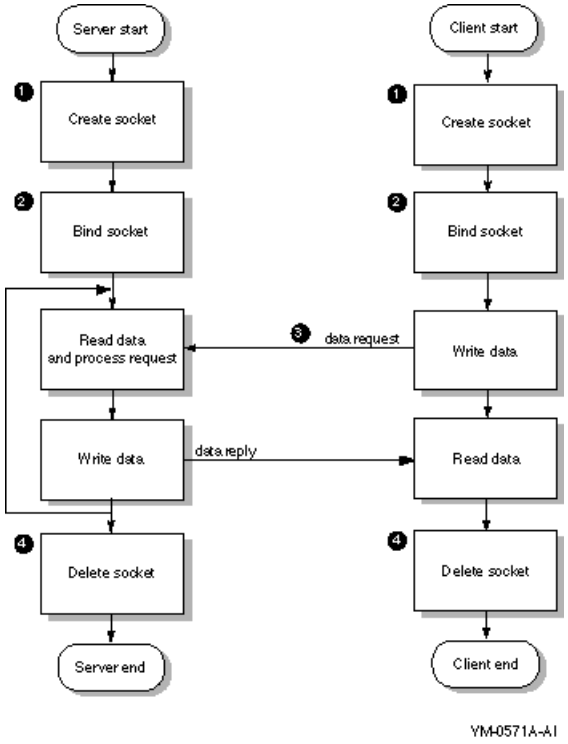
Shut down the socket (optional)	`shutdown()`	$QIO(IO$_DEACCESS|IO $M_SHUTDOWN)
Close and delete the socket	`close()`	$QIO(IO$_DEACCESS) $DASSGN

[1]The $QIO system service calls for creating a socket and binding a socket name are listed as two separate calls in this table. You can perform both steps with one $QIO(IO$_SETMODE) call.

2.1.2. Using the UDP Protocol

Figure 2.2, "UDP Socket Communication Process" shows the steps in the communication process for a client/server application using the UDP protocol.

Figure 2.2. UDP Socket Communication Process



In this figure:

1. Server and client create a socket.

2. Server and client bind the socket name. (This step is optional for a client.)

3. Data exchange takes place.

4. Server and client delete the socket.

For server applications using the UDP protocol, *Table 2.3, "UDP Server Tasks and Related Functions"* identifies the tasks in the communication process, the Sockets API functions, and the equivalent OpenVMS system services.

Table 2.3. UDP Server Tasks and Related Functions

Task	Sockets API Function	OpenVMS System Service
Create a socket	`socket()`	$ASSIGN $QIO(IO$_SETMODE)[1]
Bind socket name	`bind()`	$QIO(IO$_SETMODE)[1]

Exchange data	`read()`
	`recv()`
	`recvfrom()`
	`recvmsg()`
		$QIO(IO$_READVBLK)

	`write()`
	`send()`
	`sendto()`
	`sendmsg()`
		$QIO(IO$_WRITEVBLK)

Shut down the socket (optional)	`shutdown()`	$QIO(IO$_DEACCESS|IO $M_SHUTDOWN)
Close and delete the socket	`close()`	$QIO(IO$_DEACCESS) $DASSGN

[1]The $QIO system service calls for creating a socket and binding a socket name are listed as two separate calls in this table. You can perform both steps with one $QIO(IO$_SETMODE) call.

For client applications using the UDP protocol, *Table 2.4, "UDP Client Tasks and Related Functions"* describes the tasks in the communication process, the Sockets API function, and the equivalent OpenVMS system service.

Table 2.4. UDP Client Tasks and Related Functions

Task	Sockets API Function	OpenVMS System Service
Create a socket	`socket()`	$ASSIGN $QIO(IO$_SETMODE)[1]
Bind socket name (optional)	`bind()`	$QIO(IO$_SETMODE)[1]
Specify a destination address for outgoing datagrams	`connect()`	$QIO(IO$_ACCESS)

Task	Sockets API Function	OpenVMS System Service

Exchange data	`read()`
	`recv()`
	`recvfrom()`
	`recvmsg()`
		$QIO(IO$_READVBLK)

	`write()`
	`send()`
	`sendto()`
	`sendmsg()`
		$QIO(IO$_WRITEVBLK)

Shut down the socket (optional)	`shutdown()`	$QIO(IO$_DEACCESS| keep>(IO$M_SHUTDOWN))
Close and delete the socket	`close()`	$QIO(IO$_DEACCESS) $DASSGN

[1]The $QIO system service calls for creating a socket and binding a socket name are listed as two separate calls in this table. You can perform both of these steps with one $QIO(IO$_SETMODE) call.

2.2. Creating a Socket

For network communication to take place between two processes, each process requires an end point to establish a communication link between the two processes. This end point, called a **socket**, sends messages to and receives messages from the socket associated with the process at the other end of the communication link.

Sockets are created by issuing a call to the `socket()` Sockets API function or by the $ASSIGN and $QIO (IO$_SETMODE) system service, specifying an address family, a protocol family, and a socket type.

If the socket creation is successful, the operation returns a small positive integer value called a **socket descriptor**, or **sockfd**. From this point on, the application program uses the socket descriptor to reference the newly created socket.

In the TCP/IP Services implementation, this socket is also referred to as a **device socket**. A device socket is the pairing of an OpenVMS network device and a BSD-style socket. A device socket is either implicitly created by the Sockets API, or explicitly created using OpenVMS system services. The `socket()` function calls the $QIO system services to create the socket.

For information about creating a socket using the Sockets API, see *Section 2.2.1, "Creating Sockets (Sockets API)"*. For information about explicitly creating a device socket, see *Section 2.2.2, "Creating Sockets (System Services)"*.

To display information about a device socket, use the TCP/IP management command SHOW DEVICE_SOCKET.

TCP/IP operations are performed as I/O functions of the network device. The logical name for the network device is TCPIP$DEVICE.

2.2.1. Creating Sockets (Sockets API)

When using the Sockets API, create the socket with a call to the `socket()` function. *Example 2.1, "Creating a Socket (Sockets API)"* shows how to create a TCP socket using the Sockets API.

Example 2.1. Creating a Socket (Sockets API)

```
#include <socket.h>              /* define BSD socket api                */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */

int main( void )
{
    int sockfd;

    /*
     * create a socket
     */
❶
    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to use the `socket()` function to create a socket.

❶ This line creates the socket with the following arguments:

- `AF_INET` specifies the IPv4 address family.
- `SOCK_STREAM` specifies that the socket type is stream (TCP).
- `0` specifies that the protocol type is IPPROTO_TCP (default).

2.2.2. Creating Sockets (System Services)

When you use OpenVMS system services, you make two calls to create the socket:

- $ASSIGN to assign a channel to the network device
- $QIO or $QIOW to create the socket

  The Queue I/O Request ($QIO) service completes asynchronously. It returns to the caller immediately after queuing the I/O request, without waiting for the I/O operation to complete.

  For synchronous completion, use the Queue I/O Request and Wait ($QIOW) service. The $QIOW service is identical to the $QIO service, except the $QIOW returns to the caller after the I/O operation completes.

When you make the $QIO or $QIOW call, use either the IO$_SETMODE or the IO$_SETCHAR I/O service. You generally create, bind, and set up sockets to listen with one $QIO call. For network software, the IO$_SETMODE and IO$_SETCHAR services perform in an identical manner. However, you must have LOG_IO privilege to successfully use the IO$_SETMODE I/O service modifier.

When a channel is assigned to the TCPIP$DEVICE template network device, TCP/IP Services creates a new pseudodevice with a unique unit number and returns a channel number to use in subsequent operation requests with that device.

When the auxiliary server creates your application server process in response to incoming network traffic for a service with the `LISTEN` flag, it creates a device socket for your application server process. For your application to receive the device socket, assign a channel to SYS$NET (the logical name of a network pseudodevice) and perform an appropriate $QIO(IO$_SETMODE) function. For a discussion of the auxiliary server, see the *VSI TCP/IP Services for OpenVMS Management* manual.

Example 2.2, "Creating a Socket (System Services)" shows how to create a TCP socket using OpenVMS system services.

Example 2.2. Creating a Socket (System Services)

```
#include <descrip.h>              /* define OpenVMS descriptors           */
#include <efndef.h>               /* define 'EFN$C_ENF' event flag        */
#include <iodef.h>                /* define i/o function codes            */
#include <ssdef.h>                /* define system service status codes   */
#include <starlet.h>              /* define system service calls          */
#include <stdio.h>                /* define standard i/o functions        */
#include <stdlib.h>               /* define standard library functions    */
#include <stsdef.h>               /* define condition value fields        */
#include <tcpip$inetdef.h>        /* define tcp/ip network constants,     */
                                  /* structures, and functions            */


struct iosb
    {                              /* i/o status block                    */
    unsigned short status;         /* i/o completion status               */
    unsigned short bytcnt;         /* bytes transferred if read/write     */
    void *details;                 /* address of buffer or parameter      */
    };

struct sockchar
    {                              /* socket characteristics              */
    unsigned short prot;           /* protocol                            */
    unsigned char type;            /* type                                */
    unsigned char af;              /* address format                      */
    };


int main( void )
{
    struct iosb iosb;              /* i/o status block                    */
    unsigned int status;           /* system service return status        */
    unsigned short channel;        /* network device i/o channel          */
❶   struct sockchar sockchar;      /* socket characteristics buffer      */
    $DESCRIPTOR( inet_device,      /* string descriptor with logical      */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice      */

    /*
     * initialize socket characteristics
     */
❷
    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;
```

```
    /*
     * assign i/o channel to network device
     */
❸
    status = sys$assign( &inet_device,   /* device name                  */
                         &channel,       /* i/o channel                 */
                         0,              /* access mode                 */
                         0               /* not used                    */
                       );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel\n" );
        exit( status );
        }

    /*
     * create a socket
     */
❹
    status = sys$qiow( EFN$C_ENF,        /* event flag                  */
                       channel,          /* i/o channel                 */
                       IO$_SETMODE,      /* i/o function code           */
                       &iosb,            /* i/o status block            */
                       0,                /* ast service routine         */
                       0,                /* ast parameter               */
                       &sockchar,        /* p1 - socket characteristics */
                       0,                /* p2                          */
                       0,                /* p3                          */
                       0,                /* p4                          */
                       0,                /* p5                          */
                       0                 /* p6                          */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to create socket\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to use the $ASSIGN and $QIOW system services to:

❶ Define a `sockchar` structure to contain the characteristics of the type of socket.

❷ Initialize the `sockchar` structure with the address family, protocol family and type of socket.

❸ Assign a channel to a network device using a string descriptor with the logical name of the network pseudodevice and a structure to receive the I/O channel.

❹ Create the socket with a call to SYS$QIOW specifying the IO$_SETMODE modifier to supply the channel and the socket characteristics.

2.3. Binding a Socket (Optional for Clients)

Binding a socket associates an IP address (that is, a 32-bit IPv4 address and a 16-bit TCP or UDP port number) with a socket. To bind a socket, specify an IP address and a port number for the socket.

With the TCP protocol, you can specify an IP address, a port number, both an IP address and port number, or neither.

If the application is using the UDP protocol and needs to receive incoming multicast or broadcast datagrams destined for a specific UDP port, see *Section 2.10, "Receiving IP Multicast Datagrams"* for information about specifying the SO_REUSEPORT option when binding the socket.

For an example of binding a socket using the Sockets API, see *Section 2.3.1, "Binding a Socket (Sockets API)"*. For an example of binding a socket using the OpenVMS system services, see *Section 2.3.2, "Binding a Socket (System Services)"*.

2.3.1. Binding a Socket (Sockets API)

Example 2.3, "Binding a Socket (Sockets API)" shows an example of a TCP application using the `bind()` function to bind a structure.

Note

The process must have SYSPRV, BYPASS, or OPER privilege to bind port numbers 1 to 1023.

Example 2.3. Binding a Socket (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define PORTNUM     12345           /* server port number               */


int main( void )
{
    int sockfd;
    struct sockaddr_in addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family      = AF_INET;
    addr.sin_port        = htons( PORTNUM );
    addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a socket
     */
```

```
    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * bind ip address and port number to socket
     */

    if ( bind(sockfd,❶ (struct sockaddr *) &addr,❷ sizeof(addr)❸) < 0 )
        {
        perror( "Failed to bind socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

In this example, the `bind()` function includes the following arguments:

❶ `sockfd` specifies the socket descriptor previously created with a call to the `socket()` function.

❷ `addr` specifies the address of the `sockaddr_in` structure that assigns a name to the socket.

❸ `sizeof(addr)` specifies the size of the `sockaddr_in` structure.

2.3.2. Binding a Socket (System Services)

Use the IO$_SETMODE or IO$_SETCHAR service of the $QIO system service to bind a socket.

Note

The process must have SYSPRV, BYPASS, or OPER privileges to bind port numbers 1 to 1023.

Example 2.4, "Binding a Socket (System Services)" shows how to bind a sockets using OpenVMS system services.

Example 2.4. Binding a Socket (System Services)

```
#include <descrip.h>              /* define OpenVMS descriptors           */
#include <efndef.h>               /* define 'EFN$C_ENF' event flag        */
#include <in.h>                   /* define internet related constants,   */
                                  /* functions, and structures            */
#include <iodef.h>                /* define i/o function codes            */
#include <ssdef.h>                /* define system service status codes   */
#include <starlet.h>              /* define system service calls          */
#include <stdio.h>                /* define standard i/o functions        */
#include <stdlib.h>               /* define standard library functions    */
#include <string.h>               /* define string handling functions     */
#include <stsdef.h>               /* define condition value fields        */
#include <tcpip$inetdef.h>        /* define tcp/ip network constants,     */
                                  /* structures, and functions            */


#define PORTNUM     12345            /* server port number               */

struct iosb
```

```
    {                                   /* i/o status block                 */
    unsigned short status;              /* i/o completion status            */
    unsigned short bytcnt;              /* bytes transferred if read/write  */
    void *details;                      /* address of buffer or parameter   */
    };

struct itemlst_2
    {                                   /* item-list 2 descriptor/element   */
    unsigned short length;              /* length                           */
    unsigned short type;                /* parameter type                   */
    void *address;                      /* address of item list             */
    };

struct sockchar
    {                                   /* socket characteristics           */
    unsigned short prot;                /* protocol                         */
    unsigned char type;                 /* type                             */
    unsigned char af;                   /* address format                   */
    };


int main( void )
{
    struct iosb iosb;                   /* i/o status block                 */
    unsigned int status;                /* system service return status     */
    unsigned short channel;             /* network device i/o channel       */
    struct sockchar sockchar;           /* socket characteristics buffer    */
    struct sockaddr_in addr;            /* socket address structure         */
    struct itemlst_2 addr_itemlst;      /* socket address item-list         */
    $DESCRIPTOR( inet_device,           /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );     /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;

    /*
     * initialize socket address item-list descriptor
     */

    addr_itemlst.length  = sizeof( addr );
    addr_itemlst.type    = TCPIP$C_SOCK_NAME;
    addr_itemlst.address = &addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family      = TCPIP$C_AF_INET;
    addr.sin_port        = htons( PORTNUM );
    addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;

    /*
```

```
     * assign i/o channel to network device
     */
❶
    status = sys$assign( &inet_device,    /* device name                  */
                         &channel,        /* i/o channel                  */
                         0,               /* access mode                  */
                         0                /* not used                     */
                       );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel\n" );
        exit( status );
        }

    /*
     * create a socket
     */
❷
    status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                       channel,           /* i/o channel                  */
                       IO$_SETMODE,       /* i/o function code            */
                       &iosb,             /* i/o status block             */
                       0,                 /* ast service routine          */
                       0,                 /* ast parameter                */
                       &sockchar,         /* p1 - socket characteristics  */
                       0,                 /* p2                           */
                       0,                 /* p3                           */
                       0,                 /* p4                           */
                       0,                 /* p5                           */
                       0                  /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to create socket\n" );
        exit( status );
        }

    /*
     * bind ip address and port number to socket
     */
❸
    status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                       channel,           /* i/o channel                  */
                       IO$_SETMODE,       /* i/o function code            */
                       &iosb,             /* i/o status block             */
                       0,                 /* ast service routine          */
                       0,                 /* ast parameter                */
                       0,                 /* p1                           */
                       0,                 /* p2                           */
                       &addr_itemlst,     /* p3 - local socket name       */
                       0,                 /* p4                           */
                       0,                 /* p5                           */
                       0                  /* p6                           */
```

```
                    );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to bind socket\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to use OpenVMS system services to:

❶ Assign a network device.

❷ Bind a socket. The **p1** argument specifies the socket characteristics.

❸ Bind the IP address and the port number to the socket. The **p3** argument specifies the socket name.

2.4. Making a Socket a Listener (TCP Protocol)

Only server programs that use the TCP protocol need to set a socket to be a listener. This allows the program to receive incoming connection requests. As a connection-oriented protocol, TCP requires a connection; UDP, a connectionless protocol, does not.

The `listen()` function:

- Converts the unconnected socket into a passive socket.
- Changes the state of the socket to LISTEN.
- Remains open for the life of the server.
- Tells the kernel to accept incoming connections directed to this socket.

2.4.1. Setting a Socket to Listen (Sockets API)

Example 2.5, "Setting a Socket to Listen (Sockets API)" shows how a TCP server uses the `listen()` function to set a socket to listen for connection requests and to specify the number of incoming requests that can wait to be queued for processing.

Example 2.5. Setting a Socket to Listen (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define BACKLOG     1               /* server backlog                   */
#define PORTNUM     12345           /* server port number               */
```

```
int main( void )
{
    int sockfd;
    struct sockaddr_in addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family      = AF_INET;
    addr.sin_port        = htons( PORTNUM );
    addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a socket
     */

    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * bind ip address and port number to socket
     */

    if ( bind(sockfd, (struct sockaddr *) &addr, sizeof(addr)) < 0 )
        {
        perror( "Failed to bind socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * set socket as a listen socket
     */
    if ( listen(sockfd, ❶ BACKLOG ❷ ) < 0 )
        {
        perror( "Failed to set socket passive" );
        exit( EXIT_FAILURE );
        }
    exit( EXIT_SUCCESS );
}
```

In this example of a `listen()` function:

❶ `sockfd` is the socket descriptor previously defined by a call to the `socket()` function.

❷ `BACKLOG` specifies that only one pending connection can be queued at any given time. The maximum number of connections is specified by the system configuration variable `somaxconn`. The default value for `somaxconn` is 1024. Refer to the *VSI TCP/IP Services for OpenVMS Tuning and Troubleshooting* manual for how to display and change the `somaxconn` value dynamically.

2.4.2. Setting a Socket to Listen (System Services)

Example 2.6, "Setting a Socket to Listen (System Services)" shows how to use the IO$_SETMODE service to set the socket to listen for connection requests.

Example 2.6. Setting a Socket to Listen (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors           */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag        */
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <iodef.h>              /* define i/o function codes            */
#include <ssdef.h>              /* define system service status codes   */
#include <starlet.h>            /* define system service calls          */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */
#include <stsdef.h>             /* define condition value fields        */
#include <tcpip$inetdef.h>      /* define tcp/ip network constants,     */
                                /* structures, and functions            */


#define BACKLOG     1               /* server backlog                   */
#define PORTNUM     12345           /* server port number               */

struct iosb
    {                               /* i/o status block                 */
    unsigned short status;          /* i/o completion status            */
    unsigned short bytcnt;          /* bytes transferred if read/write  */
    void *details;                  /* address of buffer or parameter   */
    };

struct itemlst_2
    {                               /* item-list 2 descriptor/element   */
    unsigned short length;          /* length                           */
    unsigned short type;            /* parameter type                   */
    void *address;                  /* address of item list             */
    };

struct sockchar
    {                               /* socket characteristics           */
    unsigned short prot;            /* protocol                         */
    unsigned char type;             /* type                             */
    unsigned char af;               /* address format                   */
    };


int main( void )
{
    struct iosb iosb;               /* i/o status block                 */
    unsigned int status;            /* system service return status     */
    unsigned short channel;         /* network device i/o channel       */
    struct sockchar sockchar;       /* socket characteristics buffer    */
    struct sockaddr_in addr;        /* socket address structure         */
    struct itemlst_2 addr_itemlst;  /* socket address item-list         */
    $DESCRIPTOR( inet_device,       /* string descriptor with logical   */
                 "TCPIP$DEVICE:" ); /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
```

```
 */

sockchar.prot = TCPIP$C_TCP;
sockchar.type = TCPIP$C_STREAM;
sockchar.af   = TCPIP$C_AF_INET;

/*
 * initialize socket address item-list descriptor
 */

addr_itemlst.length  = sizeof( addr );
addr_itemlst.type    = TCPIP$C_SOCK_NAME;
addr_itemlst.address = &addr;

/*
 * initialize socket address structure
 */

memset( &addr, 0, sizeof(addr) );
addr.sin_family      = TCPIP$C_AF_INET;
addr.sin_port        = htons( PORTNUM );
addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;

/*
 * assign i/o channel to network device
 */

status = sys$assign( &inet_device,   /* device name                */
                     &channel,       /* i/o channel                */
                     0,              /* access mode                */
                     0               /* not used                   */
                   );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel\n" );
    exit( status );
    }

/*
 * create a socket
 */
❶

status = sys$qiow( EFN$C_ENF,        /* event flag                 */
                   channel,          /* i/o channel                */
                   IO$_SETMODE,      /* i/o function code          */
                   &iosb,            /* i/o status block           */
                   0,                /* ast service routine        */
                   0,                /* ast parameter              */
                   &sockchar,        /* p1 - socket characteristics */
                   0,                /* p2                         */
                   0,                /* p3                         */
                   0,                /* p4                         */
                   0,                /* p5                         */
                   0                 /* p6                         */
                 );

if ( status & STS$M_SUCCESS )
```

```
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to create socket\n" );
        exit( status );
        }
    /*
     * bind ip address and port number to socket
     */
❷
    status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                       channel,          /* i/o channel                  */
                       IO$_SETMODE,      /* i/o function code            */
                       &iosb,            /* i/o status block             */
                       0,                /* ast service routine          */
                       0,                /* ast parameter                */
                       0,                /* p1                           */
                       0,                /* p2                           */
                       &addr_itemlst,    /* p3 - local socket name       */
                       0,                /* p4                           */
                       0,                /* p5                           */
                       0                 /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to bind socket\n" );
        exit( status );
        }
❸
    /*
     * set socket as a listen socket
     */

    status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                       channel,          /* i/o channel                  */
                       IO$_SETMODE,      /* i/o function code            */
                       &iosb,            /* i/o status block             */
                       0,                /* ast service routine          */
                       0,                /* ast parameter                */
                       0,                /* p1                           */
                       0,                /* p2                           */
                       0,                /* p3                           */
                       BACKLOG,          /* p4 - connection backlog      */
                       0,                /* p5                           */
                       0                 /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to set socket passive\n" );
```

```
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to use three separate $QIO calls with the IO$_SETMODE service to:

❶ Create a socket, by specifying parameter **p1**.

❷ Bind a socket, by specifying parameter **p3**.

❸ Set the socket to passive (set listen on the socket) by specifying a value for parameter **p4**.

Alternatively, you can perform all three operations with one $QIO call.

2.5. Initiating a Connection (TCP Protocol)

A TCP client establishes a connection with a TCP server by issuing the `connect()` function. The `connect()` function initiates a three-way handshake between the client and the server.

2.5.1. Initiating a Connection (Sockets API)

To initiate a connection to a TCP server, use the `connect()` function. *Example 2.7, "Initiating a Connection (Sockets API)"* shows a TCP client the `connect()` function to initiate a connection to a TCP server.

Example 2.7. Initiating a Connection (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <netdb.h>              /* define network database library info */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define BUFSZ       1024            /* user input buffer size           */
#define PORTNUM     12345           /* server port number               */


void get_servaddr( void *addrptr )
{
    char buf[BUFSIZ];
    struct in_addr val;
    struct hostent *host;

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read user input\n" );
            exit( EXIT_FAILURE );
            }
```

```
        buf[strlen(buf)-1] = 0;

        val.s_addr = inet_addr( buf );

        if ( val.s_addr != INADDR_NONE )
            {
            memcpy( addrptr, &val, sizeof(struct in_addr) );
            break;
            }

        if ( (host = gethostbyname(buf)) )
            {
            memcpy( addrptr, host->h_addr, sizeof(struct in_addr) );
            break;
            }
        }
}


int main( void )
{
    int sockfd;
    struct sockaddr_in addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family = AF_INET;
    addr.sin_port   = htons( PORTNUM );
    get_servaddr( &addr.sin_addr );

    /*
     * create a socket
     */
❶
    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * connect to specified host and port number
     */

    printf( "Initiated connection to host: %s, port: %d\n",
            inet_ntoa(addr.sin_addr), ntohs(addr.sin_port)
          );
❷
    if ( connect(sockfd, (struct sockaddr *) &addr, sizeof(addr)) < 0 )
        {
        perror( "Failed to connect to server" );
        exit( EXIT_FAILURE );
        }
```

```
    exit( EXIT_SUCCESS );
}
```

This example shows how to:

❶ Create a socket of type SOCK_STREAM.

❷ Initiate a connection on the socket.

2.5.2. Initiating a Connection (System Services)

To initiate a connection to a TCP server, use the $QIO system service with the IO$_ACCESS service and the **p3** argument. The **p3** argument of the IO$_ACCESS service is the address of an item_list_2 descriptor that points to the remote socket name.

Example 2.8, "Initiating a Connection (System Services)" shows a TCP client using the IO_$ACCESS service to initiate a connection.

Example 2.8. Initiating a Connection (System Services)

```
#include <descrip.h>              /* define OpenVMS descriptors           */
#include <efndef.h>               /* define 'EFN$C_ENF' event flag        */
#include <in.h>                   /* define internet related constants,   */
                                  /* functions, and structures            */
#include <inet.h>                 /* define network address info          */
#include <iodef.h>                /* define i/o function codes            */
#include <netdb.h>                /* define network database library info */
#include <ssdef.h>                /* define system service status codes   */
#include <starlet.h>              /* define system service calls          */
#include <stdio.h>                /* define standard i/o functions        */
#include <stdlib.h>               /* define standard library functions    */
#include <string.h>               /* define string handling functions     */
#include <stsdef.h>               /* define condition value fields        */
#include <tcpip$inetdef.h>        /* define tcp/ip network constants,     */

                                  /* structures, and functions            */

#define BUFSZ       1024              /* user input buffer size           */
#define PORTNUM     12345             /* server port number               */


struct iosb
    {                                 /* i/o status block                 */
    unsigned short status;            /* i/o completion status            */
    unsigned short bytcnt;            /* bytes transferred if read/write  */
    void *details;                    /* address of buffer or parameter   */
    };

struct itemlst_2
    {                                 /* item-list 2 descriptor/element   */
    unsigned short length;            /* length                           */
    unsigned short type;              /* parameter type                   */
    void *address;                    /* address of item list             */
    };

struct sockchar
    {                                 /* socket characteristics           */
    unsigned short prot;              /* protocol                         */
```

```
    unsigned char type;              /* type                              */
    unsigned char af;                /* address format                    */
    };


void get_servaddr( void *addrptr )
{
    char buf[BUFSIZ];
    struct in_addr val;
    struct hostent *host;

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read user input\n" );
            exit( EXIT_FAILURE );
            }

        buf[strlen(buf)-1] = 0;

        val.s_addr = inet_addr( buf );

        if ( val.s_addr != INADDR_NONE )
            {
            memcpy( addrptr, &val, sizeof(struct in_addr) );
            break;
            }

        if ( (host = gethostbyname(buf)) )
            {
            memcpy( addrptr, host->h_addr, sizeof(struct in_addr) );
            break;
            }
        }
}


int main( void )
{
    struct iosb iosb;                /* i/o status block                  */
    unsigned int status;             /* system service return status      */
    unsigned short channel;          /* network device i/o channel        */
    struct sockchar sockchar;        /* socket characteristics buffer     */
    struct sockaddr_in addr;         /* socket address structure          */
    struct itemlst_2 addr_itemlst;   /* socket address item-list          */
    $DESCRIPTOR( inet_device,        /* string descriptor with logical    */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice      */

    /*
     * initialize socket characteristics
     */

    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;
```

```
/*
 * initialize socket address item-list descriptor
 */

addr_itemlst.length  = sizeof( addr );
addr_itemlst.type    = TCPIP$C_SOCK_NAME;
addr_itemlst.address = &addr;

/*
 * initialize socket address structure
 */

memset( &addr, 0, sizeof(addr) );
addr.sin_family = TCPIP$C_AF_INET;
addr.sin_port   = htons( PORTNUM );
get_servaddr( &addr.sin_addr );

/*
 * assign i/o channel to network device
 */

status = sys$assign( &inet_device,   /* device name                  */
                     &channel,       /* i/o channel                  */
                     0,              /* access mode                  */
                     0               /* not used                     */
                   );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel\n" );
    exit( status );
    }
/*
 * create a socket
 */
❶

status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                   channel,          /* i/o channel                  */
                   IO$_SETMODE,      /* i/o function code            */
                   &iosb,            /* i/o status block             */
                   0,                /* ast service routine          */
                   0,                /* ast parameter                */
                   &sockchar,        /* p1 - socket characteristics  */
                   0,                /* p2                           */
                   0,                /* p3                           */
                   0,                /* p4                           */
                   0,                /* p5                           */
                   0                 /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
```

```
        }

    /*
     * connect to specified host and port number
     */
❷
    printf( "Initiated connection to host: %s, port: %d\n",
            inet_ntoa(addr.sin_addr), ntohs(addr.sin_port)
          );

    status = sys$qiow( EFN$C_ENF,         /* event flag                    */
                       channel,           /* i/o channel                   */
                       IO$_ACCESS,        /* i/o function code             */
                       &iosb,             /* i/o status block              */
                       0,                 /* ast service routine           */
                       0,                 /* ast parameter                 */
                       0,                 /* p1                            */
                       0,                 /* p2                            */
                       &addr_itemlst,     /* p3 - remote socket name       */
                       0,                 /* p4                            */
                       0,                 /* p5                            */
                       0                  /* p6                            */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to connect to server\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to:

❶ Create a socket using the IO$_SETMODE service.

❷ Initiate a connection using the IO$_ACCESS service.

2.6. Accepting a Connection (TCP Protocol)

A TCP server program must be able to accept incoming connection requests from client programs. The `accept()` function:

- Returns the next completed connection from the completed connection queue.
- Returns a new socket descriptor that is connected with the client, called the **connected socket**. There is one connected socket for each client connected to the server. The connected socket remains until the server is finished serving the client.

2.6.1. Accepting a Connection (Sockets API)

Example 2.9, "Accepting a Connection (Sockets API)" shows how to use the `accept()` function.

Example 2.9. Accepting a Connection (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <netdb.h>              /* define network database library info */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define SERV_BACKLOG    1           /* server backlog                   */
#define SERV_PORTNUM    12345       /* server port number               */


int main( void )
{
    int conn_sockfd;                /* connection socket descriptor     */
    int listen_sockfd;              /* listen socket descriptor         */

    unsigned int cli_addrlen;       /* returned length of client socket */
                                    /* address structure                */
    struct sockaddr_in cli_addr;    /* client socket address structure  */
    struct sockaddr_in serv_addr;   /* server socket address structure  */

    /*
     * initialize client's socket address structure
     */

    memset( &cli_addr, 0, sizeof(cli_addr) );

    /*
     * initialize server's socket address structure
     */

    memset( &serv_addr, 0, sizeof(serv_addr) );
    serv_addr.sin_family      = AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a listen socket
     */

    if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * bind server's ip address and port number to listen socket
     */

    if ( bind(listen_sockfd,
              (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
        {
```

```
        perror( "Failed to bind socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * set socket as a listen socket
     */

    if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
        {
        perror( "Failed to set socket passive" );
        exit( EXIT_FAILURE );
        }

    /*
     * accept connection from a client
     */

    printf( "Waiting for a client connection on port: %d\n",
            ntohs(serv_addr.sin_port)
          );

    cli_addrlen = sizeof(cli_addr);

    conn_sockfd = accept( listen_sockfd,     ❶
                          (struct sockaddr *) &cli_addr, ❷
                          &cli_addrlen       ❸
                        );
    if ( conn_sockfd < 0 )
        {
        perror( "Failed to accept client connection" );
        exit( EXIT_FAILURE );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    exit( EXIT_SUCCESS );
}
```

In this example of an `accept()` function:

❶ `listen_sockfd` is the socket descriptor returned by the previous call to the `socket()` function. This socket is bound to an address with the `bind()` function. The `listen()` function changes the socket state from CLOSED to LISTEN (converts the unconnected socket to a passive socket).

❷ `cli_addr` receives the protocol address of the client.

❸ `cli_addrlen` is a value/result parameter that initially contains the size of the `cli_addr` structure. On return of the `accept()` function, the `cli_addr` structure contains the actual length, in bytes, of the socket address structure returned by the kernel for the connected socket.

2.6.2. Accepting a Connection (System Services)

To accept a connection request:

1. Use the $ASSIGN system service to create a channel for the new connection.
2. Use the $QIO system service using the IO$_ACCESS service with the IO$M_ACCEPT modifier.

   The **p4** argument specifies the address of a word written with the channel number of the new connection. If **p3** specifies a valid output buffer, the $QIO service returns the remote socket name.

Note

Specifying the IO$_ACCESS service is mandatory for TCP/IP. The IO$_ACCESS service uses the **p4** argument only with the IO$M_ACCEPT modifier.

Example 2.10, "Accepting a Connection (System Services)" shows a TCP server using the IO$_ACCESS service with the IO$M_ACCEPT modifier to accept incoming connection requests.

Example 2.10. Accepting a Connection (System Services)

```
#include <descrip.h>             /* define OpenVMS descriptors           */
#include <efndef.h>              /* define 'EFN$C_ENF' event flag        */
#include <in.h>                  /* define internet related constants,   */
                                 /* functions, and structures            */
#include <inet.h>                /* define network address info          */
#include <iodef.h>               /* define i/o function codes            */
#include <netdb.h>               /* define network database library info */
#include <ssdef.h>               /* define system service status codes   */
#include <starlet.h>             /* define system service calls          */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <string.h>              /* define string handling functions     */
#include <stsdef.h>              /* define condition value fields        */
#include <tcpip$inetdef.h>       /* define tcp/ip network constants,     */


                                 /* structures, and functions            */

#define SERV_BACKLOG    1            /* server backlog                   */
#define SERV_PORTNUM    12345        /* server port number               */

struct iosb
    {                                /* i/o status block                 */
    unsigned short status;           /* i/o completion status            */
    unsigned short bytcnt;           /* bytes transferred if read/write  */
    void *details;                   /* address of buffer or parameter   */
    };

struct itemlst_2
    {                                /* item-list 2 descriptor/element   */
    unsigned short length;           /* length                           */
    unsigned short type;             /* parameter type                   */
    void *address;                   /* address of item list             */
    };

struct itemlst_3
    {                                /* item-list 3 descriptor/element   */
    unsigned short length;           /* length                           */
    unsigned short type;             /* parameter type                   */
    void *address;                   /* address of item list             */
```

```
    unsigned int *retlen;            /* address of returned length       */
    };

struct sockchar
    {                                /* socket characteristics           */
    unsigned short prot;             /* protocol                         */
    unsigned char type;              /* type                             */
    unsigned char af;                /* address format                   */
    };


int main( void )
{
    struct iosb iosb;                /* i/o status block                 */
    unsigned int status;             /* system service return status     */

    unsigned short conn_channel;     /* connect inet device i/o channel  */

    unsigned short listen_channel;   /* listen inet device i/o channel   */
    struct sockchar listen_sockchar; /* listen socket characteristics    */

    unsigned int cli_addrlen;        /* returned length of client socket */
                                     /* address structure                */
    struct sockaddr_in cli_addr;     /* client socket address structure  */
    struct itemlst_3 cli_itemlst;    /* client socket address item-list  */

    struct sockaddr_in serv_addr;    /* server socket address structure  */
    struct itemlst_2 serv_itemlst;   /* server socket address item-list  */

    $DESCRIPTOR( inet_device,        /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    listen_sockchar.prot = TCPIP$C_TCP;
    listen_sockchar.type = TCPIP$C_STREAM;
    listen_sockchar.af   = TCPIP$C_AF_INET;

    /*
     * initialize client's item-list descriptor
     */

    memset( &cli_itemlst, 0, sizeof(cli_itemlst) );
    cli_itemlst.length  = sizeof( cli_addr );
    cli_itemlst.address = &cli_addr;
    cli_itemlst.retlen  = &cli_addrlen;

    /*
     * initialize client's socket address structure
     */

    memset( &cli_addr, 0, sizeof(cli_addr) );

    /*
     * initialize server's item-list descriptor
     */
```

```
    serv_itemlst.length  = sizeof( serv_addr );
    serv_itemlst.type    = TCPIP$C_SOCK_NAME;
    serv_itemlst.address = &serv_addr;

    /*
     * initialize server's socket address structure
     */

    memset( &serv_addr, 0, sizeof(serv_addr) );
    serv_addr.sin_family      = TCPIP$C_AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;

    /*
     * assign i/o channels to network device
     */

    status = sys$assign( &inet_device,   /* device name              */
                         &listen_channel, /* i/o channel             */
                         0,              /* access mode              */
                         0               /* not used                 */
                       );

    if ( status & STS$M_SUCCESS )
        status = sys$assign( &inet_device,  /* device name           */
                             &conn_channel, /* i/o channel          */
                             0,             /* access mode          */
                             0              /* not used             */
                           );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel(s)\n" );
        exit( status );
        }

    /*
     * create a listen socket
     */
❶
    status = sys$qiow( EFN$C_ENF,         /* event flag                    */
                       listen_channel,    /* i/o channel                   */
                       IO$_SETMODE,       /* i/o function code             */
                       &iosb,             /* i/o status block              */
                       0,                 /* ast service routine           */
                       0,                 /* ast parameter                 */
                       &listen_sockchar,  /* p1 - socket characteristics   */
                       0,                 /* p2                            */
                       0,                 /* p3                            */
                       0,                 /* p4                            */
                       0,                 /* p5                            */
                       0                  /* p6                            */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;
```

```
    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to create socket\n" );
        exit( status );
        }

    /*
     * bind server's ip address and port number to listen socket
     */
❷
    status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                       listen_channel,    /* i/o channel                  */
                       IO$_SETMODE,       /* i/o function code            */
                       &iosb,             /* i/o status block             */
                       0,                 /* ast service routine          */
                       0,                 /* ast parameter                */
                       0,                 /* p1                           */
                       0,                 /* p2                           */
                       &serv_itemlst,     /* p3 - local socket name       */
                       0,                 /* p4                           */
                       0,                 /* p5                           */
                       0                  /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to bind socket\n" );
        exit( status );
        }

    /*
     * set socket as a listen socket
     */
❸
    status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                       listen_channel,    /* i/o channel                  */
                       IO$_SETMODE,       /* i/o function code            */
                       &iosb,             /* i/o status block             */
                       0,                 /* ast service routine          */
                       0,                 /* ast parameter                */
                       0,                 /* p1                           */
                       0,                 /* p2                           */
                       0,                 /* p3                           */
                       SERV_BACKLOG,      /* p4 - connection backlog      */
                       0,                 /* p5                           */
                       0                  /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to set socket passive\n" );
        exit( status );
```

```
        }

    /*
     * accept connection from a client
     */

    printf( "Waiting for a client connection on port: %d\n",
            ntohs(serv_addr.sin_port)
          );
❹
    status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                       listen_channel,   /* i/o channel                  */
                       IO$_ACCESS|IO$M_ACCEPT,
                                         /* i/o function code            */
                       &iosb,            /* i/o status block             */
                       0,                /* ast service routine          */
                       0,                /* ast parameter                */
                       0,                /* p1                           */
                       0,                /* p2                           */
                       &cli_itemlst,     /* p3 - remote socket name      */
                       &conn_channel,    /* p4 - i/o channel for new     */
                                         /*      connection              */
                       0,                /* p5                           */
                       0                 /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to accept client connection\n" );
        exit( status );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    exit( EXIT_SUCCESS );
}
```

This example show how to:

❶ Create a socket using the IO$M_SETMODE service.

❷ Bind the socket using the IO$M_SETMODE service, specifying parameter **p3**.

❸ Set the socket to passive mode using the IO$M_SETMODE service, specifying parameter **p4**.

❹ Accept an incoming connection using the IO$_ACCESS|IO$_ACCEPT service.

2.7. Getting Socket Options

Obtaining socket information is useful if your program has management functions, or if you have a complex program that uses multiple connections you need to track.

2.7.1. Getting Socket Information (Sockets API)

You can use any of the following Sockets API functions to get socket information:

- `getpeername()`
- `getsockname()`
- `getsockopt()`

Example 2.11, "Getting Socket Information (Sockets API)" shows a TCP server using the `getpeername()` function to get the remote IP address and port number associated with a socket.

Example 2.11. Getting Socket Information (Sockets API)

```
#include <in.h>                  /* define internet related constants,   */
                                 /* functions, and structures            */
#include <inet.h>                /* define network address info          */
#include <netdb.h>               /* define network database library info */
#include <socket.h>              /* define BSD socket api                */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <string.h>              /* define string handling functions     */


#define SERV_BACKLOG    1            /* server backlog                   */
#define SERV_PORTNUM    12345        /* server port number               */


int main( void )
{
    int conn_sockfd;                 /* connection socket descriptor     */
    int listen_sockfd;               /* listen socket descriptor         */

    unsigned int cli_addrlen;        /* returned length of client socket */
                                     /* address structure                */
    struct sockaddr_in cli_addr;     /* client socket address structure  */
    struct sockaddr_in serv_addr;    /* server socket address structure  */

    /*
     * initialize server's socket address structure
     */

    memset( &serv_addr, 0, sizeof(serv_addr) );
    serv_addr.sin_family      = AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a listen socket
     */

    if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }
    /*
```

```
     * bind server's ip address and port number to listen socket
     */

    if ( bind(listen_sockfd,
              (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
        {
        perror( "Failed to bind socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * set socket as a listen socket
     */

    if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
        {
        perror( "Failed to set socket passive" );
        exit( EXIT_FAILURE );
        }

    /*
     * accept connection from a client
     */

    printf( "Waiting for a client connection on port: %d\n",
            ntohs(serv_addr.sin_port)
          );

    conn_sockfd = accept( listen_sockfd, (struct sockaddr *) 0, 0 );

    if ( conn_sockfd < 0 )
        {
        perror( "Failed to accept client connection" );
        exit( EXIT_FAILURE );
        }

    /*
     * log client connection request
     */

    cli_addrlen = sizeof(cli_addr);
    memset( &cli_addr, 0, sizeof(cli_addr) );

    if ( getpeername(conn_sockfd ❶,
                     (struct sockaddr * ) &cli_addr, ❷ &cli_addrlen ❸) <
 0 )
        {
        perror( "Failed to get client name" );
        exit( EXIT_FAILURE );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port) ❹
          );

    exit( EXIT_SUCCESS );
}
```

This example obtains the remote IP address and port number using the `getpeername()` function and then prints the information.

❶ `conn_sockfd` is the socket descriptor returned by the previous call to the `accept()` function.

❷ `cli_addr` is the address structure for the connected socket.

❸ `cli_addrlen` is the length of the address structure for the connected socket.

❹ The `printf` statement accesses the information stored in the address structure for the connected socket and displays the client's IP address and port number. The `inet_ntoa()` and the `ntohs()` functions are used to convert the IP address and port number from network byte order to host byte order.

2.7.2. Getting Socket Information (System Services)

To obtain information about the parts of a socket, use the $QIO system service with the IO $_SENSEMODE function.

Example 2.12, "Getting Socket Information (System Services)" shows a TCP service using the IO $_SENSEMODE function to get a client's IP address and port number.

Example 2.12. Getting Socket Information (System Services)

```
#include <descrip.h>              /* define OpenVMS descriptors           */
#include <efndef.h>               /* define 'EFN$C_ENF' event flag        */
#include <in.h>                   /* define internet related constants,   */

                                  /* functions, and structures            */
#include <inet.h>                 /* define network address info          */
#include <iodef.h>                /* define i/o function codes            */
#include <netdb.h>                /* define network database library info */
#include <ssdef.h>                /* define system service status codes   */
#include <starlet.h>              /* define system service calls          */
#include <stdio.h>                /* define standard i/o functions        */
#include <stdlib.h>               /* define standard library functions    */
#include <string.h>               /* define string handling functions     */
#include <stsdef.h>               /* define condition value fields        */
#include <tcpip$inetdef.h>        /* define tcp/ip network constants,     */
                                  /* structures, and functions            */


#define SERV_BACKLOG    1             /* server backlog                   */
#define SERV_PORTNUM    12345         /* server port number               */

struct iosb
    {                             /* i/o status block                     */
    unsigned short status;        /* i/o completion status                */
    unsigned short bytcnt;        /* bytes transferred if read/write      */
    void *details;                /* address of buffer or parameter       */
    };

struct itemlst_2
    {                             /* item-list 2 descriptor/element       */
    unsigned short length;        /* length                               */
    unsigned short type;          /* parameter type                       */
    void *address;                /* address of item list                 */
    };
```

```
struct itemlst_3
    {                                   /* item-list 3 descriptor/element   */
    unsigned short length;              /* length                           */
    unsigned short type;                /* parameter type                   */
    void *address;                      /* address of item list             */
    unsigned int *retlen;               /* address of returned length       */
    };

struct sockchar
    {                                   /* socket characteristics           */
    unsigned short prot;                /* protocol                         */
    unsigned char type;                 /* type                             */
    unsigned char af;                   /* address format                   */
    };


int main( void )
{
    struct iosb iosb;                   /* i/o status block                 */
    unsigned int status;                /* system service return status     */

    unsigned short conn_channel;        /* connect inet device i/o channel  */

    unsigned short listen_channel;      /* listen inet device i/o channel   */
    struct sockchar listen_sockchar;    /* listen socket characteristics    */

    unsigned int cli_addrlen;           /* returned length of client socket */
                                        /* address structure                */
    struct sockaddr_in cli_addr;        /* client socket address structure  */
    struct itemlst_3 cli_itemlst;       /* client socket address item-list  */

    struct sockaddr_in serv_addr;       /* server socket address structure  */
    struct itemlst_2 serv_itemlst;      /* server socket address item-list  */

    $DESCRIPTOR( inet_device,           /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );     /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    listen_sockchar.prot = TCPIP$C_TCP;
    listen_sockchar.type = TCPIP$C_STREAM;
    listen_sockchar.af   = TCPIP$C_AF_INET;

    /*
     * initialize client's item-list descriptor
     */

    cli_itemlst.length  = sizeof( cli_addr );
    cli_itemlst.type    = TCPIP$C_SOCK_NAME;
    cli_itemlst.address = &cli_addr;
    cli_itemlst.retlen  = &cli_addrlen;

    /*
     * initialize server's item-list descriptor
     */
```

```
serv_itemlst.length  = sizeof( serv_addr );
serv_itemlst.type    = TCPIP$C_SOCK_NAME;
serv_itemlst.address = &serv_addr;

/*
 * initialize server's socket address structure
 */

memset( &serv_addr, 0, sizeof(serv_addr) );
serv_addr.sin_family      = TCPIP$C_AF_INET;
serv_addr.sin_port        = htons( SERV_PORTNUM );
serv_addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;

/*
 * assign i/o channels to network device
 */

status = sys$assign( &inet_device,      /* device name                */
                     &listen_channel,   /* i/o channel                */
                     0,                 /* access mode                */
                     0                  /* not used                   */
                   );

if ( status & STS$M_SUCCESS )
    status = sys$assign( &inet_device,  /* device name                */
                         &conn_channel, /* i/o channel                */
                         0,             /* access mode                */
                         0              /* not used                   */
                       );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel(s)\n" );
    exit( status );
    }

/*
 * create a listen socket
 */

status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                   listen_channel,    /* i/o channel                  */
                   IO$_SETMODE,       /* i/o function code            */
                   &iosb,             /* i/o status block             */
                   0,                 /* ast service routine          */
                   0,                 /* ast parameter                */
                   &listen_sockchar,  /* p1 - socket characteristics  */
                   0,                 /* p2                           */
                   0,                 /* p3                           */
                   0,                 /* p4                           */
                   0,                 /* p5                           */
                   0                  /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;
```

```
if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
    }

/*
 * bind server's ip address and port number to listen socket
 */

status = sys$qiow( EFN$C_ENF,         /* event flag                    */
                   listen_channel,    /* i/o channel                   */
                   IO$_SETMODE,       /* i/o function code             */
                   &iosb,             /* i/o status block              */
                   0,                 /* ast service routine           */
                   0,                 /* ast parameter                 */
                   0,                 /* p1                            */
                   0,                 /* p2                            */
                   &serv_itemlst,     /* p3 - local socket name        */
                   0,                 /* p4                            */
                   0,                 /* p5                            */
                   0                  /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to bind socket\n" );
    exit( status );
    }

/*
 * set socket as a listen socket
 */

status = sys$qiow( EFN$C_ENF,         /* event flag                    */
                   listen_channel,    /* i/o channel                   */
                   IO$_SETMODE,       /* i/o function code             */
                   &iosb,             /* i/o status block              */
                   0,                 /* ast service routine           */
                   0,                 /* ast parameter                 */
                   0,                 /* p1                            */
                   0,                 /* p2                            */
                   0,                 /* p3                            */
                   SERV_BACKLOG,      /* p4 - connection backlog       */
                   0,                 /* p5                            */
                   0                  /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to set socket passive\n" );
    exit( status );
```

```
    }

/*
 * accept connection from a client
 */

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
      );

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   listen_channel,   /* i/o channel                   */
                   IO$_ACCESS|IO$M_ACCEPT,
                                     /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   0,                /* p1                            */
                   0,                /* p2                            */
                   0,                /* p3                            */
                   &conn_channel,    /* p4 - i/o channel for new      */
                                     /*      connection               */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to accept client connection\n" );
    exit( status );
    }

/*
 * log client connection request
 */

memset( &cli_addr, 0, sizeof(cli_addr) );
❶

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   conn_channel,     /* i/o channel                   */
                   IO$_SENSEMODE,    /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   0,                /* p1                            */
                   0,                /* p2                            */
                   0,                /* p3                            */
                   &cli_itemlst,     /* p4 - peer socket name         */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;
```

```
    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to get client name\n" );
        exit( status );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    exit( EXIT_SUCCESS );
}
```

This example show how to use the $QIOW system service to obtain remote port information.

❶ The IO$_SENSEMODE service returns the port number and IP address in the structure defined by **p4**.

2.8. Setting Socket Options

To set binary socket options and socket options that return a value, use the `setsockopt()` Sockets API function or the IO$_SETMODE system service.

2.8.1. Setting Socket Options (Sockets API)

Example 2.13, "Setting Socket Options (Sockets API)" shows a TCP server using the `setsockopt ()` function to set the `SO_REUSEADDR` option.

Example 2.13. Setting Socket Options (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <netdb.h>              /* define network database library info */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define SERV_BACKLOG    1           /* server backlog                   */
#define SERV_PORTNUM    12345       /* server port number               */


int main( void )
{
    int optval = 1;                 /* SO_REUSEADDR's option value (on) */

    int conn_sockfd;                /* connection socket descriptor     */
    int listen_sockfd;              /* listen socket descriptor         */

    unsigned int cli_addrlen;       /* returned length of client socket */
                                    /* address structure                */
    struct sockaddr_in cli_addr;    /* client socket address structure  */
    struct sockaddr_in serv_addr;   /* server socket address structure  */

    /*
```

```
 * initialize server's socket address structure
 */

memset( &serv_addr, 0, sizeof(serv_addr) );
serv_addr.sin_family      = AF_INET;
serv_addr.sin_port        = htons( SERV_PORTNUM );
serv_addr.sin_addr.s_addr = INADDR_ANY;

/*
 * create a listen socket
 */

if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
    {
    perror( "Failed to create socket" );
    exit( EXIT_FAILURE );
    }

/*
 * bind server's ip address and port number to listen socket
 */

if ( setsockopt(listen_sockfd,  ❶
     SOL_SOCKET ❷, SO_REUSEADDR ❸, &optval ❹, sizeof(optval) ❺) < 0 )
    {
    perror( "Failed to set socket option" );
    exit( EXIT_FAILURE );
    }

if ( bind(listen_sockfd,
          (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
    {
    perror( "Failed to bind socket" );
    exit( EXIT_FAILURE );
    }

/*
 * set socket as a listen socket
 */

if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
    {
    perror( "Failed to set socket passive" );
    exit( EXIT_FAILURE );
    }

/*
 * accept connection from a client
 */

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
      );

conn_sockfd = accept( listen_sockfd, (struct sockaddr *) 0, 0 );

if ( conn_sockfd < 0 )
    {
```

```
        perror( "Failed to accept client connection" );
        exit( EXIT_FAILURE );
        }

    /*
     * log client connection request
     */

    cli_addrlen = sizeof(cli_addr);
    memset( &cli_addr, 0, sizeof(cli_addr) );

    if ( getpeername(conn_sockfd,
                    (struct sockaddr *) &cli_addr, &cli_addrlen) < 0 )
        {
        perror( "Failed to get client name" );
        exit( EXIT_FAILURE );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    exit( EXIT_SUCCESS );
}
```

This example uses the `setsockopt()` function to allow local addresses to be reused.

❶ `listen_sockfd` refers to an open socket descriptor returned by the previous call to the `socket ()` function.

❷ `SOL_SOCKET` specifies that the options will be modified at socket level.

❸ `SO_REUSEADDR` is the socket option to be set. In this case, the socket option allows reuse of local addresses.

❹ `optval` is the value to set for the option. In this case, the value is 1, which enables the option.

❺ `sizeof(optval)` is the size of the option value.

Calls to `setsockopt()` specifying unsupported options return an error code of `ENOPROTOOPT`.

2.8.2. Setting Socket Options (System Services)

Example 2.14, "Setting Socket Options (System Services)" shows how to set socket options using system services.

Example 2.14. Setting Socket Options (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors           */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag        */
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <iodef.h>              /* define i/o function codes            */
#include <netdb.h>              /* define network database library info */
#include <ssdef.h>              /* define system service status codes   */
#include <starlet.h>            /* define system service calls          */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
```

```
#include <string.h>              /* define string handling functions     */
#include <stsdef.h>              /* define condition value fields        */
#include <tcpip$inetdef.h>       /* define tcp/ip network constants,     */
                                 /* structures, and functions            */


#define SERV_BACKLOG    1            /* server backlog                   */
#define SERV_PORTNUM    12345        /* server port number               */

struct iosb
    {                                /* i/o status block                 */
    unsigned short status;           /* i/o completion status            */
    unsigned short bytcnt;           /* bytes transferred if read/write  */
    void *details;                   /* address of buffer or parameter   */
    };

struct itemlst_2
    {                                /* item-list 2 descriptor/element   */
    unsigned short length;           /* length                           */
    unsigned short type;             /* parameter type                   */
    void *address;                   /* address of item list             */
    };

struct itemlst_3
    {                                /* item-list 3 descriptor/element   */
    unsigned short length;           /* length                           */
    unsigned short type;             /* parameter type                   */
    void *address;                   /* address of item list             */
    unsigned int *retlen;            /* address of returned length       */
    };

struct sockchar
    {                                /* socket characteristics           */
    unsigned short prot;             /* protocol                         */
    unsigned char type;              /* type                             */
    unsigned char af;                /* address format                   */
    };


int main( void )
{
    int optval = 1;                  /* reuseaddr option value (on)      */

    struct iosb iosb;                /* i/o status block                 */
    unsigned int status;             /* system service return status     */

    unsigned short conn_channel;     /* connect inet device i/o channel  */

    unsigned short listen_channel;   /* listen inet device i/o channel   */
    struct sockchar listen_sockchar; /* listen socket characteristics    */

    unsigned int cli_addrlen;        /* returned length of client socket */
                                     /* address structure                */
    struct sockaddr_in cli_addr;     /* client socket address structure  */
    struct itemlst_3 cli_itemlst;    /* client socket address item-list  */

    struct sockaddr_in serv_addr;    /* server socket address structure  */
    struct itemlst_2 serv_itemlst;   /* server socket address item-list  */
```

```
   struct itemlst_2 sockopt_itemlst;   /* server socket option item-list
*/
   struct itemlst_2 reuseaddr_itemlst; /* reuseaddr option item-list
*/

   $DESCRIPTOR( inet_device,        /* string descriptor with logical   */
                "TCPIP$DEVICE:" );  /* name of network pseudodevice     */

   /*
    * initialize socket characteristics
    */

   listen_sockchar.prot = TCPIP$C_TCP;
   listen_sockchar.type = TCPIP$C_STREAM;
   listen_sockchar.af   = TCPIP$C_AF_INET;

   /*
    * initialize reuseaddr's item-list element
    */

   reuseaddr_itemlst.length  = sizeof( optval );
   reuseaddr_itemlst.type    = TCPIP$C_REUSEADDR;
   reuseaddr_itemlst.address = &optval;

   /*
    * initialize setsockopt's item-list descriptor
    */

   sockopt_itemlst.length  = sizeof( reuseaddr_itemlst );
   sockopt_itemlst.type    = TCPIP$C_SOCKOPT;
   sockopt_itemlst.address = &reuseaddr_itemlst;

   /*
    * initialize client's item-list descriptor
    */

   cli_itemlst.length  = sizeof( cli_addr );
   cli_itemlst.type    = TCPIP$C_SOCK_NAME;
   cli_itemlst.address = &cli_addr;
   cli_itemlst.retlen  = &cli_addrlen;

   /*
    * initialize server's item-list descriptor
    */

   serv_itemlst.length  = sizeof( serv_addr );
   serv_itemlst.type    = TCPIP$C_SOCK_NAME;
   serv_itemlst.address = &serv_addr;

   /*
    * initialize server's socket address structure
    */

   memset( &serv_addr, 0, sizeof(serv_addr) );
   serv_addr.sin_family      = TCPIP$C_AF_INET;
   serv_addr.sin_port        = htons( SERV_PORTNUM );
   serv_addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;
```

```
/*
 * assign i/o channels to network device
 */

status = sys$assign( &inet_device,      /* device name                */
                     &listen_channel,   /* i/o channel                */
                     0,                 /* access mode                */
                     0                  /* not used                   */
                   );

if ( status & STS$M_SUCCESS )
    status = sys$assign( &inet_device,  /* device name                */
                         &conn_channel, /* i/o channel                */
                         0,             /* access mode                */
                         0              /* not used                   */
                       );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel(s)\n" );
    exit( status );
    }

/*
 * create a listen socket
 */

status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                   listen_channel,    /* i/o channel                  */
                   IO$_SETMODE,       /* i/o function code            */
                   &iosb,             /* i/o status block             */
                   0,                 /* ast service routine          */
                   0,                 /* ast parameter                */
                   &listen_sockchar,  /* p1 - socket characteristics  */
                   0,                 /* p2                           */
                   0,                 /* p3                           */
                   0,                 /* p4                           */
                   0,                 /* p5                           */
                   0                  /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
    }

/*
 * bind server's ip address and port number to listen socket
 */

status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                   listen_channel,    /* i/o channel                  */
                   IO$_SETMODE,       /* i/o function code            */
```

```
                    &iosb,              /* i/o status block             */
                    0,                  /* ast service routine          */
                    0,                  /* ast parameter                */
                    0,                  /* p1                           */
                    0,                  /* p2                           */
                    0,                  /* p3                           */
                    0,                  /* p4                           */
                ❶ &sockopt_itemlst,    /* p5 - socket options          */
                    0                   /* p6                           */
                  );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to set socket option\n" );
    exit( status );
    }

status = sys$qiow( EFN$C_ENF,          /* event flag                   */
                   listen_channel,     /* i/o channel                  */
                   IO$_SETMODE,        /* i/o function code            */
                   &iosb,              /* i/o status block             */
                   0,                  /* ast service routine          */
                   0,                  /* ast parameter                */
                   0,                  /* p1                           */
                   0,                  /* p2                           */
                   &serv_itemlst,      /* p3 - local socket name       */
                   0,                  /* p4                           */
                   0,                  /* p5                           */
                   0                   /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to bind socket\n" );
    exit( status );
    }

/*
 * set socket as a listen socket
 */

status = sys$qiow( EFN$C_ENF,          /* event flag                   */
                   listen_channel,     /* i/o channel                  */
                   IO$_SETMODE,        /* i/o function code            */
                   &iosb,              /* i/o status block             */
                   0,                  /* ast service routine          */
                   0,                  /* ast parameter                */
                   0,                  /* p1                           */
                   0,                  /* p2                           */
                   0,                  /* p3                           */
                   SERV_BACKLOG,       /* p4 - connection backlog      */
                   0,                  /* p5                           */
```

```
                    0                   /* p6                               */
                  );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to set socket passive\n" );
        exit( status );
        }

    /*
     * accept connection from a client
     */

    printf( "Waiting for a client connection on port: %d\n",
            ntohs(serv_addr.sin_port)
          );

    status = sys$qiow( EFN$C_ENF,         /* event flag                       */
                       listen_channel,    /* i/o channel                      */
                       IO$_ACCESS|IO$M_ACCEPT,
                                          /* i/o function code                */
                       &iosb,             /* i/o status block                 */
                       0,                 /* ast service routine              */
                       0,                 /* ast parameter                    */
                       0,                 /* p1                               */
                       0,                 /* p2                               */
                       0,                 /* p3                               */
                       &conn_channel,     /* p4 - i/o channel for new         */
                                          /*      connection                  */
                       0,                 /* p5                               */
                       0                  /* p6                               */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to accept client connection\n" );
        exit( status );
        }

    /*
     * log client connection request
     */

    memset( &cli_addr, 0, sizeof(cli_addr) );

    status = sys$qiow( EFN$C_ENF,         /* event flag                       */
                       conn_channel,      /* i/o channel                      */
                       IO$_SENSEMODE,     /* i/o function code                */
                       &iosb,             /* i/o status block                 */
                       0,                 /* ast service routine              */
                       0,                 /* ast parameter                    */
                       0,                 /* p1                               */
```

```
                        0,                  /* p2                              */
                        0,                  /* p3                              */
                        &cli_itemlst,       /* p4 - peer socket name           */
                        0,                  /* p5                              */
                        0                   /* p6                              */
                      );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to get client name\n" );
        exit( status );
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    exit( EXIT_SUCCESS );
}
```

This example sets socket options using the IO$SETMODE function.

❶ The **p5** parameter sets the socket options as specified in `sockopt_itemlst`.

2.9. Reading Data

TCP/IP Services allows the application to read data after it performs the following operations:

- Create a socket
- Bind a socket name to the socket
- Establish a connection

2.9.1. Reading Data (Sockets API)

Example 2.15, "Reading Data (Sockets API)" shows a TCP client using the `recv()` function to read data.

Example 2.15. Reading Data (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <netdb.h>              /* define network database library info */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */


#define BUFSZ       1024            /* user input buffer size           */
#define PORTNUM     12345           /* server port number               */
```

```
void get_servaddr( void *addrptr )
{
    char buf[BUFSIZ];
    struct in_addr val;
    struct hostent *host;

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read user input\n" );
            exit( EXIT_FAILURE );
            }

        buf[strlen(buf)-1] = 0;

        val.s_addr = inet_addr( buf );

        if ( val.s_addr != INADDR_NONE )
            {
            memcpy( addrptr, &val, sizeof(struct in_addr) );
            break;
            }

        if ( (host = gethostbyname(buf)) )
            {
            memcpy( addrptr, host->h_addr, sizeof(struct in_addr) );
            break;
            }
        }
}


int main( void )
{
    char buf[512];
    int nbytes, sockfd;
    struct sockaddr_in addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family = AF_INET;
    addr.sin_port   = htons( PORTNUM );
    get_servaddr( &addr.sin_addr );

    /*
     * create a socket
     */

    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
```

```
        }

    /*
     * connect to specified host and port number
     */

    printf( "Initiated connection to host: %s, port: %d\n",
            inet_ntoa(addr.sin_addr), ntohs(addr.sin_port)
          );

    if ( connect(sockfd, (struct sockaddr *) &addr, sizeof(addr)) < 0 )
        {
        perror( "Failed to connect to server" );
        exit( EXIT_FAILURE );
        }

    /*
     * read data from connection
     */

    nbytes = recv( sockfd,❶ buf,❷ sizeof(buf),❸ 0 ❹ );
    if ( nbytes < 0 )
        {
        perror( "Failed to read data from connection" );
        exit( EXIT_FAILURE );
        }

    buf[nbytes] = 0;
    printf( "Data received: %s\n", buf );

    exit( EXIT_SUCCESS );
}
```

This example reads data from a connection using the `recv()` function.

❶ `sockfd` is the socket descriptor previously defined by a call to the `connect()` function.

❷ `buf` points to the receive buffer where the data is placed.

❸ `sizeof (buf)` is the size of the receive buffer.

❹ `0` indicates that out-of-band data is not being received.

2.9.2. Reading Data (System Services)

The $QIO IO$_READVBLK function transfers data received from the internet host (and kept in system dynamic memory) into the address space of the user's process. After the read operation completes, the data in system dynamic memory is discarded.

Example 2.16, "Reading Data (System Services)" shows a TCP client using the IO$_READVBLK function to read data into a single I/O buffer.

Example 2.16. Reading Data (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors          */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag       */
#include <in.h>                 /* define internet related constants,  */
                                /* functions, and structures           */
```

```
#include <inet.h>                /* define network address info          */
#include <iodef.h>               /* define i/o function codes            */
#include <netdb.h>               /* define network database library info */
#include <ssdef.h>               /* define system service status codes   */
#include <starlet.h>             /* define system service calls          */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <string.h>              /* define string handling functions     */
#include <stsdef.h>              /* define condition value fields        */
#include <tcpip$inetdef.h>       /* define tcp/ip network constants,     */
                                 /* structures, and functions            */


#define BUFSZ       1024              /* user input buffer size
 */
#define PORTNUM     12345             /* server port number
 */


struct iosb
    {                                /* i/o status block                */
    unsigned short status;           /* i/o completion status           */
    unsigned short bytcnt;           /* bytes transferred if read/write  */
    void *details;                   /* address of buffer or parameter   */
    };

struct itemlst_2
    {                                /* item-list 2 descriptor/element   */
    unsigned short length;           /* length                          */
    unsigned short type;             /* parameter type                  */
    void *address;                   /* address of item list            */
    };

struct sockchar
    {                                /* socket characteristics          */
    unsigned short prot;             /* protocol                        */
    unsigned char type;              /* type                            */
    unsigned char af;                /* address format                  */
    };


void get_servaddr( void *addrptr )
{
    char buf[BUFSIZ];
    struct in_addr val;
    struct hostent *host;

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read user input\n" );
            exit( EXIT_FAILURE );
            }

        buf[strlen(buf)-1] = 0;
```

```
        val.s_addr = inet_addr( buf );

        if ( val.s_addr != INADDR_NONE )
            {
            memcpy( addrptr, &val, sizeof(struct in_addr) );
            break;
            }

        if ( (host = gethostbyname(buf)) )
            {
            memcpy( addrptr, host->h_addr, sizeof(struct in_addr) );
            break;
            }
        }
}


int main( void )
{
    char buf[512];                  /* data buffer                      */
    int buflen = sizeof( buf );     /* length of data buffer            */

    struct iosb iosb;               /* i/o status block                 */
    unsigned int status;            /* system service return status     */
    unsigned short channel;         /* network device i/o channel       */
    struct sockchar sockchar;       /* socket characteristics buffer    */
    struct sockaddr_in addr;        /* socket address structure         */
    struct itemlst_2 addr_itemlst;  /* socket address item-list         */
    $DESCRIPTOR( inet_device,       /* string descriptor with logical   */
                 "TCPIP$DEVICE:" ); /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;

    /*
     * initialize socket address item-list descriptor
     */

    addr_itemlst.length  = sizeof( addr );
    addr_itemlst.type    = TCPIP$C_SOCK_NAME;
    addr_itemlst.address = &addr;

    /*
     * initialize socket address structure
     */

    memset( &addr, 0, sizeof(addr) );
    addr.sin_family = TCPIP$C_AF_INET;
    addr.sin_port   = htons( PORTNUM );
    get_servaddr( &addr.sin_addr );

    /*
```

```
 * assign i/o channel to network device
 */

status = sys$assign( &inet_device,   /* device name                  */
                     &channel,       /* i/o channel                 */
                     0,              /* access mode                 */
                     0               /* not used                    */
                   );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel\n" );
    exit( status );
    }

/*
 * create a socket
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                  */
                   channel,          /* i/o channel                 */
                   IO$_SETMODE,      /* i/o function code           */
                   &iosb,            /* i/o status block            */
                   0,                /* ast service routine         */
                   0,                /* ast parameter               */
                   &sockchar,        /* p1 - socket characteristics */
                   0,                /* p2                          */
                   0,                /* p3                          */
                   0,                /* p4                          */
                   0,                /* p5                          */
                   0                 /* p6                          */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
    }

/*
 * connect to specified host and port number
 */

printf( "Initiated connection to host: %s, port: %d\n",
        inet_ntoa(addr.sin_addr), ntohs(addr.sin_port)
      );

status = sys$qiow( EFN$C_ENF,        /* event flag                  */
                   channel,          /* i/o channel                 */
                   IO$_ACCESS,       /* i/o function code           */
                   &iosb,            /* i/o status block            */
                   0,                /* ast service routine         */
                   0,                /* ast parameter               */
                   0,                /* p1                          */
                   0,                /* p2                          */
```

```
                        &addr_itemlst,     /* p3 - remote socket name      */
                        0,                 /* p4                           */
                        0,                 /* p5                           */
                        0                  /* p6                           */
                      );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to connect to server\n" );
        exit( status );
        }

    /*
     * read data from connection
     */

    status = sys$qiow( EFN$C_ENF,         /* event flag                   */
                       channel,           /* i/o channel                  */
                       IO$_READVBLK,      /* i/o function code            */
                       &iosb,             /* i/o status block             */
                       0,                 /* ast service routine          */
                       0,                 /* ast parameter                */
              ❶    buf,                 /* p1 - buffer address          */
                       buflen,            /* p2 - buffer length           */
                       0,                 /* p3                           */
                       0,                 /* p4                           */
                       0,                 /* p5                           */
              ❷    0                    /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to read data from connection\n" );
        exit( status );
        }

    buf[iosb.bytcnt] = 0;
    printf( "Data received: %s\n", buf );

    exit( EXIT_SUCCESS );
}
```

This example reads data from a connection using the IO$_READVLK service. The data can be written to a single buffer, as shown here, or a list of buffers.

❶ This example specifies the address of the return buffer in **p1**, and the length of the return buffer in **p2**.

❷ To specify a list of read buffers, omit the **p1** and **p2** arguments, and pass the list of buffers as the **p6** parameter. See *Section 5.5.2, "Specifying an Output Parameter List"* for more information.

2.10. Receiving IP Multicast Datagrams

Before a host can receive (read) IP multicast datagrams destined for a particular multicast group other than `all hosts group`, the application must direct the host it is running on to become a member of that multicast group.

To join a group or drop membership from a group, specify the following options. Make sure you include the IN.H header file.

- To join a multicast group, specify the appropriate option:

  - IP_ADD_MEMBERSHIP (Sockets API)
  - TCPIP$C_IP_ADD_MEMBERSHIP (system services)

  For example:

```
struct ip_mreq mreq;
if (setsockopt( sock, IPPROTO_IP, IP_ADD_MEMBERSHIP, & mreq,
           sizeof(mreq)) == -1)
           perror("setsockopt");
```

  The `mreq` variable has the following structure:

```
struct ip_mreq {
           struct in_addr (imr_multiaddr); /* IP multicast address of
 group */
           struct in_addr (imr_interface); /* local IP address of
 interface */
};
```

  In this structure, `imr_interface` can be specified as INADDR_ANY, which allows an application to choose the default multicast interface.

  Each multicast group membership is associated with a particular interface, and multiple interfaces can join the same group. Alternatively, specifying one of the host's local addresses allows an application to select a particular, multicast-capable interface. The maximum number of memberships that can be added on a single socket is subject to the IP_MAX_MEMBERSHIPS value, which is defined in the IN.H header file.

  If multiple sockets request that a host join a multicast group, the host remains a member of that multicast group until the last of those sockets is closed.

- To drop membership from a multicast group, specify the appropriate option to the `setsockopt()` function:

  - IP_DROP_MEMBERSHIP (Sockets API)
  - TCPIP$C_IP_DROP_MEMBERSHIP (system services)

  For example:

```
struct ip_mreq mreq;
if (setsockopt( sock, IPPROTO_IP, IP_DROP_MEMBERSHIP, &mreq,
         sizeof(mreq))== -1)
perror("setsockopt");
```

The `mreq` variable contains the same structure values used for adding membership.

To receive multicast datagrams sent to a specific UDP port, the receiving socket must have been bound to that port using the $QIO(IO$_SETMODE) system service function or the `bind()` Sockets API function. More than one process can receive UDP datagrams destined for the same port if the function is preceded by a `setsockopt()` function that specifies the SO_REUSEPORT option. For a complete list of the socket options, see *Appendix A, "Socket Options"*.

For example:

```
int setreuse = 1;
if (setsockopt(sock, SOL_SOCKET, SO_REUSEPORT, &setreuse,
         sizeof(setreuse)) == -1)
 perror("setsockopt");
```

When the `SO_REUSEPORT` option is set, every incoming multicast or broadcast UDP datagram destined for the shared port is delivered to all sockets bound to that port.

Delivery of IP multicast datagrams to SOCK_RAW sockets is determined by the protocol type of the destination.

2.11. Reading Out-of-Band Data (TCP Protocol)

Only stream-type (TCP/IP) sockets can receive out-of-band (OOB) data. Upon receiving a TCP/IP OOB character, TCP/IP Services stores a pointer in the received stream to the character that precedes the OOB character.

A read operation with a user buffer size larger than the size of the received stream up to the OOB character completes by returning to the user the received stream up to, but not including, the OOB character.

Poll the socket to determine whether additional read operations are needed before getting all the characters from the stream that precedes the OOB character.

2.11.1. Reading OOB Data (Sockets API)

You can use the `recv()` socket function with the MSG_OOB flag set to receive out-of-band data regardless of how many of the preceding characters in the stream you have received.

Example 2.17, "Reading OOB Data (Sockets API)" shows a TCP server using the `recv()` function to receive out-of-band data.

Example 2.17. Reading OOB Data (Sockets API)

```
retval = recv(sock_3,❶ message,❷ sizeof(message), ❸MSG_OOB);❹
if (retval == -1)
        {
    perror ("receive");
    cleanup( 2, sock_2, sock_3);
        }
else
    printf (" %s\n", message);
```

This example reads data uses the `flags` argument to the `recv()` function to specify OOB data.

❶ `sock_3` specifies that OOB data is received from socket 2.

❷ `message` points to the read buffer where the data is placed.

❸ `sizeof (message)` indicates the size of the read buffer.

❹ `flag`, when set to MSG_OOB, indicates that OOB data is being received in the specified buffer.

2.11.2. Reading OOB Data (System Services)

To receive OOB data from a remote process, use the IO$_READVBLK function with the IO $M_INTERRUPT modifier.

To poll the socket, use a $QIO command with the IO$_SENSEMODE function and the TCPIP $C_IOCTL subfunction that specifies the SIOCATMARK operation.

If the SIOCATMARK returns a value of 0, use additional read QIOs to read more data before reading the OOB character. If the SIOCATMARK returns a value of 1, the next read QIO returns the OOB character.

These functions are useful if a socket has the OOBINLINE socket option set. The OOB character is read with the characters in the stream (IO$_READVBLK) but is not read before the preceding characters. To determine whether or not the first character in the user buffer on the next read is an OOB, poll the socket.

To get a received OOB character for a socket with the socket option OOBINLINE clear, use one of the following functions:

- $QIO with the function IO$_READVBLK|IO$M_INTERRUPT
- IO$_READVBLK with the **p4** parameter TCPIP$C_MSG_OOB flag set

Example 2.18, "Reading OOB Data (System Services)" shows how to use the IO$M_INTERRUPT modifier to read out-of-band data.

Example 2.18. Reading OOB Data (System Services)

```
/*
**  Attempt to receive the OOB data from the client.
**  Use the function code of IO$_READVBLK, passing the address of the
**  input buffer to P1, and the OOB code, TCPIP$C_MSG_OOB, to P4.
**  We support the sending and receiving of a one byte of OOB data.
*/
        sysSrvSts = sys$qiow( 0,            /* efn.v | 0              */
                              IOChanClient, /* chan.v                 */
                              IO$_READVBLK, /* func.v                 */
                              &iosb,        /* iosb.r | 0             */
                              0, 0,         /* astadr, astprm: UNUSED */
❶                           &OOBBuff,      /* p1.r IO buffer         */
                              MaxBuff,      /* p2.v IO buffer  size   */
                              0,            /* p3 UNUSED              */
❷                           TCPIP$C_MSG_OOB, /* p4.v IO options flag   */
                              0, 0          /* p5, p6 UNUSED          */
                            );

        if(( sysSrvSts & 1  ) != 1 ) || /* Validate the system service. */
           ((  iosb.cond_value & 1  ) != 1))  /* Validate the IO status. */
            {
```

```
            cleanup( IOChanClient );
            cleanup( IOChannel );
            errorExit( sysSrvSts, iosb.cond_value );
            }
        else
            if( iosb.count == 0 )
                printf( "    FAILED to receive the message, no connection.
\n" );
            else
                printf( "    SUCCEEDED in receiving '%d'\n", OOBBuff );
```

This example reads OOB data using the IO$_READVBLK service to specify:

❶ The read buffer in parameter **p1** and the length of the receive buffer in parameter **p2**.

❷ OOB data, specifying the TCPIP$C_MSG_OOB flag in parameter **p4**.

2.12. Peeking at Queued Messages

You can use a read operation to look at data in a socket receive queue without removing the data from the buffer. This is called **peeking**.

2.12.1. Peeking at Data (Sockets API)

Use the MSG_PEEK flag with the `recv()` function to peek at data in the socket receive queue.

Example 2.19, "Peeking at Data (Sockets API)" shows a TCP server using the `recv()` function with the MSG_PEEK flag to peek at received data.

Example 2.19. Peeking at Data (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <netdb.h>              /* define network database library info */
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */
#include <unixio.h>             /* define unix i/o                      */


#define BUFSZ           128         /* user input buffer size           */
#define SERV_BACKLOG    1           /* server backlog                   */
#define SERV_PORTNUM    1234        /* server port number               */


int main( void )
{
    char buf[BUFSIZ];               /* user input buffer                */
    int conn_sockfd;                /* connection socket descriptor     */
    int listen_sockfd;              /* listen socket descriptor         */

    int optval = 1;                 /* SO_REUSEADDR'S option value (on) */

    unsigned int cli_addrlen;       /* returned length of client socket */
                                    /* address structure                */
    struct sockaddr_in cli_addr;    /* client socket address structure  */
```

```
    struct sockaddr_in serv_addr;    /* server socket address structure  */

    /*
     * initialize client's socket address structure
     */

    memset( &cli_addr, 0, sizeof(cli_addr) );

    /*
     * initialize server's socket address structure
     */

    memset( &serv_addr, 0, sizeof(serv_addr) );
    serv_addr.sin_family      = AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a listen socket
     */

    if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * bind server's ip address and port number to listen socket
     */

    if ( setsockopt(listen_sockfd,
                    SOL_SOCKET, SO_REUSEADDR, &optval, sizeof(optval)) <
0 )
        {
        perror( "Failed to set socket option" );
        exit( EXIT_FAILURE );
        }

    if ( bind(listen_sockfd,
              (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
        {
        perror( "Failed to bind socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * set socket as a listen socket
     */

    if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
        {
        perror( "Failed to set socket passive" );
        exit( EXIT_FAILURE );
        }

    /*
     * accept connection from a client
```

```
 */

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
      );

cli_addrlen = sizeof(cli_addr);

conn_sockfd = accept( listen_sockfd,
                      (struct sockaddr *) &cli_addr,
                      &cli_addrlen
                    );
if ( conn_sockfd < 0 )
    {
    perror( "Failed to accept client connection" );
    exit( EXIT_FAILURE );
    }

/*
 * ask client to pick a character
 */

sprintf( buf, "Please pick a character:\r\n");

if ( send(conn_sockfd, buf, strlen(buf), 0) != strlen(buf) )
    {
    perror( "Failed to write data to connection" );
    exit( EXIT_FAILURE );
    }

/*
 * peek at client's reply
 */

if ( recv(conn_sockfd ❶, buf ❷, 1 ❸, MSG_PEEK ❹) != 1 )
    {
    perror( "Failed to read data from connection" );
    exit( EXIT_FAILURE );
    }

sprintf( buf, "Before receiving, I see you picked '%c'.\r\n", buf[0] );

if ( send(conn_sockfd, buf, strlen(buf), 0) != strlen(buf) )
    {
    perror( "Failed to write data to connection" );
    exit( EXIT_FAILURE );
    }

/*
 * now, read client's reply
 */

if ( recv(conn_sockfd, buf, 1, 0) != 1 )
    {
    perror( "Failed to read data from connection" );
    exit( EXIT_FAILURE );
    }
```

```
    sprintf( buf, "Sure enough, I received '%c'.\r\n", buf[0] );

    if ( send(conn_sockfd, buf, strlen(buf), 0) != strlen(buf) )
        {
        perror( "Failed to write data to connection" );
        exit( EXIT_FAILURE );
        }

    /*
     * close sockets
     */

    if ( close(conn_sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    if ( close(listen_sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

The `recv()` function receives data from a connected socket and places it in a buffer, as follows:

❶ `conn_sockfd` is the socket descriptor created as a result of a call to the `accept()` function.

❷ `buf` points to the buffer into which received data is placed.

❸ `1` indicates the size of the buffer.

❹ `MSG_PEEK` is the flag that specifies the character entered is looked at without removing it from the buffer.

2.12.2. Peeking at Data (System Services)

To peek at data that is next in the socket receive queue, use the IO$_READVBLK function of the $QIO system service and use the TCPIP$C_MSG_PEEK flag. This allows you to use multiple read operations on the same data. The code is similar to the example shown in *Section 2.11.2, "Reading OOB Data (System Services)"*.

2.13. Writing Data

For programs that use TCP, data writing occurs after a client program initiates a connection and after the server program accepts the connection. When using UDP, you also have the option of establishing a default peer address with a specific socket, but this is not required for data transfer.

2.13.1. Writing Data (Sockets API)

Example 2.20, "Writing Data (Sockets API)" shows a TCP server using the `send()` function to transmit data.

Example 2.20. Writing Data (Sockets API)

```
#include <in.h>                  /* define internet related constants,   */
                                 /* functions, and structures            */
#include <inet.h>                /* define network address info          */
#include <netdb.h>               /* define network database library info */
#include <socket.h>              /* define BSD socket api                */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <string.h>              /* define string handling functions     */


#define SERV_BACKLOG    1            /* server backlog                   */
#define SERV_PORTNUM    12345        /* server port number               */


int main( void )
{
    int optval = 1;                  /* SO_REUSEADDR's option value (on) */

    int conn_sockfd;                 /* connection socket descriptor     */
    int listen_sockfd;               /* listen socket descriptor         */

    unsigned int cli_addrlen;        /* returned length of client socket */
                                     /* address structure                */
    struct sockaddr_in cli_addr;     /* client socket address structure  */
    struct sockaddr_in serv_addr;    /* server socket address structure  */

    char buf[] = "Hello, world!";    /* data buffer                      */

    /*
     * initialize server's socket address structure
     */

    memset( &serv_addr, 0, sizeof(serv_addr) );
    serv_addr.sin_family      = AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = INADDR_ANY;

    /*
     * create a listen socket
     */

    if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }
    /*
     * bind server's ip address and port number to listen socket
     */

    if ( setsockopt(listen_sockfd,
                    SOL_SOCKET, SO_REUSEADDR, &optval, sizeof(optval)) <
 0 )
        {
        perror( "Failed to set socket option" );
        exit( EXIT_FAILURE );
```

```
    }

if ( bind(listen_sockfd,
          (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
    {
    perror( "Failed to bind socket" );
    exit( EXIT_FAILURE );
    }

/*
 * set socket as a listen socket
 */

if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
    {
    perror( "Failed to set socket passive" );
    exit( EXIT_FAILURE );
    }

/*
 * accept connection from a client
 */

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
      );

conn_sockfd = accept( listen_sockfd, (struct sockaddr *) 0, 0 );

if ( conn_sockfd < 0 )
    {
    perror( "Failed to accept client connection" );
    exit( EXIT_FAILURE );
    }

/*
 * log client connection request
 */

cli_addrlen = sizeof(cli_addr);
memset( &cli_addr, 0, sizeof(cli_addr) );

if ( getpeername(conn_sockfd,
                 (struct sockaddr *) &cli_addr, &cli_addrlen) < 0 )
    {
    perror( "Failed to get client name" );
    exit( EXIT_FAILURE );
    }

printf( "Accepted connection from host: %s, port: %d\n",
        inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
      );

/*
 * write data to connection
 */

if ( send(conn_sockfd, ❶ buf, ❷ sizeof(buf),❸ 0 ❹) < 0 )
```

```
        {
        perror( "Failed to write data to connection" );
        exit( EXIT_FAILURE );
        }

    printf( "Data sent: %s\n", buf );

    exit( EXIT_SUCCESS );
}
```

In this example, the `send()` function include the following arguments:

❶ `conn_sockfd` specifies the connected socket that is to receive the data.

❷ `buf` is the address of the send buffer where the data to be sent is placed.

❸ `sizeof (buf)` indicates the size of the send buffer.

❹ `flag`, when set to 0, indicates that OOB data is not being sent.

2.13.2. Writing Data (System Services)

The IO$_WRITEVBLK function of the $QIO system service copies data from the address space of the user's process to system dynamic memory and then transfers the data to an internet host or port.

Example 2.21, "Writing Data (System Services)" shows a TCP server using the IO$_WRITEVBLK function to transmit a single data buffer.

Example 2.21. Writing Data (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors           */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag        */
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <iodef.h>              /* define i/o function codes            */
#include <netdb.h>              /* define network database library info */
#include <ssdef.h>              /* define system service status codes   */
#include <starlet.h>            /* define system service calls          */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */
#include <stsdef.h>             /* define condition value fields        */
#include <tcpip$inetdef.h>      /* define tcp/ip network constants,     */
                                /* structures, and functions            */


#define SERV_BACKLOG    1           /* server backlog                   */
#define SERV_PORTNUM    12345       /* server port number               */

struct iosb
    {                               /* i/o status block                 */
    unsigned short status;          /* i/o completion status            */
    unsigned short bytcnt;          /* bytes transferred if read/write  */
    void *details;                  /* address of buffer or parameter   */
    };

struct itemlst_2
```

```
    {                                   /* item-list 2 descriptor/element   */
    unsigned short length;              /* length                           */
    unsigned short type;                /* parameter type                   */
    void *address;                      /* address of item list             */
    };

struct itemlst_3
    {                                   /* item-list 3 descriptor/element   */
    unsigned short length;              /* length                           */
    unsigned short type;                /* parameter type                   */
    void *address;                      /* address of item list             */
    unsigned int *retlen;               /* address of returned length       */
    };

struct sockchar
    {                                   /* socket characteristics           */
    unsigned short prot;                /* protocol                         */
    unsigned char type;                 /* type                             */
    unsigned char af;                   /* address format                   */
    };


int main( void )
{
    int optval = 1;                     /* reuseaddr option value (on)      */

    struct iosb iosb;                   /* i/o status block                 */
    unsigned int status;                /* system service return status     */

    unsigned short conn_channel;        /* connect inet device i/o channel  */

    unsigned short listen_channel;      /* listen inet device i/o channel   */
    struct sockchar listen_sockchar; /* listen socket characteristics    */

    unsigned int cli_addrlen;           /* returned length of client socket */
                                        /* address structure                */
    struct sockaddr_in cli_addr;        /* client socket address structure  */
    struct itemlst_3 cli_itemlst;       /* client socket address item-list  */

    struct sockaddr_in serv_addr;       /* server socket address structure  */
    struct itemlst_2 serv_itemlst;      /* server socket address item-list  */

    struct itemlst_2 sockopt_itemlst; /* server socket option item-list
 */
    struct itemlst_2 reuseaddr_itemlst; /* reuseaddr option item-list
 */

    char buf[] = "Hello, world!";       /* data buffer                      */
    int buflen = sizeof( buf );         /* length of data buffer            */

    $DESCRIPTOR( inet_device,           /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    listen_sockchar.prot = TCPIP$C_TCP;
```

```
listen_sockchar.type = TCPIP$C_STREAM;
listen_sockchar.af   = TCPIP$C_AF_INET;

/*
 * initialize reuseaddr's item-list element
 */

reuseaddr_itemlst.length  = sizeof( optval );
reuseaddr_itemlst.type    = TCPIP$C_REUSEADDR;
reuseaddr_itemlst.address = &optval;

/*
 * initialize setsockopt's item-list descriptor
 */

sockopt_itemlst.length  = sizeof( reuseaddr_itemlst );
sockopt_itemlst.type    = TCPIP$C_SOCKOPT;
sockopt_itemlst.address = &reuseaddr_itemlst;

/*
 * initialize client's item-list descriptor
 */

cli_itemlst.length  = sizeof( cli_addr );
cli_itemlst.type    = TCPIP$C_SOCK_NAME;
cli_itemlst.address = &cli_addr;
cli_itemlst.retlen  = &cli_addrlen;

/*
 * initialize server's item-list descriptor
 */

serv_itemlst.length  = sizeof( serv_addr );
serv_itemlst.type    = TCPIP$C_SOCK_NAME;
serv_itemlst.address = &serv_addr;

/*
 * initialize server's socket address structure
 */

memset( &serv_addr, 0, sizeof(serv_addr) );
serv_addr.sin_family      = TCPIP$C_AF_INET;
serv_addr.sin_port        = htons( SERV_PORTNUM );
serv_addr.sin_addr.s_addr = TCPIP$C_INADDR_ANY;

/*
 * assign i/o channels to network device
 */

status = sys$assign( &inet_device,      /* device name              */
                     &listen_channel,   /* i/o channel              */
                     0,                 /* access mode              */
                     0                  /* not used                 */
                   );

if ( status & STS$M_SUCCESS )
    status = sys$assign( &inet_device,  /* device name              */
                         &conn_channel, /* i/o channel              */
```

```
                          0,            /* access mode                */
                          0             /* not used                   */
                        );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel(s)\n" );
        exit( status );
        }

    /*
     * create a listen socket
     */

    status = sys$qiow( EFN$C_ENF,        /* event flag                 */
                       listen_channel,   /* i/o channel                */
                       IO$_SETMODE,      /* i/o function code          */
                       &iosb,            /* i/o status block           */
                       0,                /* ast service routine        */
                       0,                /* ast parameter              */
                       &listen_sockchar, /* p1 - socket characteristics */
                       0,                /* p2                         */
                       0,                /* p3                         */
                       0,                /* p4                         */
                       0,                /* p5                         */
                       0                 /* p6                         */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to create socket\n" );
        exit( status );
        }

    /*
     * bind server's ip address and port number to listen socket
     */

    status = sys$qiow( EFN$C_ENF,        /* event flag                 */
                       listen_channel,   /* i/o channel                */
                       IO$_SETMODE,      /* i/o function code          */
                       &iosb,            /* i/o status block           */
                       0,                /* ast service routine        */
                       0,                /* ast parameter              */
                       0,                /* p1                         */
                       0,                /* p2                         */
                       0,                /* p3                         */
                       0,                /* p4                         */
                       &sockopt_itemlst, /* p5 - socket options        */
                       0                 /* p6                         */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;
```

```
if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to set socket option\n" );
    exit( status );
    }

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   listen_channel,   /* i/o channel                   */
                   IO$_SETMODE,      /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   0,                /* p1                            */
                   0,                /* p2                            */
                   &serv_itemlst,    /* p3 - local socket name        */
                   0,                /* p4                            */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to bind socket\n" );
    exit( status );
    }

/*
 * set socket as a listen socket
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   listen_channel,   /* i/o channel                   */
                   IO$_SETMODE,      /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   0,                /* p1                            */
                   0,                /* p2                            */
                   0,                /* p3                            */
                   SERV_BACKLOG,     /* p4 - connection backlog       */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to set socket passive\n" );
    exit( status );
    }

/*
 * accept connection from a client
```

```
 */

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
      );
```

❶

```
status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                   listen_channel,   /* i/o channel                  */
                   IO$_ACCESS|IO$M_ACCEPT,
                                     /* i/o function code            */
                   &iosb,            /* i/o status block             */
                   0,                /* ast service routine          */
                   0,                /* ast parameter                */
                   0,                /* p1                           */
                   0,                /* p2                           */
                   0,                /* p3                           */
                   &conn_channel,    /* p4 - i/o channel for new     */
                                     /*      connection              */
                   0,                /* p5                           */
                   0                 /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to accept client connection\n" );
    exit( status );
    }

/*
 * log client connection request
 */

memset( &cli_addr, 0, sizeof(cli_addr) );

status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                   conn_channel,     /* i/o channel                  */
                   IO$_SENSEMODE,    /* i/o function code            */
                   &iosb,            /* i/o status block             */
                   0,                /* ast service routine          */
                   0,                /* ast parameter                */
                   0,                /* p1                           */
                   0,                /* p2                           */
                   0,                /* p3                           */
                   &cli_itemlst,     /* p4 - peer socket name        */
                   0,                /* p5                           */
                   0                 /* p6                           */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to get client name\n" );
    exit( status );
```

```
        }

    printf( "Accepted connection from host: %s, port: %d\n",
            inet_ntoa(cli_addr.sin_addr), ntohs(cli_addr.sin_port)
          );

    /*
     * write data to connection
     */

    status = sys$qiow( EFN$C_ENF,         /* event flag                    */
                       conn_channel,      /* i/o channel                   */
                       IO$_WRITEVBLK,     /* i/o function code             */
                       &iosb,             /* i/o status block              */
                       0,                 /* ast service routine           */
                       0,                 /* ast parameter                 */
           ❷           buf,              /* p1 - buffer address           */
                       buflen,            /* p2 - buffer length            */
                       0,                 /* p3                            */
                       0,                 /* p4                            */
           ❸           0,                 /* p5                            */
           ❹           0                  /* p6                            */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to write data to connection\n" );
        exit( status );
        }

    printf( "Data sent: %s\n", buf );

    exit( EXIT_SUCCESS );
}
```

This example uses OpenVMS system services to transmit a single buffer of data.

❶ The $QIO(IO$_ACCESS|IO$M_ACCEPT) function establishes the connection with the client.

❷ The IO$WRITEVBLK function specifies the address of the return buffer in **p1**, and the length of the return buffer in **p2**.

❸ You can also specify a list of write buffers by omitting the **p1** and **p2** parameters and instead passing the list of buffers as the **p5** parameter.

❹ When writing a list of buffers, the **p5** parameter is used; when reading a list, the **p6** parameter is used. For information about specifying input parameter lists, see *Section 5.5.1, "Specifying an Input Parameter List"*.

2.14. Writing OOB Data (TCP Protocol)

If your application uses TCP, you can send out-of-band (OOB) data to a remote process. At the remote process, the message is delivered to the user through either the data receive or the OBB data receive mechanism. You can write only 1 byte of OOB data at a time.

2.14.1. Writing OOB Data (Sockets API)

To send OOB data to a remote process, use the MSG_OOB flag with the `send()`, `sendmsg()`, and `sendto()` functions.

Example 2.22, "Writing OOB Data (Sockets API)" shows a TCP server using the MSG_OOB flag with the `send()` routine.

Example 2.22. Writing OOB Data (Sockets API)

```
/* This program accepts a connection on TCP port 1234, sends the string,
   "Hello, world!", waits two seconds, sends an urgent BEL (^G), waits
   another two seconds, repeats the Hello message, and terminates. */

#include <types.h>
#include <in.h>
#include <socket.h>
#include <unixio.h>

#define PORTNUM 123

main() {
   struct sockaddr_in lcladdr;
   int r, s, one = 1;
   char *message = "Hello, world!\r\n",
        *oob_message = "\007";
   memset()

   lcladdr.sin_family = AF_INET;
   lcladdr.sin_addr.s_addr = INADDR_ANY;
   lcladdr.sin_port = htons(PORTNUM);
   if ((s = socket(AF_INET, SOCK_STREAM, 0)) < 0) perror("socket");
   if (setsockopt(s, SOL_SOCKET, SO_REUSEADDR, &one, sizeof(one)))
      perror("setsockopt");
   if (bind(s, &lcladdr, sizeof(lcladdr))) perror("bind");
   if (listen(s, 1)) perror("listen");
   if ((r = accept(s, 0, 0)) < 0) perror("accept");
   if (send(r, message, strlen(message), 0) != strlen(message))
      perror("send");
   sleep(2);
   if (send(r,❶ oob_message,❷ strlen(oob_message),❸ MSG_OOB ❹) !=
            strlen(oob_message)) perror("send");
   sleep(2);
   if (send(r, message, strlen(message), 0) != strlen(message))
      perror("send");
   sleep(2);
   if (close(r)) perror("close");
   if (close(s)) perror("close");
}
```

The `send()` routine is used to send OOB data to a remote socket, as follows:

❶ `r` specifies the remote socket descriptor connected to the local socket as a result of a call to the `socket()` routine.

❷ `oob_message` is the buffer containing the OOB data.

❸ `strlen(oob_message)` specifies the length, in bytes, of the buffer containing the out-of-band data.

❹ `MSG_OOB` is the flag that indicates the data will be sent out of band.

2.14.2. Writing OOB Data (System Services)

To send out-of-band data to a remote process, use the IO$_WRITEVBLK function with the IO $M_INTERRUPT modifier. *Example 2.23, "Writing OOB Data (System Services)"* shows a TCP server using the TCPIP$C_MSG_OOB flag.

Example 2.23. Writing OOB Data (System Services)

```
/*
**
**  Attempt to send Out Of Band data to a previously established network
**  connection. Use the function code of IO$_WRITEVBLK, passing the address
**  of the buffer to P1, and the OOB code, TCPIP$C_MSG_OOB, to P4.
**
*/
    OOBBuff = 7;
    sysSrvSts = sys$qiow( 0,              /* efn.v | 0              */
                          IOChannel,      /* chan.v                 */
                  ❶ IO$_WRITEVBLK,     /* func.v                 */
                          &iosb,          /* iosb.r | 0             */
                          0, 0,           /* astadr, astprm: UNUSED */
                  ❷ &OOBBuff,          /* p1.r IO buffer         */
                          1,              /* p2.v IO buffer  size   */
                          0,              /* p3 UNUSED              */
                  ❸ TCPIP$C_MSG_OOB,   /* p4.v IO options flag   */
                          0, 0            /* p5, p6 UNUSED          */
                        );

    if((( sysSrvSts & 1  ) != 1 ) || /* Validate the system service status.
 */
       ((  iosb.cond_value & 1  ) != 1))  /* Validate the IO status. */
        {
        cleanup( IOChannel );
        errorExit( sysSrvSts, iosb.cond_value );
        }
    else
        if( iosb.count == 0 )
            printf( "    FAILED to send the OOB message, no connection.
\n" );
        else
            printf( "    SUCCEEDED in sending the OOB message.\n" );
```

This example writes the data that is in the buffer.

❶ Use the IO$_WRITEVBLK function to send OOB data.

❷ Specify the buffer address of the OOB data in **p1** and the length of the buffer in **p2**.

❸ Specify the TCPIP$C_MSG_OOB flag to indicate the type of data, in **p4**.

2.15. Sending Datagrams (UDP Protocol)

An application that uses UDP can send a datagram to a remote host, send broadcast datagrams to multiple remote hosts, or send multicast datagrams to members of a group.

With broadcasting, you send datagrams in one operation to multiple remote hosts on the specified subnetwork. With multicasting, you send datagrams in one operation to all hosts that are members of a particular group. The member hosts can be located on the local network or on remote networks, as long as the routers are configured to support multicasting.

2.15.1. Sending Datagrams (System Services)

You can use either of the following methods to send datagrams:

- To send datagrams from the local host to one remote host, use the $QIO system service with the IO $_ACCESS modifier. This allows you to specify the remote socket name once, and then to use the IO$_WRITEVBLK routine to send each datagram without specifying the socket name again.
- To send datagrams from the local host to several remote hosts, use the $QIO system service with the IO$_WRITEVBLK routine, and specify the remote socket name in the **p3** argument field.

2.15.2. Sending Broadcast Datagrams (Sockets API)

You can broadcast datagrams by calling the `sendto()` function.

2.15.3. Sending Broadcast Datagrams (System Services)

To broadcast datagrams, use a $QIO system service command with the IO$_WRITEVBLK routine.

Before issuing broadcast messages, the application must issue the IO$_SETMODE function. This sets the broadcast option in the socket. The process must have SYSPRV, BYPASS, or OPER privilege to issue broadcast messages. However, the system manager can disable privilege checking by using the management command SET PROTOCOL UDP /BROADCAST. For more information, refer to the *VSI TCP/IP Services for OpenVMS Management Command Reference* guide.

2.15.4. Sending Multicast Datagrams

To send IP multicast datagrams, specify the IP destination address in the range of 224.0.0.0 to 239.255.255.255 using the IO$_WRITEVBLK routine or the `sendto()` Sockets API function. Make sure you include the IN.H header file.

The system maps the specified IP destination address to the appropriate Ethernet or FDDI multicast address before it transmits the datagram.

You can control multicast options by specifying the following arguments to the `setsockopt()` Sockets API, or the IO$SETMODE system service.

- Time to Live (TTL)

  IP_MULTICAST_TTL (Sockets API)

  TCPIP$C_IP_MULTICAST_TTL (OpenVMS system services)

Specifies the distance the multicast datagrame will travel as an integer value between 0 and 255.

Value	Result
0	Restricts distribution to applications running on the local host.
1	Forwards the multicast datagram to hosts on the local subnet.
1 – 255	With a multicast router attached to the sending host's network, forwards multicast datagrams beyond the local subnet. Multicast routers forward the datagram to known networks that have hosts belonging to the specified multicast group. The TTL value is decremented by each multicast router in the path. When the TTL value reaches 0, the datagram is no longer forwarded.

For example:

```
u_char ttl;
ttl=2;

if (setsockopt(sock, IPPROTO_IP, IP_MULTICAST_TTL, &ttl,
         sizeof(ttl)) == -1)
 perror("setsockopt");
```

- Multicast interface

  IP_MULTICAST_IF (Sockets API)

  TCPIP$C_MULTICAST_IF (OpenVMS system services)

  Specifies a network interface other than that specified by the route in the kernel routing table.

  Unless the application specifies that an alternate network interface is associated with the socket, the datagram addressed to an IP multicast destination is transmitted from the default network interface. The default interface is determined by the interface associated with the default route in the kernel routing table or by the interface associated with an explicit route, if one exists.

  For example:

```
int sock;

struct in_addr ifaddress;

char *if_to_use = "16.141.64.251";
.
.
.

  ifaddress.s_addr = inet_addr(if_to_use);

  if (setsockopt(sock, IPPROTO_IP, IP_MULTICAST_IF, &ifaddress,

                               sizeof(ifaddress)) == -1)

     perror ("error from setsockopt IP_MULTICAST_IF");

  else
```

```
        printf ("new interface set for sending multicast datagrams\n");
```

- Disable loopback

  IP_MULTICAST_LOOP (Sockets API)

  TCPIP$C_MULTICAST_LOOP (OpenVMS system services)

  If a multicast datagram is sent to a group of which the sending host is a member, a copy of the datagram is looped back by the IP layer for local delivery (default). To disable loopback delivery, specify the loop value as 0.

  For example:

```
u_char loop=0;
if (setsockopt( sock, IPPROTO_IP, IP_MULTICAST_LOOP, &loop
         sizeof(loop)) == -1)
 perror("setsockopt");
```

  To enable loopback delivery, specify a `loop` value of 1. For improved performance, VSI recommends that you disable loopback unless the host must receive copies of the datagrams.

For a complete list of socket options, see *Appendix A, "Socket Options"*.

2.16. Using the Berkeley Internet Name Domain Service

The Berkeley Internet Name Domain (BIND) service is a host name and address lookup service for the Internet. If BIND is enabled on your system, you can make a call to the BIND resolver to obtain host names and addresses.

Typically, you make a call to the BIND resolver either before you bind a socket or before you make a connection to a socket. You can also use this service to translate either the local or remote host name to an address before making a connection.

2.16.1. BIND Lookups (Sockets API)

If the BIND resolver is enabled on your system and the host name is not found in the local database, you can use either of the following functions to search the BIND database:

- `gethostbyaddr()` gets a host record from the local host or BIND database when given the host address.
- `gethostbyname()` gets a host record from the local host or BIND database when given the host name.

The host record contains both name and address information.

Example 2.24, "BIND Lookup (Sockets API)" shows how to use the `gethostname()`, `gethostbyname()`, and `gethostbyaddr()` functions to find a local host name and address.

Example 2.24. BIND Lookup (Sockets API)

```
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
```

```
#include <netdb.h>               /* define network database library info */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */

int main( void )
{
    char host[1024];
    struct in_addr addr;
    struct hostent *hptr;

    /*
     * get name of local host
     */
    if ( (gethostname(host, sizeof(host))) < 0 )  ❶
        {
        perror( "Failed to get host's local name" );
        exit( EXIT_FAILURE );
        }

    printf( "Local hostname: %s\n", host );

    /*
     * lookup local host record by name
     */

    if ( !(hptr = gethostbyname(host)) )    ❷
        {
        perror( "Failed to find record for local host" );
        exit( EXIT_FAILURE );
        }

    addr.s_addr = *(int *) hptr->h_addr;
    printf( "Official hostname: %s  address: %s\n",
            hptr->h_name, inet_ntoa(addr) );

    /*
     * lookup local host record by address
     */

    hptr = gethostbyaddr( &addr.s_addr, sizeof(addr.s_addr), AF_INET );  ❸
    if ( !hptr )
        {
        perror( "Failed to find record for local host" );
        exit( EXIT_FAILURE );
        }

    printf( "Back-translated hostname: %s\n", hptr->h_name );

    exit( EXIT_SUCCESS );
}
```

In this example, the following functions and arguments were used to find a local host name and address:

❶ `gethostname()` gets the local host name.

`host` is the address of the buffer that receives the host name.

`sizeof(host)` is the size of the buffer that receives the host name.

❷ `gethostbyname()` looks for the host record that has the specified name.

On successful return of the `gethostbyname()` function, `hptr` receives the address of a `hostent` structure containing the host name, alias names, host address type, length of address (4 or 16), and an array of IPv4 addresses of the host being sought `gethostbyaddr()` looks for the host record that has the specified address.

❸ `addr.s_addr` specifies the address of the host being sought. It points to a series of bytes in network order, not to an ASCII string.

`sizeof(addr.s_addr)` specifies the number of bytes in the address to which the first argument points.

`AF_INET` points to the IPv4 Internet address family.

2.16.2. BIND Lookups (System Services)

If BIND is enabled on your system, the IO$_ACPCONTROL system service searches the BIND database for the host name if it does not find the name in the local host database.

Example 2.25, "BIND Lookup (System Services)" shows how to use OpenVMS system services to find a host name and address.

Example 2.25. BIND Lookup (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors           */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag        */
#include <in.h>                 /* define internet related constants,   */
                                /* functions, and structures            */
#include <inet.h>               /* define network address info          */
#include <iodef.h>              /* define i/o function codes            */
#include <netdb.h>              /* define network database library info */
#include <ssdef.h>              /* define system service status codes   */
#include <starlet.h>            /* define system service calls          */
#include <stdio.h>              /* define standard i/o functions        */
#include <stdlib.h>             /* define standard library functions    */
#include <string.h>             /* define string handling functions     */
#include <stsdef.h>             /* define condition value fields        */
#include <tcpip$inetdef.h>      /* define tcp/ip network constants,     */
                                /* structures, and functions            */


struct iosb
    {                               /* i/o status block                 */
    unsigned short status;          /* i/o completion status            */
    unsigned short bytcnt;          /* bytes transferred if read/write  */
    void *details;                  /* address of buffer or parameter   */
    };

struct acpfunc
    {                               /* acp subfunction                  */
    unsigned char code;             /* subfunction code                 */
    unsigned char type;             /* call code                        */
    unsigned short reserved;        /* reserved (must be zero)          */
    };
```

```
int main( void )
{
    char host[1024];
    char hostent[2048];
    struct in_addr addr;
    struct hostent *hptr;

    struct iosb iosb;                /* i/o status block                 */
    unsigned int status;             /* system service return status     */
    unsigned short channel;          /* network device i/o channel       */

❶  struct acpfunc func_byaddr =        /* acp gethostbyaddr function code
 */
        { INETACP_FUNC$C_GETHOSTBYADDR, INETACP$C_HOSTENT_OFFSET, 0 };

    struct acpfunc func_byname =     /* acp gethostbyname function code  */
        { INETACP_FUNC$C_GETHOSTBYNAME, INETACP$C_HOSTENT_OFFSET, 0 };

    struct dsc$descriptor p1_dsc =   /* acp function descriptor          */
        { 0, DSC$K_CLASS_S, DSC$K_DTYPE_T, 0 };

    struct dsc$descriptor p2_dsc =   /* acp p2 argument descriptor       */
        { 0, DSC$K_CLASS_S, DSC$K_DTYPE_T, 0 };

    struct dsc$descriptor p4_dsc =   /* acp p4 argument descriptor       */
        { 0, DSC$K_CLASS_S, DSC$K_DTYPE_T, 0 };

    $DESCRIPTOR( inet_device,        /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice     */

    /*
     * get name of local host
     */

    if ( (gethostname(host, sizeof(host))) < 0 )
        {
        perror( "Failed to get host's local name" );
        exit( EXIT_FAILURE );
        }

    printf( "Local hostname: %s\n", host );

    /*
     * assign i/o channel to network device
     */

    status = sys$assign( &inet_device,   /* device name                  */
                         &channel,       /* i/o channel                  */
                         0,              /* access mode                  */
                         0               /* not used                     */
                       );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel\n" );
        exit( status );
        }
```

```
    /*
     * lookup local host record by name
     */

❷  p1_dsc.dsc$w_length  = sizeof(func_byname);
    p1_dsc.dsc$a_pointer = (char *) &func_byname;

    p2_dsc.dsc$w_length  = strlen( host );
    p2_dsc.dsc$a_pointer = host;

    p4_dsc.dsc$w_length  = sizeof(hostent);
    p4_dsc.dsc$a_pointer = hostent;
❸
    status = sys$qiow( EFN$C_ENF,        /* event flag                   */
                       channel,          /* i/o channel                  */
                       IO$_ACPCONTROL,   /* i/o function code            */
                       &iosb,            /* i/o status block             */
                       0,                /* ast service routine          */
                       0,                /* ast parameter                */
                       &p1_dsc,          /* p1 - acp subfunction code    */
                       &p2_dsc,          /* p2 - hostname to lookup      */
                       &p4_dsc.dsc$w_length,/* p3 - return length address
 */
                       &p4_dsc,          /* p4 - output buffer address   */
                       0,                /* p5                           */
                       0                 /* p6                           */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to find record for local host\n" );
        exit( status );
        }

    hptr = (struct hostent *) hostent;
    hptr->h_name += (unsigned int) hptr;
    *(char **) &hptr->h_addr_list += (unsigned int) hptr;
    *(char **) hptr->h_addr_list  += (unsigned int) hptr;

    addr.s_addr = *(int *) hptr->h_addr;
    printf( "Official hostname: %s  address: %s\n",
            hptr->h_name, inet_ntoa(addr) );

    /*
     * lookup local host record by address
     */

    p1_dsc.dsc$w_length  = sizeof(func_byaddr);
    p1_dsc.dsc$a_pointer = (char *) &func_byaddr;

    p2_dsc.dsc$w_length  = strlen( inet_ntoa(addr) );
    p2_dsc.dsc$a_pointer = inet_ntoa( addr );

    p4_dsc.dsc$w_length  = sizeof(hostent);
    p4_dsc.dsc$a_pointer = hostent;
```

❹

```
    status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                       channel,          /* i/o channel                   */
                       IO$_ACPCONTROL,   /* i/o function code             */
                       &iosb,            /* i/o status block              */
                       0,                /* ast service routine           */
                       0,                /* ast parameter                 */
                       &p1_dsc,          /* p1 - acp subfunction code     */
                       &p2_dsc,          /* p2 - ip address to lookup     */
                       &p4_dsc.dsc$w_length,/* p3 - return length address
 */
                       &p4_dsc,          /* p4 - output buffer address    */
                       0,                /* p5                            */
                       0                 /* p6                            */
                     );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to find record for local host\n" );
        exit( status );
        }

    hptr = (struct hostent *) hostent;
    hptr->h_name += (unsigned int) hptr;

    printf( "Back-translated hostname: %s\n", hptr->h_name );

    /*
     * deassign i/o channel to network device
     */

    status = sys$dassgn( channel );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to deassign i/o channel\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example looks up nodes by either host name or IP address.

❶ Structure setup for IO$_ACPCONTROL parameter **p1**.

❷ Address and size of buffer to receive network information.

❸ The first call to the IO$_ACPCONTROL service specifies the host name in argument **p2**.

❹ The second call to the IO$_ACPCONTROL service specifies the IP address in argument **p2**.

2.17. Closing and Deleting a Socket

Closing a socket means that the program can no longer transmit data. Depending on how you close the socket, the program can receive data until the peer program also closes the socket.

When a remote system closes a socket, notification is not immediate, and another thread can erroneously attempt to use the socket.

If you send data to a closed socket, you might not receive an appropriate error message. Set the TCPIP $FULL_DUPLEX_CLOSE socket option if you want to have your application notified of an error when it sends data on a socket that has already been closed by the peer.

When you delete a socket, all pending messages queued for transmission are sent to the receiving socket before closing the connection.

2.17.1. Closing and Deleting (Sockets API)

Example 2.26, "Closing and Deleting a Socket (Sockets API)" shows a TCP application using the `close()` function to close and delete a socket.

Example 2.26. Closing and Deleting a Socket (Sockets API)

```
#include <socket.h>             /* define BSD socket api                */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <unixio.h>              /* define unix i/o                      */



int main( void )
{
    int sockfd;

    /*
     * create a socket
     */

    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * close socket
     */

    if ( close(sockfd) < 0 )  ❶
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

This example creates and closes a socket.

❶ The `sockfd` argument for the `close()` function closes the socket and deletes the socket descriptor previously defined by the `socket()` function.

2.17.2. Closing and Deleting (System Services)

Example 2.27, "Closing and Deleting a Socket (System Services)" shows a TCP application using $QIO system services to close and delete a socket.

Example 2.27. Closing and Deleting a Socket (System Services)

```
#include <descrip.h>              /* define OpenVMS descriptors           */
#include <efndef.h>               /* define 'EFN$C_ENF' event flag        */
#include <iodef.h>                /* define i/o function codes            */
#include <ssdef.h>                /* define system service status codes   */
#include <starlet.h>              /* define system service calls          */
#include <stdio.h>                /* define standard i/o functions        */
#include <stdlib.h>               /* define standard library functions    */
#include <stsdef.h>               /* define condition value fields        */
#include <tcpip$inetdef.h>        /* define tcp/ip network constants,     */
                                  /* structures, and functions            */


struct iosb
    {                                 /* i/o status block                 */
    unsigned short status;            /* i/o completion status            */
    unsigned short bytcnt;            /* bytes transferred if read/write  */
    void *details;                    /* address of buffer or parameter   */
    };

struct sockchar
    {                                 /* socket characteristics           */
    unsigned short prot;              /* protocol                         */
    unsigned char type;               /* type                             */
    unsigned char af;                 /* address format                   */
    };


int main( void )
{
    struct iosb iosb;                 /* i/o status block                 */
    unsigned int status;              /* system service return status     */
    unsigned short channel;           /* network device i/o channel       */
    struct sockchar sockchar;         /* socket characteristics buffer    */
    $DESCRIPTOR( inet_device,         /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );   /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;

    /*
     * assign i/o channel to network device
     */
```

```
status = sys$assign( &inet_device,   /* device name                  */
                     &channel,       /* i/o channel                 */
                     0,              /* access mode                 */
                     0               /* not used                    */
                   );

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to assign i/o channel\n" );
    exit( status );
    }

/*
 * create a socket
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                  */
                   channel,          /* i/o channel                 */
                   IO$_SETMODE,      /* i/o function code           */
                   &iosb,            /* i/o status block            */
                   0,                /* ast service routine         */
                   0,                /* ast parameter               */
                   &sockchar,        /* p1 - socket characteristics */
                   0,                /* p2                          */
                   0,                /* p3                          */
                   0,                /* p4                          */
                   0,                /* p5                          */
                   0                 /* p6                          */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
    }

/*
 * close socket
 */
```

❶

```
status = sys$qiow( EFN$C_ENF,        /* event flag                  */
                   channel,          /* i/o channel                 */
                   IO$_DEACCESS,     /* i/o function code           */
                   &iosb,            /* i/o status block            */
                   0,                /* ast service routine         */
                   0,                /* ast parameter               */
                   0,                /* p1                          */
                   0,                /* p2                          */
                   0,                /* p3                          */
                   0,                /* p4                          */
                   0,                /* p5                          */
                   0                 /* p6                          */
                 );
```

```
    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to close socket\n" );
        exit( status );
        }

    /*
     * deassign i/o channel to network device
     */

❷  status = sys$dassgn( channel );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to deassign i/o channel\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example closes the socket using the IO$_DEACCESS service and deletes it with the $DASSGN service.

❶ The IO$_DEACCESS service stops transmitting data and closes the socket.

❷ The $DASSGN service deletes the network device and deassigns the I/O channel previously acquired with the $ASSIGN service.

2.18. Shutting Down Sockets

You can shut down a socket before closing and deleting it. The shutdown operation allows you to shut down communication one process at a time. This maintains unidirectional rather than the normal bidirectional connections, allowing you to shut down communications on receive or transmit data queues, or both. For example, if you no longer want to transmit data but want to continue receiving data, shut down the transmit side of the socket connection and keep open the receive side.

2.18.1. Shutting Down a Socket (Sockets API)

Example 2.28, "Shutting Down a Socket (Sockets API)" shows a TCP application using the `shutdown()` function.

Example 2.28. Shutting Down a Socket (Sockets API)

```
#include <socket.h>             /* define BSD socket api               */
#include <stdio.h>              /* define standard i/o functions       */
#include <stdlib.h>             /* define standard library functions   */
#include <unixio.h>             /* define unix i/o                     */



int main( void )
{
    int sockfd;
```

```
    /*
     * create a socket
     */

    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    /*
     * shutdown a socket
     */

❶   if ( shutdown(sockfd, 2 ) < 0 )
        {
        perror( "Failed to shutdown socket connections" );
        exit( EXIT_FAILURE );
        }

    /*
     * close socket
     */
❷
    if ( close(sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

This example shows how to use the `shutdown()` function to shut down a socket.

❶ The `shutdown()` function calls the socket descriptor (`sockfd`). The corresponding values are:

- **0 –** Closes the receive socket queue.
- **1 –** Shuts down the socket.
- **2 –** Closes both the transmit and receive socket queues.

❷ The `close()` function then closes the socket and deletes the socket descriptor.

2.18.2. Shutting Down a Socket (System Services)

Example 2.29, "Shutting Down a Socket (System Services)" shows a TCP server using the IO $_DEACCESS function with the IO$M_SHUTDOWN function modifier to shut down all communications. In this example, no data is received or transmitted and all queued data is discarded.

Example 2.29. Shutting Down a Socket (System Services)

```
#include <descrip.h>            /* define OpenVMS descriptors          */
#include <efndef.h>             /* define 'EFN$C_ENF' event flag       */
#include <iodef.h>              /* define i/o function codes           */
#include <ssdef.h>              /* define system service status codes  */
```

```
#include <starlet.h>             /* define system service calls          */
#include <stdio.h>               /* define standard i/o functions        */
#include <stdlib.h>              /* define standard library functions    */
#include <stsdef.h>              /* define condition value fields        */
#include <tcpip$inetdef.h>       /* define tcp/ip network constants,     */
                                 /* structures, and functions            */


struct iosb
    {                                /* i/o status block                 */
    unsigned short status;           /* i/o completion status            */
    unsigned short bytcnt;           /* bytes transferred if read/write  */
    void *details;                   /* address of buffer or parameter   */
    };

struct sockchar
    {                                /* socket characteristics           */
    unsigned short prot;             /* protocol                         */
    unsigned char type;              /* type                             */
    unsigned char af;                /* address format                   */
    };


int main( void )
{
    struct iosb iosb;                /* i/o status block                 */
    unsigned int status;             /* system service return status     */
    unsigned short channel;          /* network device i/o channel       */
    struct sockchar sockchar;        /* socket characteristics buffer    */
    $DESCRIPTOR( inet_device,        /* string descriptor with logical   */
                 "TCPIP$DEVICE:" );  /* name of network pseudodevice     */

    /*
     * initialize socket characteristics
     */

    sockchar.prot = TCPIP$C_TCP;
    sockchar.type = TCPIP$C_STREAM;
    sockchar.af   = TCPIP$C_AF_INET;

    /*
     * assign i/o channel to network device
     */

    status = sys$assign( &inet_device,   /* device name                  */
                         &channel,       /* i/o channel                  */
                         0,              /* access mode                  */
                         0               /* not used                     */
                       );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to assign i/o channel\n" );
        exit( status );
        }

    /*
     * create a socket
```

```
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   channel,          /* i/o channel                   */
                   IO$_SETMODE,      /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   &sockchar,        /* p1 - socket characteristics   */
                   0,                /* p2                            */
                   0,                /* p3                            */
                   0,                /* p4                            */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to create socket\n" );
    exit( status );
    }

/*
 * shutdown a socket
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
                   channel,          /* i/o channel                   */
           ❶   IO$_DEACCESS|IO$M_SHUTDOWN,
                                     /* i/o function code             */
                   &iosb,            /* i/o status block              */
                   0,                /* ast service routine           */
                   0,                /* ast parameter                 */
                   0,                /* p1                            */
                   0,                /* p2                            */
                   0,                /* p3                            */
           ❷   TCPIP$C_DSC_ALL,     /* p4 - discard all packets     */
                   0,                /* p5                            */
                   0                 /* p6                            */
                 );

if ( status & STS$M_SUCCESS )
    status = iosb.status;

if ( !(status & STS$M_SUCCESS) )
    {
    printf( "Failed to shutdown socket connections\n" );
    exit( status );
    }

/*
 * close socket
 */

status = sys$qiow( EFN$C_ENF,        /* event flag                    */
```

```
                        channel,          /* i/o channel                  */
                        IO$_DEACCESS,     /* i/o function code            */
                        &iosb,            /* i/o status block             */
                        0,                /* ast service routine          */
                        0,                /* ast parameter                */
                        0,                /* p1                           */
                        0,                /* p2                           */
                        0,                /* p3                           */
                        0,                /* p4                           */
                        0,                /* p5                           */
                        0                 /* p6                           */
                      );

    if ( status & STS$M_SUCCESS )
        status = iosb.status;

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to close socket\n" );
        exit( status );
        }

    /*
     * deassign i/o channel to network device
     */

    status = sys$dassgn( channel );

    if ( !(status & STS$M_SUCCESS) )
        {
        printf( "Failed to deassign i/o channel\n" );
        exit( status );
        }

    exit( EXIT_SUCCESS );
}
```

This example shuts down a socket without completing pending I/O operations.

❶ To shut down a socket, use the IO$_DEACCESS service with the IO$M_SHUTDOWN modifier. This shuts down all or part of the full-duplex connection on the socket.

❷ In **p4**, the TCPIP$C_DSC_ALL flag specifies that pending I/O operations be discarded.

After the IO$_DEACCESS service completes, messages can no longer be transmitted or received on the socket.

2.19. Canceling I/O Operations

The $CANCEL system service cancels pending I/O requests on a specific channel Or socket. This includes all I/O requests queued and in progress.

There is no Sockets API function for this operation; the Sockets API library functions are synchronous.

Chapter 3. Using the Sockets API

This chapter describes how to use the Sockets API functions.

3.1. Internet Protocols

The IP (Internet Protocol) family is a collection of protocols on the Transport layer that use the Internet address format. The two basic Internet protocols are:

- TCP (Transmission Control Protocol)
- UDP (User Datagram Protocol)

The TCP/IP protocol suite has been extended beyond the basic 32-bit addressing capabilities of IPv4. With the new IPv6 protocol, the address size is increased to 128 bits. The basic syntax of socket functions remains the same, with extensions to the basic sockets API and advanced sockets application programming interfaces.

The following sections describe the basic TCP and UDP protocols, including the extensions provided for IPv6.

3.1.1. TCP Sockets

TCP provides reliable, flow-controlled, two-way transmission of data. A byte-stream protocol used to support the `SOCK_STREAM` abstraction, TCP uses standard IP address formats and provides a per-host collection of **port addresses**. Thus, each address consists of an internet address specifying the host and network, with a specific TCP port on the host identifying the peer entity.

Sockets using TCP are either **active** or **passive**, as described in *Table 3.1, "TCP Socket Types"*.

Table 3.1. TCP Socket Types

Socket Type	Description
Active	Initiates connections to passive sockets. By default, TCP sockets are active. Active sockets use the `connect()` function to initiate connections.
Passive	Listens for connection requests from active sockets. To create a passive socket, use the `bind()` function and then the `listen()` function. Passive sockets use the `accept()` function to accept incoming connections. If the server is running on a multihomed system, you can specify **wildcard addressing**. Wildcard addressing allows a single server to provide service to clients on multiple networks. (See *Section 3.1.1.1, "Wildcard Addressing"*.)

3.1.1.1. Wildcard Addressing

When a server is running on a host that has more than one network interface installed, you can use wildcard addressing to configure it to accept incoming connections on all the interfaces.

The wildcard address is the any-interface choice. You specify this address by setting the IP address in the socket address structure to `INADDR_ANY` (for IPv4) or `in6addr_any` (for IPv6) before calling the `bind()` function.

To create a socket that listens to all hosts on any network interface, perform these steps:

1. Bind the IP address (`INADDR_ANY` or `in6addr_any`). See *Section 2.3, "Binding a Socket (Optional for Clients)"*.
2. Specify the TCP port.

   If you do not specify the port, the system assigns a unique port, starting at port number 49152. Once connected, the socket's address is fixed by the peer entity's location.

The address assigned to the socket is the address associated with the network interface through which packets from the peer are being transmitted and received. This address corresponds to the peer entity's network.

TCP supports the setting of socket options with the `setsockopt()` function and the checking of current option settings with the `getsockopt()` function. Under most circumstances, TCP sends data when it is presented. When outstanding data has not been acknowledged, TCP gathers small amounts of output and sends it in a single packet when an acknowledgment is received.

Note

For some clients, such as Microsoft Windows systems, which send a stream of mouse events that receive no replies, this packetization can cause significant delays. TCP/IP Services provides the `TCP_NODELAY` option (defined in the TCP.H header file) to manage this problem. Refer to *Table A.2, "TCP Protocol Options"* for more information about setting this option. Note that this solution may cause an increase in network traffic.

3.1.2. UDP Sockets

UDP is a protocol that supports the `SOCK_DGRAM` abstraction for the internet protocol family. UDP sockets are connectionless and are normally used with the `sendto()` and `recvfrom()` functions. You can also use the `connect()` function to establish the destination address for future datagrams; then you use the `read()`, `write()`, `send()`, or `recv()` function to transmit or receive datagrams.

UDP address formats are identical to those used by TCP. In particular, UDP provides a port identifier in addition to the normal internet address format. Note that the UDP port space is separate from the TCP port space (for example, a UDP port cannot be connected to a TCP port). Also, you can send broadcast packets (assuming the underlying network supports broadcasting) by using a reserved broadcast address. This address is network-interface dependent. The `SO_BROADCAST` option must be set on the socket, and the process must have SYSPRV, BYPASS, or OPER privilege for broadcasting to succeed.

3.2. Structures

This section describes, in alphabetical order, the structures you supply as arguments to the various Sockets API functions. *Table 3.2, "Structures for Sockets API"* lists these structures.

Table 3.2. Structures for Sockets API

Structure	Description
`addrinfo`	This structure describes the type of socket, the address family, and the protocol.
`cmsghdr`	This structure describes ancillary data objects transferred by the `sendmsg()` and `recvmsg()` functions.

Structure	Description
`hostent`	This structure holds a canonical host name, alias names, a host address type, the length of the address, and a pointer to a list of host addresses. This structure is a parameter value for host name and address lookup functions.
`in_addr`	This structure holds a 32-bit IPv4 address stored in network byte order.
`in6_addr`	This structure holds a 128-bit IPv6 address stored in network byte order as an array of sixteen 8-bit elements.
`iovec`	This structure holds the beginning address and length of an I/O buffer.
`linger`	This structure holds option information for the `close` function.
`msghdr`	This structure holds the protocol address, the size of the protocol address, a scatter-and-gather array, the number of elements in the scatter-and-gather array, ancillary data, the length of the ancillary data, and returned flags. The structure is a parameter of the `recvmsg()` and `sendmsg()` functions.
`netent`	This structure holds a network name, a list of aliases associated with the network, and the network number.
`protoent`	This structure describes a protocol.
`servent`	This structure describes a network service.
`sockaddr`	The socket functions use this generic socket address structure to function with any of the supported protocol families.
`sockaddr_in`	This IPv4 socket address structure holds the length of the structure, the address family, either a TCP or a UDP port number, and a 32-bit IPv4 address stored in network byte order. The structure has a fixed length of 16 bytes.
`sockaddr_in6`	This IPv6 socket address structure holds the length of the structure, the address family, the transport layer port number, a priority and flow label, and a 128-bit IPv6 address. The structure has a fixed length of 28 bytes.
`timeval`	This structure holds a time interval specified in seconds and microseconds.

3.2.1. addrinfo Structure

The `addrinfo` structure is defined in the NETDB.H header file, and consists of the following components:

```
struct addrinfo {
     int              ai_flags;      /* input flags                    */
     int              ai_family;     /* protofamily for socket         */
     int              ai_socktype;   /* socket type                    */
     int              ai_protocol;   /* protocol for socket            */
     size_t           ai_addrlen;    /* length of socket-address       */
     char            *ai_canonname;  /* service location canonical name */
     struct sockaddr *ai_addr;       /* socket-address for socket      */
     struct addrinfo *ai_next;       /* pointer to next in list        */
};
```

3.2.2. cmsghdr Structure

The `cmsghdr` structure describes ancillary data objects transferred by the `sendmsg` and `recvmsg` functions.

The `msg_control` member of the `msghdr` data structure points to the ancillary data that are contained in a `cmsghdr` structure. Typically, only one data object is passed in a `cmsghdr` structure. However, the IPv6 advanced sockets API enables the `sendmsg` and `recvmsg` functions to pass multiple objects. For information about using raw IPv6 sockets, see *Section 3.6.1, "Using IPv6 Raw Sockets"*.

The data structure is defined in the SOCKET.H header file.

The `cmsghdr` data structure consists of the following components

```
struct cmsghdr {
     socklen_t cmsg_len;     /* #bytes, including this header */
     int cmsg_level;         /* originating protocol          */
     int cmsg_type;          /* protocol-specific type        */
     /* followed by unsigned char cmsg_data[];                */
};
```

3.2.3. hostent Structure

The `hostent` structure, defined in the NETDB.H header file, holds a host name, a list of aliases associated with the network, and the network's number as specified in an internet address from the hosts database.

The `hostent` structure definition is as follows:

```
struct  hostent {
     char    *h_name;        /* official name of host              */
     char    **h_aliases;    /* alias list                         */
     int     h_addrtype;     /* host address type                  */
     int     h_length;       /* length of address                  */
     char    **h_addr_list;  /* list of addresses from name server  */
};
#define h_addr  h_addr_list[0]  /* address, for backward compatibility */
```

The `hostent` structure members are as follows:

- `h_name` is a pointer to a null-terminated character string that is the official (canonical) name of the host.
- `h_aliases` is a pointer to an array of pointers to alias names for the host.

- `h_addrtype` is the type of host address being returned (AF_INET or AF_INET6).
- `h_length` is the length, in bytes, of the address. (For IPv4, this value is 4 bytes.)
- `h_addr_list` is a pointer to an array of pointers to the network addresses for the host. Each host address is represented by a series of bytes in network order. The list is terminated with a null pointer value.
- `h_addr` is the first address in the `h_addr_list`.

3.2.4. in_addr Structure

The `in_addr` structure, defined in the IN.H header file, holds an IPv4 address. The address format can be any of the supported internet address notation formats.

The `in_addr` structure definition is as follows:

```
struct in_addr {
    union {
              struct { u_char s_b1,s_b2,s_b3,s_b4; } S_un_b;
              struct { u_short s_w1,s_w2; } S_un_w;
              u_long S_addr;
}       S_un;
#define s_addr  S_un.S_addr       /* can be used for most tcp & ip code */
#define s_host  S_un.S_un_b.s_b2  /* host on imp                        */
#define s_net   S_un.S_un_b.s_b1  /* network                            */
#define s_imp   S_un.S_un_w.s_w2  /* imp                                */
#define s_impno S_un.S_un_b.s_b4  /* imp #                              */
#define s_lh    S_un.S_un_b.s_b3  /* logical host                       */
};
```

3.2.5. in6_addr Structure (IPv6)

The `in6_addr` structure, defined in the IN6.H header file, holds an IPv6 address. The address format can be any of the supported internet address notation formats. The address is stored in network byte order as an array of sixteen 8-bit elements.

The `in6_addr` structure definition is as follows:

```
     struct in6_addr {
          u_int8_t s6_addr[16]
     }
```

A wildcard address, defined in network byte order, has the following forms:

- A global variable, `in6addr_any`, that is an `in6_addr` structure.
- A symbolic constant, IN6ADDR_ANY_INIT, that can be used to initialize an `in6_addr` structure only when it is declared.

A loopback address, defined in network byte order, has the following forms:

- A global variable, `in6addr_loopback`, that is an `in6_addr` structure.
- A symbolic constant, IN6ADDR_LOOPBACK_INIT, that can be used to initialize an `in6_addr` structure only when it is declared.

3.2.6. iovec Structure

The `iovec` structure holds one scatter-and-gather buffer. Multiple scatter-and-gather buffer descriptors are stored as an array of `iovec` elements.

The `iovec` structure definition is defined in the SOCKET.H header file.

The `iovec` structure definition is as follows:

```
struct iovec {
       char *iov_base;
       int  iov_len;
}
```

The `iovec` structure members are as follows:

- `iov_base` is a pointer to a buffer.
- `iov_len` contains the size of the buffer to which `iov_base` points.

3.2.7. linger Structure

The `linger` structure, defined in the SOCKET.H header file, specifies the setting or resetting of the socket option for the time interval that the socket lingers for data. The `linger` structure is supported only by connection-based (SOCK_STREAM) sockets.

The `linger` structure definition is as follows:

```
struct  linger {
        int     l_onoff;              /* option on/off  */
        int     l_linger;             /* linger time    */
};
```

The `linger` structure members are as follows:

- `l_onoff`=1 sets `linger`; `l_onoff`=0 resets `linger`.
- `l_linger` is the number of seconds to linger. (The default is 120 seconds, or 2 minutes.)

3.2.8. msghdr Structure

The `msghdr` structure specifies the buffer parameter for the `recvmsg` and `sendmsg` I/O functions. The structure allows you to specify an array of scatter and gather buffers. The `recvmsg` function scatters the data to several user receive buffers, and the `sendmsg` function gathers data from several user transmit buffers before being transmitted.

The SOCKET.H header file defines the following structures for BSD Versions 4.3 and 4.4:

- `omsghdr` structure (BSD Version 4.3)
- `msghdr` structure (32- and 64-bit) (BSD Version 4.4)

3.2.8.1. BSD Version 4.3

The `omsghdr` structure definition for use with BSD Version 4.3 is as follows:

```
struct omsghdr {
    char          *msg_name;         /* protocol address              */
    int           msg_namelen;       /* size of address               */
    struct iovec  *msg_iov;          /* scatter/gather array          */
    int           msg_iovlen;        /* number of elements in msg_iov  */
    char          *msg_accrights;    /* access rights sent/received    */
    int           msg_accrightslen;  /* length of access rights buffer */
};
```

The `omsghdr` structure members are as follows:

- `msg_name` is the address of the destination socket if the socket is not connected. If no address is required, you can set this field to null.
- `msg_namelen` is the length of the `msg_name` field.
- `msg_iov` is an array of I/O buffer pointers of the `iovec` structure form. See *Section 3.2.6, "iovec Structure"* for a description of the `iovec` structure.
- `msg_iovlen` is the number of buffers in the `msg_iov` array.
- `msg_accrights` points to a buffer containing access rights sent with the message.
- `msg_accrightslen` is the length of the `msg_accrights` buffer.

3.2.8.2. BSD Version 4.4

The `msghdr` structure definition for use with BSD Version 4.4 is as follows:

```
struct msghdr {
    void         *msg_name;       /* protocol address               */
    int          msg_namelen;     /* size of address                */
    struct iovec *msg_iov;        /* scatter/gather array           */
    int          msg_iovlen;      /* number of elements in msg_iov   */
    void         *msg_control;    /* ancillary data; must be aligned
                                     for a cmsghdr structure         */
    int          msg_controllen;  /* length of ancillary data buffer */
    int          msg_flags;       /* flags on received message       */
};
```

The `msghdr` structure members are as follows:

- `msg_name` is the address of the destination socket if the socket is not connected. If no address is required, you can set this field to null.
- `msg_namelen` is the length of the `msg_name` field.
- `msg_iov` is an array of I/O buffer pointers of the `iovec` structure form. See *Section 3.2.6, "iovec Structure"* for a description of the `iovec` structure.
- `msg_iovlen` is the number of buffers in the `msg_iov` array.
- `msg_control` specifies the location of the optional ancillary data or control information.
- `msg_controllen` is the size of the ancillary data in the `msg_control` buffer.
- `msg_flags`, used only with the `recvmsg` function, is the value used by the kernel to drive its receive processing.

3.2.9. netent Structure

The `netent` structure, defined in the NETDB.H header file, holds a network name, a list of aliases associated with the network, and the network's number specified as an internet address from the network database.

The `netent` structure definition is as follows:

```
struct  netent {
     char    *n_name;       /* official name of net */
     char    **n_aliases;   /* alias list           */
     int     n_addrtype;    /* net address type     */
     long    n_net;         /* net number           */
};
```

The `netent` structure members are as follows:

- `n_name` is the official network name.
- `n_aliases` is a null-terminated list of pointers to alternate names for the network.
- `n_addrtype` is the type of the network number returned (AF_INET or AF_INET6).
- `n_net` is the network number returned in host byte order.

3.2.10. protoent Structure

The `protoent` structure, defined in the NETDB.H header file, holds the description of the protocol from the protocols table.

A protocol is described by the `protoent` structure, as follows:

```
struct  protoent {
     char   *p_name;       /* official name of protocol */
     char   **p_aliases;   /* alias list                */
     long   p_proto;       /* protocol number           */
};
```

The members of this structure are:

`p_name`	The official name of the protocol.
`p_aliases`	A zero-terminated list of alternate names for the protocol.
`p_proto`	The protocol number.

3.2.11. servent Structure

The `servent` structure, defined in the NETDB.H header file, specifies or obtains a service name, a list of aliases associated with the service, and the service's number specified as an Internet address from the services database. An entry in the services database is created with the following TCP/IP management command:

```
SET SERVICE service
```

For more information, refer to the *VSI TCP/IP Services for OpenVMS Management Command Reference* guide.

A service mapping is described by the `servent` structure, as follows:

```
struct servent {
   char *s_name;     /* official service name           */
   char **s_aliases; /* alias list                      */
   int  s_port;      /* port number, network byte order */
   char *s_proto;    /* protocol to use                 */
};
```

The `servent` structure members are as follows:

- `s_name` is the official name of the service.
- `s_aliases` is a null-terminated list of pointers to alternate names for the service.
- `s_port` is the port number at which the service resides in network byte order.
- `s_proto` is the name of the protocol to use with the service.

The `getservbyname()` function maps service names to a `servent` structure by specifying a service name and, optionally, a qualifying protocol.

3.2.12. sockaddr Structure

The `sockaddr` structure, defined in the SOCKET.H header file, holds a general address family.

The SOCKET.H header file defines the following structures for BSD Versions 4.3 and 4.4:

- `osockaddr` structure (BSD Version 4.3)
- `sockaddr` structure (BSD Version 4.4)

3.2.12.1. BSD Version 4.3

The `osockaddr` structure definition for use with BSD Version 4.3 is as follows:

```
   struct osockaddr {
       u_short sa_family;     /* address family                  */
       char    sa_data[14];   /* up to 14 bytes of direct address */
};
```

The `osockaddr` structure members are as follows:

- `sa_family` is the address family or domain in which the socket was created.
- `sa_data` is the data string of up to 14 bytes of direct address.

3.2.12.2. BSD Version 4.4

The `sockaddr` structure definition for use with BSD Version 4.4 is as follows:

```
   struct sockaddr {
```

```
        u_char  sa_len;         /* total length                    */
        u_char  sa_family;      /* address family                  */
        char    sa_data[14];    /* up to 14 bytes of direct address */
};
```

The `sockaddr` structure members are as follows:

- `sa_len` is the length of the structure.
- `sa_family` is the address family or domain in which the socket was created.
- `sa_data` is the data string of up to 14 bytes of direct address.

3.2.13. sockaddr_in Structure

The `sockaddr_in` structure, defined in the IN.H header file, specifies an internet address family.

The `sockaddr_in` structure definition is as follows:

```
struct sockaddr_in {
     short   sin_family;            /* address family             */
     u_short sin_port;              /* port number                */
     struct  in_addr sin_addr;      /* internet address           */
     char    sin_zero[8];           /* 8-byte field of all zeroes */
};
```

The `sockaddr_in` structure members are as follows:

- `sin_family` is the address family (AF_INET or AF_INET6).
- `sin_port` is the port number in network order.
- `sin_addr` is the internet address in network order.
- `sin_zero` is an 8-byte field containing all zeros.

3.2.14. sockaddr_in6 Structure (IPv6)

The `sockaddr_in6` structure, defined in the IN6.H header file, defines an IPv6 socket address.

The IN6.H file defines the following structures depending on the setting of the `_SOCKADDR_LEN` compilation symbol:

- `sockaddr_in6` for BSD Version 4.3 (described in *Section 3.2.14.1, "BSD Version 4.3"*).
- `sockaddr_in6` for BSD Version 4.4 (described in *Section 3.2.14.2, "BSD Version 4.4"*).

3.2.14.1. BSD Version 4.3

If an application does not define the `_SOCKADDR_LEN` compilation symbol, the compiler generates the following BSD Version 4.3 structure:

```
struct sockaddr_in6 {
    sa_family_t     sin6_family;        /* AF_INET6                    */
```

```
    in_port_t       sin6_port;          /* Transport layer port #        */
    uint32_t        sin6_flowinfo;      /* IPv6 flow information         */
    struct in6_addr sin6_addr;          /* IPv6 address                  */
    uint32_t        sin6_scope_id;      /* set of interfaces for a scope */
};
```

The `sockaddr_in6` structure members are as follows:

- `sin6_family` is the address family (AF_INET6).
- `sin6_port` is the transport layer port number stored in network byte order.
- `sin6_flowinfo` is the priority and flow label stored in network byte order.
- `sin6_addr` is the internet address stored in network byte order.
- `sin6_scope_id` is a 32-bit integer identifying a set of interfaces appropriate for the scope of the address specified by the `sin6_addr` field. For a link scope, `sin6_scope_id` specifies an interface index. For a site scope, `sin6_scope_id` specifies a site identifier.

3.2.14.2. BSD Version 4.4

If an application defines the `_SOCKADDR_LEN` compilation symbol, the compiler generates the following BSD Version 4.4 structure.

```
struct sockaddr_in6 {
# define SIN6_LEN
    uint8_t         sin6_len;           /* length of this struct         */
    sa_family_t     sin6_family;        /* AF_INET6                      */
    in_port_t       sin6_port;          /* Transport layer port #        */
    uint32_t        sin6_flowinfo;      /* IPv6 flow information         */
    struct in6_addr sin6_addr;          /* IPv6 address                  */
    uint32_t        sin6_scope_id;      /* set of interfaces for a scope */
};
```

The `sockaddr_in6` structure members are as follows:

- `sin6_len` is the length of this structure (28 bytes).
- `sin6_family` is the address family (AF_INET6).
- `sin6_port` is the transport layer port number stored in network byte order.
- `sin6_flowinfo` is the priority and flow label stored in network byte order.
- `sin6_addr` is the internet address stored in network byte order.
- `sin6_scope_id` is a 32-bit integer identifying a set of interfaces appropriate for the scope of the address specified by the `sin6_addr` field. For a link scope, `sin6_scope_id` specifies an interface index. For a site scope, `sin6_scope_id` specifies a site identifier.

3.2.15. timeval Structure

The `timeval` structure, defined in the SOCKET.H header file, specifies time intervals. The `timeval` structure definition is as follows:

```
struct timeval {
    long tv_sec;
    long tv_usec;
};
```

The `timeval` structure members are as follows:

- `tv_sec` specifies the number of seconds to wait.
- `tv_usec` specifies the number of microseconds to wait.

3.3. Header Files

You can include header files on a OpenVMS system using any one of the following preprocessor directive statements:

```
#include types
#include <types.h>
#include <sys/types.h>
```

The `#include types` form of the `#include` preprocessor directive is possible on OpenVMS systems because all header files are located in a text library in the SYS$LIBRARY directory. On UNIX systems, you must specify header files (and subdirectories that locate a header file) within angle brackets (< >) or quotation marks (" ") .

For example, to include the header file TYPES.H on a UNIX system, use the following form of the `#include` directive:

```
#include <sys/types.h>
```

3.4. Constants and Address Variables (IPv6)

Table 3.3, "Constants and Address Variables (IPv6)" lists the constants and address variables available for use with the IPv6 structures.

Table 3.3. Constants and Address Variables (IPv6)

Entry	Description
in6addr_any	The wildcard address in network byte order for the structure `in6_addr`.
IN6ADDR_ANY_INIT	A symbolic constant used to initialize an `in6_addr` structure when it is declared.
in6addr_loopback	A loopback address defined in network byte order.
IN6ADDR_LOOPBACK_INIT	A symbolic constant used to initialize an `in6_addr` structure when it is declared.

3.5. Interface Identification (IPv6)

When TCP/IP Services initializes an interface, it assigns an integer known as an **interface index** to identify the interface. This interface identification is used to determine the interface on which a datagram is sent or received, or on which a multicast group is joined.

Table 3.4, "Interface Identification Functions" lists the functions related to handling the interface identification.

Table 3.4. Interface Identification Functions

Function	Description
`if_nametoindex()`	Maps an interface name to its corresponding index.
`if_indextoname()`	Maps an interface index to its corresponding name.
`if_nameindex()`	Returns an array of all interface names and indexes.
`if_freenameindex()`	Frees dynamic memory allocated by `if_nameindex()` to the array of interface names and indexes.

3.5.1. Sending IPv6 Multicast Datagrams

To send IPv6 multicast datagrams, an application indicates the multicast group to send to by specifying an IPv6 multicast address in a `sendto()` function. The system maps the specified IPv6 destination address to the appropriate Ethernet or FDDI multicast address prior to transmitting the datagram.

An application can explicitly control multicast options with arguments to the `setsockopt()` function. The following options can be set by an application using the `setsockopt()` function:

- Hop limit (IPV6_MULTICAST_HOPS)

  The IPV6_MULTICAST_HOPS option to the `setsockopt()` function allows an application to specify a value between 0 and 255 for the hop limit field.

  Multicast datagrams with a hop limit value of 0 restrict distribution of the multicast datagram to applications running on the local host. Multicast datagrams with a hop limit value of 1 are forwarded only to hosts on the local link. If a multicast datagram has a hop limit value greater than 1 and a multicast router is attached to the sending host's network, multicast datagrams can be forwarded beyond the local link. Multicast routers forward the datagram to known networks that have hosts belonging to the specified multicast group. The hop limit value is decremented by each multicast router in the path. When the hop limit value is decremented to 0, the datagram is not forwarded further.

  The following example shows how to use the IPV6_MULTICAST_HOPS option to the `setsockopt()` function:

  ```
  u_char hops;
  hops=2;

  if (setsockopt(sock, IPPROTO_IPV6, IPV6_MULTICAST_HOPS, &hops,
                 sizeof(hops)) < 0)
                 perror("setsockopt: IPV6_MULTICAST_HOPS error");
  ```

- Multicast interface (IPV6_MULTICAST_IF)

  A datagram addressed to an IPv6 multicast address is transmitted from the default network interface unless the application specifies that an alternate network interface is associated with the socket. The default interface is determined by the interface associated with the default route in the kernel routing table or by the interface associated with an explicit route, if one exists. Using the

IPV6_MULTICAST_IF option to the `setsockopt()` function, an application can specify a network interface other than that specified by the route in the kernel routing table.

The following example shows how to use the IPV6_MULTICAST_IF option to the `setsockopt()` function to specify an interface other than the default:

```
u_int if_index = 1;
.
.
.
if (setsockopt(sock, IPPROTO_IPV6, IPV6_MULTICAST_IF, &if_index,
               sizeof(if_index)) < 0)
               perror ("setsockopt: IPV6_MULTICAST_IF error");
               else
               printf ("new interface set for sending multicast
 datagrams\n");
```

The **if_index** parameter specifies the interface index of the desired interface, or specifies 0 to select a default interface. You can use the `if_nametoindex()` function to find the interface index.

- Disabling loopback of local delivery (IPV6_MULTICAST_LOOP)

  If a multicast datagram is sent to a group that has the sending node as a member, a copy of the datagram is, by default, looped back by the IP layer for local delivery. The IPV6_MULTICAST_LOOP option to the `setsockopt()` function allows an application to disable this loopback delivery.

  The following example shows how to use the IPV6_MULTICAST_LOOP option to the `setsockopt()` function:

```
u_char loop=0;
if (setsockopt( sock, IPPROTO_IPV6, IPV6_MULTICAST_LOOP, &loop,
                sizeof(loop)) < 0)
                perror("setsockopt: IPV6_MULTICAST_LOOP error");
```

  If the value of **loop** is 0, loopback is disabled; if the value of **loop** is 1, loopback is enabled. For performance reasons, you should disable the default by setting loop to 0, unless applications on the same host must receive copies of the datagrams.

3.5.2. Receiving IPv6 Multicast Datagrams

Before a node can receive IPv6 multicast datagrams destined for a particular multicast group other than the All Nodes group, an application must direct the node to become a member of that multicast group.

This section describes how an application can direct a node to add itself to and remove itself from a multicast group.

An application can direct the node it is running on to join a multicast group by using the IPV6_JOIN_GROUP option to the `setsockopt()` function:

```
struct ipv6_mreq imr6;
.
.
.
imr6.ipv6mr_interface = if_index;
if (setsockopt( sock, IPPROTO_IPV6, IPV6_JOIN_GROUP,
                (char *)&imr6, sizeof(imr6)) < 0)
```

```
                perror("setsockopt: IPV6_JOIN_GROUP error");
```

The **imr6** parameter has the following structure:

```
structipv6_mreq {
     struct in6_addr ipv6mr_multiaddr; /* IP multicast address of group */
     unsigned int ipv6mr_interface;    /* local interface index         */
     };
```

Each multicast group membership is associated with a particular interface. It is possible to join the same group on multiple interfaces. The *ipv6mr_interface* variable can be specified with a value of 0, which allows an application to choose the default multicast interface. Alternatively, specifying one of the host's local interfaces allows an application to select a particular multicast-capable interface. The maximum number of memberships that can be added on a single socket is subject to the IPV6_MAX_MEMBERSHIPS value, which is defined in the IN6.H header file.

To drop membership from a particular multicast group, use the IPV6_LEAVE_GROUP option to the `setsockopt` function:

```
struct ipv6_mreq imr6;
if (setsockopt( sock, IPPROTO_IPV6, IPV6_LEAVE_GROUP, &imr6,
                sizeof(imr6)) < 0)
                perror("setsockopt: IPV6_LEAVE_GROUP error");
```

The **imr6** parameter contains the same structure values used for adding membership.

If multiple sockets request that a node join a particular multicast group, the node remains a member of that multicast group until the last of those sockets is closed.

To receive multicast datagrams sent to a specific UDP port, the receiving socket must be bound to that port using the `bind()` function. More than one process can receive UDP datagrams destined for the same port if the `bind()` function is preceded by a `setsockopt()` function that specifies the SO_REUSEPORT option.

Delivery of IP multicast datagrams to SOCK_RAW sockets is determined by the protocol type of the destination.

3.5.3. Address Translation and Conversion Functions

The following functions are available for node name to address translation:

Function	Description
`gethostbyname()`	Returns IPv4 addresses.
`getaddrinfo()`	Protocol-independent function for mapping names to addresses.
`freeaddrinfo()`	Returns `addrinfo()` structures and dynamic storage to the system.

The following functions are available for address to node name translation:

Function	Description
`gethostbyaddr()`	Returns a node name for an IPv4 address.

Function	Description
`getnameinfo()`	Protocol-independent function for mapping addresses to names.
`freeaddrinfo()`	Returns `addrinfo()` structures and dynamic storage to the system.

The following address conversion functions convert both IPv4 and IPv6 addresses.

Function	Description
`inet_pton()`	Converts an address in its standard text presentation form to its numeric binary form, in network byte order.
`inet_ntop()`	Converts a numeric address to a text string suitable for presentation.

3.5.4. Address-Testing Macros

Table 3.5, "Summary of Address-Testing Macros" lists the currently defined address-testing macros and the return value for a valid test. To use these macros, include the IN.H file in your application.

Table 3.5. Summary of Address-Testing Macros

Macro	Return
IN6_IS_ADDR_UNSPECIFIED	True, if specified type.
IN6_IS_ADDR_LOOPBACK	True, if specified type.
IN6_IS_ADDR_MULTICAST	True, if specified type.
IN6_IS_ADDR_LINKLOCAL	True, if specified type.
IN6_IS_ADDR_SITELOCAL	True, if specified type.
IN6_IS_ADDR_V4MAPPED	True, if specified type.
IN6_IS_ADDR_V4COMPAT	True, if specified type.
IN6_IS_ADDR_MC_NODELOCAL	True, if specified scope.
IN6_IS_ADDR_MC_LINKLOCAL	True, if specified scope.
IN6_IS_ADDR_MC_SITELOCAL	True, if specified scope.
IN6_IS_ADDR_MC_ORGLOCAL	True, if specified scope.
IN6_IS_ADDR_MC_GLOBAL	True, if specified scope.
IN6_ARE_ADDR_EQUAL	True, if addresses are equal.

3.6. Advanced API (IPv6)

The advanced API provides support for advanced applications that may need knowledge of IPv6 headers. These applications commonly use raw sockets to access IPv6 or ICMPv6 header fields. The advanced interface provides the following:

- Support for portable interfaces for applications that use raw sockets under IPv6.
- Functions to access router headers.

- Functions to access option headers.

3.6.1. Using IPv6 Raw Sockets

Raw sockets are used in both IPv4 and IPv6 to bypass the TCP and UDP transport layers.

Table 3.6, "Differences Between IPv4 and IPv6 Raw Sockets" describes the principal differences between IPv4 and IPv6 raw sockets.

Table 3.6. Differences Between IPv4 and IPv6 Raw Sockets

	IPv4	**IPv6**
Use	Access ICMPv4, IGMPv4, and to read and write IPv4 datagrams that contain a protocol field the kernel does not recognize.	Access ICMPv6 and to read and write IPv6 datagrams that contain a Next Header field the kernel does not recognize.
Byte order	Not specified.	Network byte order for all data sent and received.
Send and receive complete packets	Yes	No. Uses ancillary data objects to transfer extension headers and hop limit information.

For output, applications can modify all fields, except for the flow label field, by using ancillary data or socket options, or both.

For input, applications can access all fields, except for the flow label, version number, and Next Header fields, and all extension headers by using ancillary data.

For IPv6 raw sockets other than ICMPv6 raw sockets, the application must set the `IPV6_CHECKSUM` socket option. For example:

```
int offset = 2;
setsockopt (fd, IPPROTO_IPV6, IPV6_CHECKSUM, &offset, sizeof(offset));
            perror("setsockopt: IPV6_CHECKSUM error")
```

This enables the kernel to compute and store a checksum for output and to verify the checksum on input. This relieves the application from having to perform source address selection on all outgoing packets. This socket option is disabled by default. You can explicitly disable this option by setting the offset variable to -1.

Using IPv6 raw sockets, an application can access the following information:

- ICMPv6 messages
- IPv6 header
- Routing header
- IPv6 options headers: hop-by-hop options header and destination options header

The following sections describe how to access this information.

3.6.1.1. Accessing ICMPv6 Messages

An ICMPv6 raw socket is a socket that is created by calling the `socket()` function with the `PF_INET6`, `SOCK_RAW`, and `IPPROTO_ICMPV6` arguments.

The kernel calculates and inserts the ICMPv6 checksum for all outbound ICMPv6 packets and verifies the checksum for all received packets. If the received checksum is incorrect, the packet is discarded.

Because ICMPv6 is a superset of ICMPv4, an ICMPv6 raw socket can receive many more messages than an ICMPv4 raw socket. By default, when you create an ICMPv6 raw socket, it passes all ICMPv6 message types to an application. An application, however, does not need access to all messages. An application can specify the ICMPv6 message types it wants passed by creating an ICMPv6 filter.

The ICMPv6 filter has a datatype of `struct icmp6_filter`. Use `getsockopt()` to retrieve the current filter and `setsockopt()` to store the filter. For example, to enable filtering of ICMPv6 messages, use the `ICMP6_FILTER` option, as follows:

```
struct icmp6_filter myfilter;

setsockopt (fd, IPPROTO_ICMPV6, IPV6_FILTER, &(myfilter), (sizeof)
(myfilter));
            perror("setsockopt: IPV6_FILTER error")
```

The value of *myfilter* is an ICMPv6 message type between 0 and 255.

Table 3.7, "ICMPv6 Filtering Macros" describes the ICMPv6 filter macros.

Table 3.7. ICMPv6 Filtering Macros

Macro	Description
`ICMP6_FILTER_SETPASSALL`	Passes all ICMPv6 messages to an application.
`ICMP6_FILTER_SETBLOCKALL`	Blocks all ICMPv6 messages from being passed to an application.
`ICMP6_FILTER_SETPASS`	Passes ICMPv6 messages of a specified type to an application.
`ICMP6_FILTER_SETBLOCK`	Blocks ICMPv6 messages of a specified type from being passed to an application.
`ICMP6_FILTER_WILLPASS`	Returns true, if specified message type is passed to application.
`ICMP6_FILTER_WILLBLOCK`	Returns true, if the specified message type is blocked from being passed to an application.

To clear an installed filter, call `setsockopt()` for the `ICMP_FILTER` option with a zero-length filter.

The kernel does not perform any validity checks on message type, message content, or packet structure. The application is responsible for checking them.

3.6.1.2. Accessing the IPv6 Header

When using IPv6 raw sockets, applications must be able to receive the IPv6 header content. To receive this optional information, use the `setsockopt()` function with the appropriate socket option.

Table 3.8, "Optional Information and Socket Options" describes the socket options for receiving optional information.

Table 3.8. Optional Information and Socket Options

Optional Information	Socket Option	cmsg_type
Source and destination IPv6 address, and sending and receiving interface	IPV6_RECVPKTINFO	IPV6_PKTINFO
Hop limit	IPV6_RECVHOPLIMIT	IPV6_HOPLIMIT
Routing header	IPV6_RECVRTHDR	IPV6_RTHDR
Hop-by-hop options	IPV6_RECVHOPOPTS	IPV6_HOPOPTS
Destination options	IPV6_RECVDSTOPTS	IPV6_DSTOPTS

The recvmsg() function returns the received data as one or more ancillary data objects in a cmsghdr data structure.

To determine the value of a socket option, use the getsockopt() function with the corresponding option. If the IPV6_RECVPKTINFO option is not set, the function returns an in6_pktinfo data structure with ipi6_addr set to in6addr_any and ipi6_addr set to zero. For other options, the function returns an option_len value of zero if there is no option value.

An application can receive the following IPv6 header information as ancillary data from incoming packets:

- Destination IPv6 address
- Interface index
- Hop limit

The IPv6 address and interface index are contained in a in6_pktinfo data structure that is received as ancillary data with the recvmsg() function. The in6_pktinfo data structure is defined in IN.H. The tasks associated with the IPv6 header are:

- Receiving an IPv6 address

  If the IPV6_RECVPKTINFO option is enabled, the recvmsg() function returns a in6_pktinfo data structure as ancillary data. The ipi6_addr member contains the destination IPv6 address from the received packet. For TCP sockets, the destination address is the local address of the connection.

- Receiving an interface

  If the IPV6_RECVPKTINFO option is enabled, the recvmsg() function returns a in6_pktinfo data structure as ancillary data. The ipi6_ifindex member contains the interface index of the interface that received the packet.

- Receiving a hop limit

  If the IPV6_RECVHOPLIMIT option is enabled, the recvmsg() function returns a cmsghdr data structure as ancillary data. The cmsg_type member is IPV6_HOPLIMIT and the cmsg_data[] member contains the first byte of the integer hop limit.

3.6.1.3. Accessing the IPv6 Routing Header

The advanced Sockets API enables you to access the IPv6 routing header. The routing header is an IPv6 extension header that enables an application to perform source routing. The type 0 routing header supports up to 127 intermediate nodes, or 128 hops.

Table 3.9, "Socket Calls for Routing Header Name Description" describes the sockets calls that an application uses to build and examine routing headers.

Table 3.9. Socket Calls for Routing Header Name Description

Function	Description
`inet6_rth_space()`	Returns the number of bytes required for a routing header.
`inet6_rth_init()`	Initializes buffer data for a routing header.
`inet6_rth_add()`	Adds one address to a routing header.
`inet6_rth_reverse()`	Reverses the order of fields in a routing header.
`inet6_rth_segments()`	Returns the number of segments, or addresses, in a routing header.
`inet6_rth_getaddr()`	Fetches one address from a routing header.

The tasks associated with the routing header are:

- Receiving a routing header

  To receive a routing header, an application calls `setsockopt()` with the `IPV6_RECVRTHDR` option enabled.

  For each received routing header, the kernel passes one ancillary data object in a `cmsghdr` structure with the `cmsg_type` member set to `IPV6_RTHDR`. An application processes a routing header by calling `inet6_rth_reverse()`, `inet6_rth_segments()`, and `inet6_rth_getaddr()`.

- Sending a routing header

  To send a routing header, an application specifies the header either as ancillary data in a call to `sendmsg()` or by calling `setsockopt()`. An application can remove a sticky routing header by calling `setsockopt()` for the `IPV6_RTHDR` option and specifying an option length of zero.

  When using ancillary data, the application sets the `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_RTHDR`. Use the `inet6_rth_space()`, `inet6_rth_init()`, and `inet6_rth_add()` functions to build the routing header.

  When an application specifies a routing header, the destination address specified in a call to the `connect()`, `sendto()`, or `sendmsg()` function is the final destination of the datagram. Therefore, the routing header contains the addresses of all intermediate nodes.

  The order of extension headers is static; therefore, an application can specify only one outgoing routing header.

3.6.1.4. Accessing the IPv6 Options Headers

The advanced Sockets API enables applications to access the following IPv6 options headers:

- Hop-by-hop header

A single hop-by-hop options header can contain a variable number of hop-by-hop options. Each option is encoded with a type, length, and value (TLV). The application uses sticky options or ancillary data to communicate this information with the kernel.

- Destination header

  One or more destination options headers can contain a variable number of destination options. A destination options header appearing before a routing header is processed by the first and subsequent destinations specified in the routing header. A destination option appearing after the routing header is processed only by the final destination. Each option is encoded with a type, length, and value (TLV). The application uses sticky options or ancillary data to communicate this information with the kernel.

For additional information about the alignment requirements of the headers and ordering of the extensions headers, see RFC 2460.

Table 3.10, "Socket Calls for Options Headers" lists the sockets calls that an application uses to build and examine hop-by-hop and destination headers.

Table 3.10. Socket Calls for Options Headers

Function	Description
`inet6_opt_init()`	Initializes buffer data for options.
`inet6_opt_append()`	Adds an option to the options header.
`inet6_opt_finish()`	Finishes adding options to the options header.
`inet6_opt_set_val()`	Adds one component of the option content to the options header.
`inet6_opt_next()`	Extracts the next option from the options header.
`inet6_opt_find()`	Extracts an option of a specified type from the options header.
`inet6_opt_get_val()`	Retrieves one component of the option content from the options header.

The tasks associated with the options headers are:

- Receiving hop-by-hop options

  To receive a hop-by-hop options header, an application calls `setsockopt()` with the `IPV6_RECVHOPOPTS` option enabled.

  When using ancillary data, the kernel passes a hop-by-hop options header to the application and sets the `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_HOPOPTS`.

  An application retrieves these options by calling `inet6_opt_next()`, `inet6_opt_find()`, and `inet6_opt_get_val()`.

- Sending hop-by-hop options

  To send a hop-by-hop options header, an application specifies the header either as ancillary data in a call to `sendmsg()` or by calling `setsockopt()` An application can remove a sticky hop-by-

hop options header by calling `setsockopt()` for the `IPV6_HOPOPTS` option and specifying an option length of zero (0).

When using ancillary data, all hop-by-hop options are specified by a single ancillary data object. The application sets `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_HOPOPTS`. Use the `inet6_opt_init()`, `inet6_opt_append()`, `inet6_opt_finish()`, and `inet6_opt_set_val()` calls to build the option header.

- Receiving destination options

  To receive a destination options header, an application calls `setsockopt()` with the `IPV6_RECVDSTOPTS` option enabled. The kernel passes each destination option to the application as one ancillary data object and sets the `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_DSTOPTS`.

  An application processes these options by calling `inet6_opt_next()`, `inet6_opt_find()`, and `inet6_opt_get_val()`.

- Sending destination options

  To send a destination options header, an application specifies the header either as ancillary data in a call to `sendmsg()` or by calling `setsockopt()`.

  An application can remove a sticky hop-by-hop options header by calling `setsockopt()` for either the `IPV6_RTHDRDSTOPTS` or the `IPV6_DSTOPTS` option and specifying a option length of zero (0).

  The API assumes that the extension headers are in order. Only one set of destination options can precede a routing header and only one set of destination options can follow a routing header.

  Each set can contain one or more options, but each set is considered a single extension header.

  When using ancillary data, the application passes a destination options header to the kernel in one of the following ways:

  - For destination options that precede a routing header, the application sets the `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_RTHDRDSTOPTS`. Any `setsockopt()` or ancillary data is ignored unless the application explicitly specifies its own routing header.
  - For destination options that follow a routing header or when no routing header is specified, the application sets the `cmsg_level` member to `IPPROTO_IPV6` and the `cmsg_type` member to `IPV6_DSTOPTS`.

  An application builds these options by calling `inet6_opt_init()`, `inet6_opt_append()`, `inet6_opt_finish()`, and `inet6_opt_set_val()`.

3.7. Calling a Socket Function from an AST State

Calls to various Sockets API functions return information in a static area. The OpenVMS environment allows an asynchronous system trap (AST) function to interrupt a Sockets API function during its execution. In addition, the ASTs of more privileged modes can interrupt ASTs of less privileged modes. Therefore, be careful when calling a Sockets API function from an AST state while a similar Sockets

API function is being called from either a non-AST state or a less-privileged access mode. You can use the SYS$SETAST system service to enable and disable the reception of AST requests.

The Sockets API functions that use a static area are:

- `gethostbyaddr()`
- `gethostbyname()`
- `getnetbyaddr()`
- `getnetbyname()`
- `getservbyname()`
- `getservbyport()`
- `getprotobyname()`
- `getprotobynumber()`

Caution

Because these Sockets API functions access files to retrieve information, you should not call these functions from either the KERNEL or the EXEC mode when the ASTs are disabled.

3.8. Using 64-Bit Buffer Addresses (Alpha and I64 Only)

The following functions accept both 32-bit and 64-bit addresses:

- `send()`
- `recv()`
- `sendto()`
- `sendmsg()`
- `recvfrom()`
- `recvmsg()`

To accept 64-bit addresses, the program must have the _INITIAL_POINTER_SIZE compiler option set to 64.

The `sendmsg()` and `recvmsg()` functions accept a pointer to the `msghdr` structure, which can be specified for either 32-bit or 64-bit addresses, as described in *Section 3.2.8, "msghdr Structure"*.

3.9. Standard I/O Functions

You cannot use standard I/O functions with the Sockets API. Specifically, the `fdopen()` function does not support sockets.

3.10. Guidelines for Compiling and Linking IPv6 Applications

To compile an IPv6 application that includes a file specification preceded by `"path/"`, you need to set up the environment as described in this section.

For example, if the application includes the following:

```
#include <path/file.h>
```

Set up the environment using the following commands:

```
$ DEFINE DECC$SYSTEM_INCLUDE TCPIP$EXAMPLES:
$ DEFINE ARPA TCPIP$EXAMPLES:
$ DEFINE NET TCPIP$EXAMPLES:
$ DEFINE NETINET TCPIP$EXAMPLES:
$ DEFINE SYS TCPIP$EXAMPLES:
```

If you are using any of the advanced APIs, you should:

- Add /INCLUDE_DIRECTORY=TCPIP$EXAMPLES: to the COMPILE command line. This allows the compiler to use the updated header files that exist in the TCPIP$EXAMPLES directory. Otherwise, the compiler will use the header files from the OpenVMS C Run-Time Library.
- Add TCPIP$LIBRARY:TCPIP$LIB/LIBRARY to the LINK command line. This allows the linker to resolve references to functions from TCPIP$LIB.OLB provided by TCP/IP Services.

See *Section E.6, "Sample Client/Server Programs"* for examples of the COMPILE and LINK command lines.

3.11. Compatibility with the OpenVMS VSI C Run-Time Library

To maintain compatibility with the VSI VSI C Run-Time Library for OpenVMS Version 4.0, use the predefined macro _DECC_V4_SOURCE, as shown in the format of the socket functions listed in *Chapter 4, "Sockets API Reference"*. For more information about using macros, refer to the *VSI C Run-Time Library Reference Manual for OpenVMS Systems* [https://docs.vmssoftware.com/vsi-c-run-time-library-reference-manual-for-openvms-systems/].

3.12. Error Checking: errno Values

Most Sockets API functions return a value that indicates whether the function was successful or unsuccessful. A return value of zero (0) indicates success, and a value of –1 indicates the function was unsuccessful.

If the function is not successful, it stores an additional value in the external variable `errno`. The value stored in `errno` is valid only when the function is not successful. The error codes are defined in the ERRNO.H header file.

All return codes and error values are of type `integer` unless otherwise noted.

The `errno` values can be translated to a message similar to those found on UNIX systems by using the `perror()` function. The `perror()` function writes a message on the standard error stream that describes the current setting of the external variable `errno`. The error message includes a character

string containing the name of the function that caused the error followed by a colon (:), a blank space, the system message string, and a newline character.

3.12.1. errno values

Table 3.11, "errno Values" lists the possible `errno` values.

Table 3.11. errno Values

Error	Description
EADDRINUSE	Address already in use. Each address can be used only once.
EADDRNOTAVAIL	Cannot assign requested address. Normally, these values result from an attempt to create a socket with an address not on this machine.
EAFNOSUPPORT	Address family not supported by protocol family. An address incompatible with the requested protocol was used.
EALREADY	Operation already in progress. An operation was attempted on a nonblocking object that already had an operation in progress.
ECONNABORTED	Software caused connection abort. Indicates that the software caused a connection abort because there is no space on the socket's queue and the socket cannot receive further connections. A connection abort occurred internal to your host machine.
ECONNREFUSED	Connection refused. No connection could be made because the target machine actively refused it. This usually results from trying to connect to a service that is inactive on a remote host.
ECONNRESET	Connection reset by peer. A connection was forcibly closed by a peer. This usually results from the peer executing a `shutdown()` call.
EDESTADDRREQ	Destination address required. A required address was omitted from an operation on a socket.
EHOSTDOWN	Host is down.

Error	Description
	A socket operation failed because the destination host was down.
EHOSTUNREACH	No route to host. A socket operation to an unreachable host was attempted.
EINPROGRESS	Operation now in progress. An operation that takes a long time to complete, such as `connect()`, was attempted on a nonblocking object.
EISCONN	Socket is already connected. A `connect()` request was made on a socket that was already connected, or a `sendto()` or `sendmsg()` request on a connected socket specified a destination other than the connected party. A path name lookup involved more than eight symbolic links.
EMSGSIZE	Message too long. A message sent on a socket was larger than the internal message buffer.
ENETDOWN	Network is down. A socket operation encountered a dead network.
ENETRESET	Network dropped connection on reset. The host you were connected to failed and rebooted.
ENETUNREACH	Network is unreachable. A socket operation to an unreachable network was attempted.
ENOBUFS	No buffer space available. An operation on a socket or pipe was not performed because the system lacked sufficient buffer space.
ENOPROTOOPT	Protocol not available. An invalid option was specified in a `getsockopt()` or `setsockopt()` call.
ENOTSOCK	Socket operation on a nonsocket.
ENTOTCONN	Socket is not connected.

Error	Description
	Request to send or receive data was not allowed because the socket is not connected.
EOPNOTSUPP	Operation not supported. For example, trying to accept a connection on a datagram socket.
EPFNOSUPPORT	Protocol family not supported. The protocol family was not configured into the system or no implementation for it exists.
EPROTONOSUPPORT	Protocol not supported. The protocol was not configured into the system or no implementation for it exists.
EPROTOTYPE	Protocol wrong type for socket. A protocol was specified that does not support the semantics of the socket type requested. For example you cannot use the ARPA Internet UDP protocol with type `SOCK_STREAM`.
ESHUTDOWN	Cannot send after socket shutdown. A request to send data was not allowed because the socket had already been shut down with a previous `shutdown()` call.
ESOCKTNOSUPPORT	Socket type not supported. Support for the socket type was not configured into the system or no implementation for it exists.
ETIMEDOUT	Connection timed out. A `connect()` request failed because the connected party did not respond properly after a period of time. (The timeout period is dependent on the communication protocol.)
EVMSERR	OpenVMS error code is nontranslatable.

3.12.2. Relationship Between errno and h_errno

A function failure sets either `h_errno` or `errno`, depending on which is appropriate for the failing condition.

The following example shows how to handle errors from the `gethostbyname()` function.

```
#include   <errno.h>
#include   <stdio.h>
#include   <netdb.h>

main()
{
    static char hostname[256];
```

```
    struct hostent *hostentptr;

    errno = 0;
    h_errno = 0;
    if ((hostentptr = gethostbyname("hndy")) == NULL) {
        printf("unknown host name errno is: %d h_errno is: %d\n",
errno, h_errn                                    ❶
        perror("p_gethostbyname");
        herror("h_gethostbyname");
    }

    errno = 0;
    h_errno = 0;
    if ((hostentptr = gethostbyname(0)) == NULL) {
        printf("illegal host name errno is: %d h_errno is: %d\n",
errno, h_errn                                    ❷
        perror("p_gethostbyname");
        herror("h_gethostbyname");
    }
}
```

This example handles two types of errors from the `gethostbyname()` function.

❶ The host name parameter `hndy` does not represent a known host. In this case, `gethostbyname()` sets `h_errno` to HOST_NOT_FOUND, but does not set `errno`.

The call to `perror` in this example would output:

```
p_gethostbyname: Error 0
```

The call to `herror` in this example would print a message describing the failure:

```
h_gethostbyname: Unknown
```

❷ The host name parameter is 0 (zero), an invalid argument. In this case, `gethostbyname()` sets `errno` to EINVAL, but does not set `h_errno`.

A call to `perror` would print a message describing the failure:

```
p_gethostbyname: Invalid
```

A call to `herror` would print:

```
h_gethostbyname: Error 0
```

Chapter 4. Sockets API Reference

This chapter describes the Sockets API functions.

4.1. Summary of Socket Functions

This chapter describes the Sockets API functions that are listed in *Table 4.1, "Sockets API Functions"*.

Table 4.1. Sockets API Functions

Function	Description
`accept()`	Accepts a connection on a passive socket.
`bind()`	Binds a name to a socket.
`close()`	Closes a connection and deletes a socket descriptor.
`connect()`	Initiates a connection on a socket.
`decc$get_sdc()`	Returns the socket device's OpenVMS I/O channel associated with a socket descriptor (for use with the VSI VSI C Run-Time Library).
`decc$socket_fd()`	Returns the socket descriptor associated with a Socket Device Channel (SDC).
`endhostent()`	Closes the hosts database file.
`endnetent()`	Closes the network database file.
`endprotent()`	Resets the index for the protocols table.
`endservent()`	Closes the network services database file.
`freeaddrinfo()`	Returns `addrinfo` structures and dynamic storage to the system.
`freehostent()`	Deprecated function. Replace with `freeaddrinfo()`.
`gai_strerror()`	Describes an error value for the `getaddrinfo()` and `getnameinfo()` functions.
`getaddrinfo()`	Protocol-independent function for mapping names to addresses.
`gethostaddr()`	Returns the standard host address for the processor.
`gethostbyaddr()`	Searches the hosts database for a host record with a given IPv4 address.
`gethostbyname()`	Searches the hosts database for a host record with a given name or alias.
`gethostbyname_r()`	The reentrant version of `gethostbyname()`.
`gethostent()`	Retrieves an entry from the hosts database file.
`gethostname()`	Returns the fully qualified name of the local host.
`getipnodebyaddr()`	Deprecated function. Replace with `getaddrinfo()`.
`getipnodebyname()`	Deprecated function. Replace with `getnameinfo()`.
`getnameinfo()`	Protocol-independent function for mapping addresses to names.
`getnetbyaddr()`	Searches the network database for a network record with a given address.
`getnetbyname()`	Searches the network database for a network record with a given name or alias.
`getnetent()`	Gets a network file entry from the networks database file.

Function	Description
`getservent()`	Retrieves an entry from the services database file.
`getpeername()`	Returns the name of the connected peer.
`getprotobyname()`	Searches the protocols database until a matching protocol name is found or until end of file is encountered.
`getprotobynumber()`	Searches the protocols database until a matching protocol number is found or until end of file is encountered.
`getprotoent()`	Gets a protocol database entry from the network services database.
`getservbyname()`	Gets information on the named service from the network services database.
`getservbyport()`	Gets information on the named port from the network services database.
`getsockname()`	Returns the name associated with a socket.
`getsockopt()`	Returns the options set on a socket.
`herror()`	Writes a message to standard error explaining `h_error`.
`hostalias()`	Searches for host aliases associated with a name.
`hsterror()`	Returns an error message string.
`htonl()`	Converts longwords from host byte order to network byte order.
`htons()`	Converts short integers from host byte order to network byte order.
`if_freenameindex()`	Frees dynamic memory allocated by `if_nameindex()` to the array of interface names and indexes.
`if_indextoname()`	Maps an interface index to its corresponding name.
`if_nameindex()`	Returns an array of all interface names and indexes.
`if_nametoindex()`	Maps an interface name to its corresponding index.
`inet6_opt_append()`	Returns the length of an IPv6 extension header with a new option and appends the option.
`inet6_opt_find()`	Finds a specific option in an extension header.
`inet6_opt_finish()`	Returns the total length of an IPv6 extension header, including padding, and initializes the option.
`inet6_opt_get_val()`	Extracts data items from the data portion of an IPv6 option.
`inet6_opt_init()`	Returns the length of an IPv6 extension header with no options and initializes the header.
`inet6_opt_next()`	Parses received option extension headers.
`inet6_opt_set_val()`	Adds one component of the option content to the options header.
`inet6_rth_add()`	Adds an IPv6 address to the routing header under construction.
`inet6_rth_getaddr()`	Retrieves an address for an index from an IPv6 routing header.
`inet6_rth_init()`	Initializes an IPv6 routing header.
`inet6_rth_reverse()`	Reverses the order of addresses in an IPv6 routing header.
`inet6_rth_segments()`	Returns the number of segments (addresses) in an IPv6 routing header.
`inet6_rth_space()`	Returns the number of bytes required for an IPv6 routing header.
`inet_addr()`	Deprecated function. Replace with `inet_aton()`.

Function	Description
inet_aton()	Converts a string to an IP address stored in a structure. Replaces the inet_addr() function.
inet_lnaof()	Returns the local network address portion of an IP address.
inet_makeaddr()	Returns an IP address, given a network address and a local address on that network.
inet_netof()	Returns the IP network address portion of an IP address.
inet_network()	Converts a null-terminated text string representing an IP address into a network address in local host format.
inet_ntoa()	Converts an IP address into an ASCII (null-terminated) string.
inet_ntop()	Converts a numeric address into a text string suitable for presentation.
inet_pton()	Converts an address in its standard text presentation form into its numeric binary form, in network byte order.
ioctl()	Controls devices. Used for setting sockets for nonblocking I/O.
listen()	Converts an unconnected socket into a passive (listen) socket and indicates that the TCP/IP kernel should accept incoming requests directed to the socket.
ntohl()	Converts longwords from network byte order into host byte order.
ntohs()	Converts short integers from network byte order into host byte order.
poll()	Monitors conditions on multiple file descriptors.
read()	Reads bytes from a file or socket and places them into a user-defined buffer.
recv()	Receives bytes from a connected socket and places them into a user-defined buffer.
recvfrom()	Receives bytes for a socket from any source.
recvmsg()	Receives bytes on a socket and places them into scattered buffers.
select()	Allows the polling or checking of a group of sockets for I/O activity.
send()	Sends bytes through a socket to a connected peer.
sendmsg()	Sends gathered bytes through a socket to any other socket.
sendto()	Sends bytes through a socket to any other socket.
sethostent()	Opens the hosts database file.
setnetent()	Opens the networks database file.
setprotent()	Sets the state of the protocols table.
setservent()	Opens the services database file.
setsockopt()	Sets options on a socket.
shutdown()	Shuts down all or part of a bidirectional connection on a socket.
socket()	Creates an endpoint for communication by returning a socket descriptor.
socketpair()	Creates a pair of connected sockets.
write()	Writes bytes from a user-defined buffer to a file or socket.
vaxc$get_sdc()	Not supported. Replace with decc$get_sdc().

4.2. Socket API Functions

This section describes functions that comprise the Sockets API and that are supported by TCP/IP Services.

accept()

accept() — Accepts a connection on a passive socket. The $QIO equivalent is the IO$_ACCESS system service with the IO$M_ACCEPT modifier.

Format

```
#include <types.h>
#include <socket.h>
int accept ( int s, struct sockaddr *addr, int *addrlen);
(_DECC_V4_SOURCE)
int accept ( int s, struct sockaddr *addr, size_t *addrlen);
(not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor returned by `socket()`, subsequently bound to an address with `bind()`, which is listening for connections after a `listen()`.

addr

A result argument filled in with the address of the connecting entity, as known to the TCP/IP kernel. The exact format of the structure to which the address parameter points is determined by the address family. Specify either the IPv4 address family (AF_INET) or the IPv6 address family (AF_INET6).

addrlen

A value/result argument. It should initially contain the size of the structure pointed to by **addr**. On return it will contain the actual length, in bytes, of the `sockaddr` structure that has been filled in by the TCP/IP kernel. See *Section 3.2.12, "sockaddr Structure"* for a description of the `sockaddr` structure.

Description

This function completes the first connection on the queue of pending connections, creates a new socket with the same properties as **s**, and allocates and returns a new descriptor for the socket. If no pending connections are present on the queue and the socket is not marked as nonblocking, `accept()` blocks the caller until a connection request is present. If the socket is marked nonblocking by using a `setsockopt()` call and no pending connections are present on the queue, `accept()` returns an error. You cannot use the accepted socket to accept subsequent connections. The original socket **s** remains open (listening) for other connection requests. This call is used with connection-based socket types (`SOCK_STREAM`).

You can `select` a socket for the purposes of performing an `accept` by selecting it for a read.

Related Functions

See also `bind()`, `connect()`, `listen()`, `select()`, and `socket()`.

Return Values

x

A positive integer that is a descriptor for the accepted socket.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNABORTED

A connection has been aborted.

EFAULT

The **addr** argument is not in a writable part of the user address space.

EINTR

The `accept()` function was interrupted by a signal before a valid connection arrived.

EINVAL

The socket is not accepting connections.

EMFILE

There are too many open file descriptors.

ENFILE

The maximum number of file descriptors in the system is already open.

ENETDOWN

TCP/IP Services was not started.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system was unable to allocate kernel memory.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The reference socket is not of type `SOCK_STREAM`.

EPROTO

A protocol error occurred.

EWOULDBLOCK

The socket is marked nonblocking, and no connections are present to be accepted.

bind()

bind() — Binds a name to a socket. The $QIO equivalent is the IO$_SETMODE system service with the **p3** argument.

Format

```
#include <types.h>
#include <socket.h>
int bind(int s, struct sockaddr *name, int namelen);
(_DECC_V4_SOURCE)
int bind(int s, const struct sockaddr *name, size_t namelen);
(not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with the `socket() function`.

name

Address of a structure used to assign a name to the socket in the format specific to the family (AF_INET or AF_INET6) socket address. See *Section 3.2.12, "sockaddr Structure"* for a description of the `sockaddr` structure.

namelen

The size, in bytes, of the structure pointed to by **name**.

Description

This function assigns a port number and IP address to an unnamed socket. When a socket is created with the `socket()` function, it exists in a name space (address family) but has no name assigned. The `bind()` function requests that a name be assigned to the socket.

Related Functions

See also `connect()`, `getsockname()`, `listen()`, and `socket()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EACCESS

The requested address is protected, and the current user has inadequate permission to access it.

EADDRINUSE

The specified internet address and ports are already in use.

EADDRNOTAVAIL

The specified address is not available from the local machine.

EAFNOSUPPORT

The specified address is invalid for the address family of the specified socket.

EBADF

The socket descriptor is invalid.

EDESTADDRREQ

The address argument is a null pointer.

EFAULT

The **name** argument is not a valid part of the user address space.

EINVAL

The socket is already bound to an address and the protocol does not support binding to a new address, the socket has been shut down, or the length or the **namelen** argument is invalid for the address family.

EISCONN

The socket is already connected.

EISDIR

The address argument is a null pointer.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The socket type of the specified socket does not support binding to an address.

close()

close() — Closes a connection and deletes a socket descriptor. The $QIO equivalent is the $DASSGN system service.

Format

```
#include <unixio.h>
int close (s);
```

Argument

s

A socket descriptor.

Description

This function deletes a descriptor from the per-process object reference table. Associated TCP connections close first.

If a call to `connect()` fails for a socket in connection mode, applications should use `close()` to deallocate the socket and descriptor.

Related Functions

See also `accept()`, `socket()`, and `write()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

EINTR

The `close()` function was interrupted by a signal that was caught.

connect()

connect() — Initiates a connection on a socket. The $QIO equivalent is the IO$_ACCESS system service.

Format

```
#include  <types.h>
#include <socket.h>
int connect (int s, struct sockaddr *name, int namelen); (_DECC_V4_SOURCE)
int connect (int s, const struct sockaddr *name, size_t namelen);
(not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with `socket()`.

name

The address of a structure that specifies the name of the remote socket in the format specific to the address family (AF_INET or AF_INET6).

namelen

The size, in bytes, of the structure pointed to by **name**.

Description

This function initiates a connection on a socket.

If **s** is a socket descriptor of type `SOCK_DGRAM`, then this call permanently specifies the peer where the data is sent. If **s** is of type `SOCK_STREAM`, then this call attempts to make a connection to the specified socket.

If a call to `connect()` fails for a connection-mode socket, applications should use `close()` to deallocate the socket and descriptor. If attempting to reinitiate the connection, applications should create a new socket.

Related Functions

See also `accept()`, `select()`, `socket()`, `getsockname()`, and `shutdown()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EADDRINUSE

Configuration problem. There are insufficient ports available for the attempted connection. The `inet` subsystem attribute `ipport_userreserved` should be increased.

EADDRNOTAVAIL

The specified address is not available from the local machine.

EAFNOSUPPORT

The addresses in the specified address family cannot be used with this socket.

EALREADY

A connection request is already in progress for the specified socket.

EBADF

The socket descriptor is invalid.

ECONNREFUSED

The attempt to connect was rejected.

EFAULT

The **name** argument is not a valid part of the user address space.

EHOSTUNREACH

The specified host is not reachable.

EINPROGRESS

O_NONBLOCK is set for the file descriptor for the socket, and the connection cannot be immediately established; the connection will be established asynchronously.

EINTR

The `connect()` function was interrupted by a signal while waiting for the connection to be established. Once established, the connection may continue asynchronously.

EINVAL

The value of the **namelen** argument is invalid for the specified address family, or the `sa_family` member in the socket address structure is invalid for the protocol.

EISCONN

The socket is already connected.

ELOOP

Too many symbolic links were encountered in translating the file specification in the address.

ENETDOWN

The local network connection is not operational.

ENETUNREACH

No route to the network or host is present.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The socket is listening and cannot be connected.

EPROTOTYPE

The specified address has a different type than the socket bound to the specified peer address.

ETIMEDOUT

The connection request timed out without establishing a connection.

EWOULDBLOCK

The socket is nonblocking, and the connection cannot be completed immediately. It is possible to use the `select()` function to select the socket for writing.

decc$get_sdc()

decc$get_sdc() — Returns the socket device's OpenVMS I/O channel (SDC) associated with a socket descriptor.

Format

```
#include  <socket.h>
short int decc$get_sdc (int s);
```

Argument

s

A socket descriptor.

Description

This function returns the SDC associated with a socket. Normally, socket descriptors are used either as file descriptors or with one of the functions that takes an explicit socket descriptor as its argument. Sockets are implemented using TCP/IP device sockets. This function returns the SDC used by a given socket descriptor so you can directly access the TCP/IP facilities by means of $QIO system services.

Return Values

0

Indicates that **s** is not an open socket descriptor.

x

The SDC number.

decc$socket_fd

decc$socket_fd — Returns the socket descriptor associated with a Socket Device Channel (SDC) for direct use with the VSI VSI C Run-Time Library.

Format

```
#include  <socket.h>
int decc$socket_fd (int channel);
```

Argument

channel

A valid SDC.

Description

This function associates a valid socket channel with an VSI VSI C Run-Time Library file descriptor, and returns the file descriptor. The file descriptor can then be used with any VSI VSI C Run-Time Library function that takes a file descriptor or socket descriptor as an input parameter.

Return Values

x

The socket descriptor.

-1

Indicates an error; the socket descriptor cannot be allocated.

endhostent()

endhostent() — Closes hosts database file.

Format

```
#include <netdb.h>
void endhostent (void);
```

Description

This function closes the hosts database file (TCPIP$ETC:IPNODES.DAT), previously opened with a `gethostbyaddr()`, `gethostent()`, or `gethostbyname()` function call.

If the most recent `sethostent()` function call is executed with a nonzero **stay_open** parameter, the `endhostent()` function does not close the hosts database file. You cannot close the hosts database

file until you make a call to `exit()`. A second call to `sethostent()` is issued with a **stay_open** parameter equal to 0 (zero). This ensures that a subsequent `endhostent()` call succeeds.

Related Functions

See also `gethostbyaddr()`, `gethostent()`, and `gethostbyname()`.

endnetent()

endnetent() — Closes the networks database file.

Format

```
#include <netdb.h>
void endnetent (void);
```

Description

This function closes the networks database file (TCPIP$SYSTEM:NETWORKS.DAT), previously opened with the `getnetent()`, `setnetent()`, `getnetbyaddr()`, or `getnetbyname()` function.

Related Functions

See also `getnetent()`, `getnetbyaddr()`, `getnetbyname()`, and `setnetent()`.

endprotoent()

endprotoent() — Resets the index for the protocols table.

Format

```
#include <netdb.h>
void endprotoent (void);
```

Description

This function resets the index for the protocols table previously accessed with a `getprotoent()`, `getprotobyname()`, or `getprotobynumber()` function call.

Related Functions

See also `getprotobyname()`, `getprotoent()`, and `getprotobynumber()`.

endservent()

endservent() — Closes the services database file.

Format

```
#include <netdb.h>
```

```
void endservent (void);
```

Description

This function closes the services database file (TCPIP$ETC:SERVICES.DAT), previously opened with the `getservent()`, `getservbyname()`, or `getservbyport()` function.

Related Functions

See also `getservent()`, `getservbyname()`, and `getservbyport()`.

freeaddrinfo()

freeaddrinfo() — Frees system resources used by an address information structure.

Format

```
#include <netdb.h>
void freeaddrinfo (struct addrinfo *ai);
```

Arguments

ai

Points to an `addrinfo` structure to be freed. The NETDB.H header file defines the `addrinfo` structure.

Description

This function frees an `addrinfo` structure and any dynamic storage pointed to by the structure. The process continues until the function encounters a NULL `ai_next` pointer.

gai_strerror()

gai_strerror() — Provides a descriptive text string that corresponds to an EAI_*xxx* error value.

Format

```
#include <netdb.h>
const char *gai_strerror ( int ecode );
```

Arguments

ecode

The **ecode** argument is one of the EAI_*xxx* values defined for the `getaddrinfo()` and `getnameinfo()` functions.

The values for **ecode** are:

EAI_AGAIN	The name could not be resolved at this time. Future attempts may succeed.

EAI_BADFLAGS	The flags parameter had an invalid value.
EAI_FAIL	A nonrecoverable error occurred when attempting to resolve the name.
EAI_FAMILY	The address family was not recognized.
EAI_MEMORY	There was a memory allocation failure when trying to allocate storage for the return value.
EAI_NONAME	The name does not resolve for the supplied parameters. Neither **nodename** nor **servname** were supplied. At least one of these must be supplied.
EAI_SERVICE	The service passed was not recognized for the specified socket type.
EAI_SOCKTYPE	The intended socket type was not recognized.
EAI_SYSTEM	A system error occurred; the error code can be found in `errno`.

Description

This function returns a descriptive text string that corresponds to an EAI_*xxx* error value. The return value points to a string that describes the error. If the argument is not one of the EAI_*xxx* values, the function returns a pointer to a string whose contents indicate an unknown error.

For a complete list of error codes, see *Appendix D, "Error Codes"*.

Return Values

x

Text string

-1

Failure

getaddrinfo()

getaddrinfo() — Takes a service location (**nodename**) or a service name (**servname**), or both, and returns a pointer to a linked list of one or more structures of type `addrinfo`.

Format

```
#include <socket.h>
#include <netdb.h>
int getaddrinfo ( const char *nodename, const char *servname,
const struct addrinfo *hints, struct addrinfo **res );
```

Arguments

nodename

Points to a network node name, alias, or numeric host address (for example, an IPv4 dotted-decimal address or an IPv6 hexadecimal address). An IPv6 nonglobal address with an intended scope zone may also be specified. This is a null-terminated string or NULL. NULL means the service location is local to the caller. The **nodename** and **servname** arguments must not both be NULL.

servname

Points to a network service name or port number. This is a null-terminated string or NULL; NULL returns network-level addresses for the specified nodename. The **nodename** and **servname** arguments must not both be NULL.

hints

Points to an `addrinfo` structure that contains information about the type of socket, address family, or protocol the caller supports. The NETDB.H header file defines the `addrinfo` structure. If **hints** is a null pointer, the behavior is the same as if `addrinfo` contained the value 0 for the `ai_flags`, `ai_socktype` and `ai_protocol` members and AF_UNSPEC for the `ai_family` member.

res

Points to a linked list of one or more `addrinfo` structures.

Description

This function takes a service location (**nodename**) or a service name (**servname**), or both, and returns a pointer to a linked list of one or more structures of type `addrinfo`. Its members specify data obtained from the local hosts database TCPIP$ETC:IPNODES.DAT file, the local TCPIP$HOSTS.DAT file, or one of the files distributed by DNS/BIND.

The NETDB.H header file defines the `addrinfo` structure.

If the **hints** argument is non-NULL, all `addrinfo` structure members other than the following members must be zero or a NULL pointer:

- `ai_flags`

  Controls the processing behavior of `getaddrinfo()`. See *Table 4.2, "ai_flags Member Values"* for a complete description of the flags.

- `ai_family`

  Specifies to return addresses for use with a specific protocol family.

  - If you specify a value of AF_UNSPEC, `getaddrinfo()` returns addresses for any protocol family that can be used with **nodename** or **servname**.
  - If the value is not AF_UNSPEC and `ai_protocol` is not zero, `getaddrinfo()` returns addresses for use only with the specified protocol family and protocol.
  - If the application handles only IPv4, set this member of the **hints** structure to PF_INET.

- `ai_socktype`

  Specifies a socket type for the given service. If you specify a value of 0, you will accept any socket type. This resolves the service name for all socket types and returns all successful results.

- `ai_protocol`

  Specifies a network protocol. If you specify a value of 0, you will accept any protocol. If the application handles only TCP, set this member to IPPROTO_TCP.

Table 4.2, "ai_flags Member Values" describes the values for `ai_flags` members.

Table 4.2. ai_flags Member Values

Flag Value	Description
AI_V4MAPPED	If `ai_family` is AF_INET, the flag is ignored. If `ai_family` is AF_INET6, `getaddrinfo()` searches for AAAA records. The lookup sequence is: 1. Local hosts database 2. TCPIP$ETC:IPNODES.DAT 3. BIND database The lookup for a particular type of record, for example an AAAA record, will be performed in each database before moving on to perform a lookup for the next type of record. ● If AAAA records are found, returns IPv6 addresses; no search for A records is performed. ● If no AAAA records are found, searches for A records. ● If A records found, returns IPv4-mapped IPv6 addresses. ● If no A records found, returns a NULL pointer.
AI_ALL|AI_V4MAPPED	If `ai_family` is AF_INET, the flag is ignored. If the `ai_family` is AF_INET6, `getaddrinfo()` searches for AAAA records. The lookup sequence is: 1. Local hosts database 2. TCPIP$ETC:IPNODES.DAT 3. BIND database The lookup for a particular type of record, for example an AAAA record, will be performed in each database before moving on to perform a lookup for the next type of record. ● If AAAA records are found, IPv6 addresses will be included with the returned addresses. ● If A records are found, returns IPv4-mapped IPv6 addresses and also any IPv6 addresses that were found with the AAAA record search. ● If no A records found, returns a NULL pointer.
AI_CANONNAME	If the **nodename** argument is not NULL, the function searches for the specified node's canonical name.

Flag Value	Description
	Upon successful completion, the `ai_canonname` member of the first `addrinfo` structure in the linked list points to a null-terminated string containing the canonical name of the specified node name. If the **nodename** argument is an address literal, the `ai_cannonname` member will refer to the **nodename** argument that has been converted to its numeric binary form, in network byte order. If the canonical name is not available, the `ai_canonname` member refers to the **nodename** argument or to a string with the same contents. The `ai_flags` field contents are undefined.
AI_NUMERICHOST	A non-NULL node name string must be a numeric host address string. Resolution of the service name is not performed.
AI_NUMERICSERV	A non-NULL service name string must be a numeric port string. Resolution of the service name is not performed.
AI_PASSIVE	Returns a socket address structure that your application can use in a call to `bind()`. If the **nodename** parameter is a NULL pointer, the IP address portion of the socket address structure is set to INADDR_ANY (for an IPv4 address) or IN6ADDR_ANY_INIT (for an IPv6 address). If not set, returns a socket address structure that your application can use to call `connect()` (for a connection-oriented protocol) or either `connect()`, `sendto()`, or `sendmsg()` (for a connectionless protocol). If the **nodename** argument is a NULL pointer, the IP address portion of the socket address structure is set to the loopback address.
AI_ADDRCONFIG	Used in combination with other flags, modifies the search based on the source address or addresses configured on the system.

You can use the flags in any combination to achieve finer control of the translation process. Many applications use the combination of the AI_ADDRCONFIG and AI_V4MAPPED flags to control their search.

- If the value of `ai_family` is AF_INET, and an IPv4 source address is configured on the system, `getaddrinfo()` searches for A records only. If found, `getaddrinfo()` returns IPv4 addresses. If not, `getaddrinfo()` returns a NULL pointer.

- If the value of `ai_family` is AF_INET6 and an IPv6 source address is configured on the system, `getaddrinfo()` searches for AAAA records. If found, `getaddrinfo()` returns IPv6 addresses. If not, and if an IPv4 address is configured on the system, `getaddrinfo()` searches for A records. If found, `getaddrinfo()` returns IPv4-mapped IPv6 addresses. If not, `getaddrinfo()` returns a NULL pointer.

These flags are defined in the NETDB.H header file.

addrinfo Structure Processing

Upon successful return, `getaddrinfo()` returns a pointer to a linked list of one or more `addrinfo` structures. The application can process each `addrinfo` structure in the list by following the `ai_next` pointer until a NULL pointer is encountered. In each returned `addrinfo` structure, the `ai_family`, `ai_socktype`, and `ai_protocol` members are the corresponding arguments for a call to the `socket()` function. The `ai_addr` member points to a filled-in socket address structure whose length is specified by the `ai_addrlen` member.

Return Values

0

Indicates success

-1

Indicates an error

Errors

EAI_AGAIN

The name could not be resolved at this time. Future attempts may succeed.

EAI_BADFLAGS

The flags parameter had an invalid value.

EAI_FAIL

A nonrecoverable error occurred when attempting to resolve the name.

EAI_FAMILY

The address family was not recognized.

EAI_MEMORY

There was a memory allocation failure when trying to allocate storage for the return value.

EAI_NONAME

The name does not resolve for the supplied parameters. Neither **nodename** nor **servname** were supplied. At least one of these must be supplied.

EAI_SERVICE

The service passed was not recognized for the specified socket type.

EAI_SOCKTYPE

The intended socket type was not recognized.

EAI_SYSTEM

A system error occurred; the error code can be found in `errno`.

gethostaddr

gethostaddr — Returns the standard host address for the processor.

Format

```
#include <socket.h>
int gethostaddr (char *addr);
```

Argument

addr

A pointer to the buffer in which the standard host address for the current processor is returned.

Description

This function returns the standard host address for the current processor. The returned address is null-terminated. The *addr* parameter must point to at least 16 bytes of free space.

Host addresses are limited to 16 characters.

Return Values

0

Indicates success.

-1

Indicates that an error has occurred and is further specified in the global `errno`.

gethostbyaddr()

gethostbyaddr() — Searches the hosts database that is referenced by the TCPIP$HOST logical name for a host record with a given IPv4 address. If the host record is not found there, the function may also invoke the BIND resolver to query the appropriate name server. The $QIO equivalent is the IO$_ACPCONTROL function with the INETACP_FUNC$C_GETHOSTBYADDR subfunction code.

Format

```
#include <netdb.h>
struct hostent *gethostbyaddr (const void *addr, size_t len, int type);
```

Arguments

addr

A pointer to a series of bytes in network order specifying the address of the host sought.

len

The number of bytes in the address pointed to by the **addr** argument.

type

The type of address format being sought (AF_INET).

Description

This function finds the first host record with the specified address in the hosts database or using DNS/BIND.

The `gethostbyaddr()` function uses a common static area for its return values. This means that subsequent calls to this function overwrite previously returned host entries. You must make a copy of the host entry if you want to save it.

Return Values

x

A pointer to an object having the `hostent` structure. See *Section 3.2.3, "hostent Structure"* for a description of the `hostent` structure.

NULL

Indicates an error; `errno` is set to one of the following values.

Errors

ENETDOWN

TCP/IP Services was not started.

HOST_NOT_FOUND

Host is unknown.

NO_DATA

The server recognized the request and the name, but no address is available for the name. Another type of name server request may be successful.

NO_RECOVERY

An unexpected server failure occurred. This is a nonrecoverable error.

TRY_AGAIN

A transient error occurred; for example, the server did not respond. A retry may be successful.

gethostbyname()

gethostbyname() — Searches the hosts database that is referenced by the TCPIP$HOST logical name for a host record with the specified name or alias. If the host record is not found, this function may also invoke the BIND resolver to query the appropriate name server for the information. The $QIO equivalent is the IO$_ACPCONTROL function with the INETACP_FUNC$C_GETHOSTBYNAME subfunction code.

Format

```
#include <netdb.h>
struct hostent *gethostbyname (char *name);
```

Argument

name

A pointer to a null-terminated character string containing the name or an alias of the host being sought.

Description

This function finds the first host with the specified name or alias in the hosts database, or using DNS/BIND.

The `gethostbyname()` function uses a common static area for its return values. This means that subsequent calls to this function overwrite previously returned host entries. You must make a copy of the host entry if you want to save it.

Note

Modules that include calls to `gethostbyname` or `gethostbyname_r` must be compiled with the C switch /PREFIX=ALL.

Return Values

x

A pointer to an object having the `hostent` structure. See *Section 3.2.3, "hostent Structure"* for a description of the `hostent` structure.

NULL

Indicates an error. `errno` is set to one of the following values.

Errors

ENETDOWN

TCP/IP Services was not started.

HOST_NOT_FOUND

Host is unknown.

NO_DATA

The server recognized the request and the name, but no address is available for the name. Another type of name server request may be successful.

NO_RECOVERY

An unexpected server failure occurred. This is a nonrecoverable error.

TRY_AGAIN

A transient error occurred; for example, the server did not respond. A retry may be successful.

gethostbyname_r()

gethostbyname_r() — Searches the hosts database that is referenced by the TCPIP$HOST logical name for a host record with the specified name or alias (reentrant). If the host record is not found, this function may also invoke the BIND resolver to query the appropriate name server for the information.

Format

```
#include <netdb.h>
int gethostbyname_r(const char *name, struct hostent *ret, char *buffer,
size_t buflen, struct hostent **result, int *h_errnop);
```

Arguments

name

The name or alias of the host which entry you want to find.

ret

The storage area to hold the retrieved host entry.

buffer

A pointer to a temporary buffer that the function can use during the operation to store the data associated with the host entry.

buflen

The length of the temporary buffer.

result

A pointer to a `struct hostent` where the function can store the host entry.

h_errnop

A pointer to a location where the function can store an error number if an error occurs.

Description

The `gethostbyname_r()` function is the reentrant version of `gethostbyname()`. The caller supplies a `hostent` structure **ret** which will be filled in on success, and a temporary buffer **buffer** of size **buflen**.

On success, **result** will point to the `hostent` structure. In case of an error or if no host is found, **result** will be NULL. The function returns 0 on success and a nonzero error number on failure.

Note

Modules that include calls to `gethostbyname` or `gethostbyname_r` must be compiled with the C switch /PREFIX=ALL.

Return Values

0

Successful completion.

nonzero

On error, the function returns an error number. The global variable `h_errno` is not modified, but the address of a variable in which to store error numbers is passed in `h_errnop`.

Errors

ENETDOWN

TCP/IP Services was not started.

ERANGE

The **buffer** is too small. The call should be retried with a larger **buffer**.

HOST_NOT_FOUND

Host is unknown.

NO_DATA

The server recognized the request and the name, but no address is available for the name. Another type of name server request may be successful.

NO_RECOVERY

An unexpected server failure occurred. This is a nonrecoverable error.

TRY_AGAIN

A transient error occurred; for example, the server did not respond. A retry may be successful.

gethostent()

gethostent() — Retrieves an entry from the hosts database file.

Format

```
#include <netdb.h>
struct hostent *gethostent (void);
```

Description

The `gethostent()` function reads the next entry of the hosts database file (TCPIP$ETC:IPNODES.DAT).

See the NETDB.H header file for a description of the `hostent` structure.

The `gethostent()` function uses a common static area for its return values. Therefore, subsequent calls to `gethostent()` overwrite any existing host entry. You must make a copy of the host entry, if you wish to save it.

Return Values

x

A pointer to an object having the `hostent` structure. See *Section 3.2.3, "hostent Structure"* for a description of the `hostent` structure.

NULL

Indicates an error; `errno` is set to one of the following values.

Errors

ENETDOWN

TCP/IP Services was not started.

HOST_NOT_FOUND

Host is unknown.

NO_DATA

The server recognized the request and the name, but no address is available for the name. Another type of name server request may be successful.

NO_RECOVERY

An unexpected server failure occurred. This is a nonrecoverable error.

TRY_AGAIN

A transient error occurred; for example, the server did not respond. A retry may be successful.

gethostname()

gethostname() — Returns the fully-qualified name of the local host.

Format

```
#include <types.h>
#include <socket.h>
int gethostname ( char *name, int namelen); (_DECC_V4_SOURCE)
int gethostname ( char *name, size_t namelen); (not_DECC_V4_SOURCE)
```

Arguments

name

The address of a buffer where the name should be returned. The returned name is null terminated unless sufficient space is not provided.

namelen

The size of the buffer pointed to by **name**.

Description

This function returns the translation of the logical names TCPIP$INET_HOST and TCPIP$INET_DOMAIN when used with the TCP/IP Services software.

Return Values

0

Indicates successful completion.

-1

Indicates an error occurred. The value of `errno` indicates the error.

Errors

EFAULT

The buffer described by **name** and **namelen** is not a valid, writable part of the user address space.

getnameinfo()

getnameinfo() — Maps addresses to names in a protocol-independent way.

Format

```
#include <socket.h>
#include <netdb.h>
int getnameinfo (const struct sockaddr *sa, size_t salen, char *node,
size_t nodelen, char *service, size_t servicelen, int flags);
```

Arguments

sa

Points either to a `sockaddr_in` structure (for IPv4) or to a `sockaddr_in6` structure (for IPv6) that holds the IP address and port number.

salen

Specifies the length of either the `sockaddr_in` structure or the `sockaddr_in6` structure.

node

Points to a buffer in which to receive the null-terminated network node name or alias corresponding to the address contained in the **sa**. A NULL pointer instructs `getnameinfo()` to not return a node name. The **node** argument and **service** argument must not both be zero.

nodelen

Specifies the length of the node buffer. A value of zero instructs `getnameinfo()` to not return a node name.

service

Points to a buffer in which to receive the null-terminated network service name associated with the port number contained in **sa**. A NULL pointer instructs `getnameinfo()` to not return a service name. The **node** argument and **service** argument must not both be 0.

servicelen

Specifies the length of the **service** buffer. A value of zero instructs `getnameinfo()` to not return a service name.

flags

Specifies changes to the default actions of `getnameinfo()`. By default, `getnameinfo()` searches for the fully-qualified domain name of the node in the hosts database and returns it. See *Table 4.3, "`getnameinfo()` Flags"* for a list of flags and their meanings.

Description

This function looks up an IP address and port number in a `sockaddr` structure specified by **sa** and returns node name and service name text strings in the buffers pointed to by the **node** and **service** arguments, respectively.

If the node name is not found, `getnameinfo()` returns the numeric form of the node address, regardless of the value of the **flags** argument. If the service name is not found, `getnameinfo()` returns the numeric form of the service address (port number) regardless of the value of the **flags** argument.

The application must provide buffers large enough to hold the fully-qualified domain name and the service name, including the terminating null characters.

Table 4.3, "`getnameinfo()` Flags" describes the flag bits and, if set, their meanings. The flags are defined in the NETDB.H header file.

Table 4.3. `getnameinfo()` Flags

Flag Value	Description
NI_DGRAM	Specifies that the service is a datagram service (SOCK_DGRAM). The default assumes a stream service (SOCK_STREAM). This is required for the few ports (512-514) that have different services for UDP and TCP.
NI_NAMEREQD	Returns an error if the host name cannot be located in the hosts database.
NI_NOFQDN	Searches the hosts database and returns the node name portion of the fully-qualified domain name for local hosts.
NI_NUMERICHOST[1]	Returns the numeric form of the host's address instead of its name. Resolution of the host name is not performed.
NI_NUMERICSERV[1]	Returns the numeric form (port number) of the service address instead of its name. The host name is not resolved.

[1]The two NI_NUMERIC* flags are required to support the -n flag that many commands provide.

Return Values

0

Indicates success.

x

Indicates an error occurred. The value of `errno` indicates the error.

Errors

EAI_AGAIN

The name could not be resolved at this time. Future attempts may succeed.

EAI_BADFLAGS

The **flags** argument had an invalid value.

EAI_FAIL

A nonrecoverable error occurred when attempting to resolve the name.

EAI_FAMILY

The address family was not recognized.

EAI_MEMORY

There was a memory allocation failure when trying to allocate storage for the return value.

EAI_NONAME

The name does not resolve for the supplied parameters. Neither the node name nor the service name were supplied. At least one of these must be supplied.

EAI_SYSTEM

A system error occurred; the error code can be found in `errno`.

getnetbyaddr()

getnetbyaddr() — Searches the network database that is referenced by the TCPIP$NETWORK logical name for a network record with the specified address. If the network record is not found, this function may invoke the BIND resolver to search TCPIP$SYSTEM:NETWORKS.DAT. The $QIO equivalent is the IO$_ACPCONTROL function with the INETACP_FUNC$C_GETNETBYADDR subfunction code.

Format

```
#include <netdb.h>
struct netent *getnetbyaddr (long net, int type) ;
```

Arguments

net

The network number, in host byte order, of the networks database entry required.

type

The type of network being sought (AF_INET or AF_INET6).

Description

This function finds the first network record in the networks database with the given address.

The `getnetbyaddr()` and `getnetbyname()` functions use a common static area for their return values. Subsequent calls to any of these functions overwrite any previously returned network entry. You must make a copy of the network entry if you want to save it.

Return Values

x

A pointer to an object having the `netent` structure. See *Section 3.2.9, "netent Structure"* for a description of the `netent` structure.

NULL

Indicates end of file or an error.

Errors

EINVAL

The *net* argument is invalid.

ESRCH

The search failed.

getnetbyname()

getnetbyname() — Searches the networks database for a network record with a specified name or alias. If the network record is not found, this function may invoke the BIND resolver to search TCPIP$SYSTEM:NETWORKS.DAT. The $QIO equivalent is the IO$_ACPCONTROL function with the INETACP_FUNC$C_GETNETBYNAME subfunction code.

Format

```
#include <netdb.h>
struct netent *getnetbyname (char *name);
```

Argument

name

A pointer to a null-terminated character string containing either the network name or an alias for the network name.

Description

This function finds the first network record in the networks database with the given name or alias.

The `getnetbyaddr()` and `getnetbyname()` functions use a common static area for their return values. Subsequent calls to any of these functions overwrite previously returned network entries. You must make a copy of the network entry if you want to save it.

Return Values

NULL

Indicates end of file or an error.

x

A pointer to an object having the `netent` structure. See *Section 3.2.9, "netent Structure"* for a description of the `netent` structure.

Errors

EFAULT

The buffer described by **name** is not a valid, writable part of the user address space.

EINVAL

The **name** argument is invalid.

ESRCH

The search failed.

getnetent()

getnetent() — Retrieves an entry from the networks database file.

Format

```
#include <netdb.h>
struct netent *getnetnet (void);
```

Description

This function opens and sequentially reads the networks database file (TCPIP$SYSTEM:NETWORKS.DAT) to retrieve network information.

Returns a pointer to a `netent` structure that contains the equivalent fields for a network description line in the networks database file. The `netent` structure is defined in the NETDB.H header file.

The networks database file remains open after a call by the `getservent()` function. Use the `endnetent()` function to close the networks database file. Use the `setnetent()` function to open the networks database file and reset the file marker to the beginning of the file.

The `getnetent()` function uses a common static area for its return values, so subsequent calls to this function overwrite any existing network entry. To save the network entry, you must make a copy of it.

Related Functions

See also `setnetent` and `endnetent`.

Return Values

x

A pointer to a `netent` structure.

0

Indicates an error or end of file.

getpeername()

getpeername() — Returns the name of the connected peer. The $QIO equivalent is the IO$_SENSEMODE function with the **p4** argument.

Format

```
#include <types.h>
#include <socket.h>
int getpeername ( int s, struct sockaddr*name, int *namelen);
 (_DECC_V4_SOURCE)
int getpeername ( int s, struct sockaddr*name, size_t *namelen);
 (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created using `socket()`.

name

A pointer to a buffer where the peer name is to be returned.

namelen

An address of an integer that specifies the size of the **name** buffer. On return, it is modified to reflect the actual length, in bytes, of the **name** returned.

Description

This function returns the name of the peer connected to the specified socket descriptor.

Related Functions

See also `bind()`, `socket()`, and `getsockname()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The descriptor is invalid.

EFAULT

The **name** argument is not a valid part of the user address space.

EINVAL

The socket has been shut down.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTCONN

The socket is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The operation is not supported for the socket protocol.

getprotobyname()

getprotobyname() — Searches the protocols table until a matching protocol name is found or until the end of the table is encountered.

Format

```
#include <netdb.h>
struct protoent *getprotobyname (char *name);
```

Argument

name

A pointer to a string containing the desired protocol name.

Description

This function returns a pointer to a `protoent` structure containing data from the protocols table. For information about the `protoent` structure, refer to *Section 3.2.10, "protoent Structure"*.

All information is contained in a static area, so it must be copied to be saved.

Related Functions

See also `getprotoent()` and `getprotobynumber()`.

Return Values

NULL

Indicates the end of the table or an error.

x

A pointer to a `protoent` structure.

getprotobynumber()

getprotobynumber() — Searches the protocols table until a matching protocol number is found or until the end of the table is encountered.

Format

```
#include <netdb.h>
struct protoent *getprotobynumber (int *proto);
```

Argument

proto

A pointer to a string containing the desired protocol number.

Description

This function returns a pointer to a `protoent` structure containing the data from the protocols table. For information about the `protoent` structure, refer to *Section 3.2.10, "protoent Structure"*.

All information is contained in a static area, so it must be copied to be saved.

Related Functions

See also `getprotoent()` and `getprotobyname()`.

Return Values

NULL

Indicates end of table or an error.

x

A pointer to a `protoent` structure.

getprotoent()

getprotoent() — Reads the next entry from the protocols table.

Format

```
#include <netdb.h>
struct protoent *getprotoent();
```

Description

This function returns a pointer to a `protoent` structure containing the data from the protocols table. For information about the `protoent` structure, refer to *Section 3.2.10, "protoent Structure"*.

The `getprotoent()` function keeps an index to the table, allowing successive calls to be used to search the entire table.

All information is contained in a static area, so it must be copied to be saved.

Related Functions

See also `getprotobyname()` and `getprotobynumber()`.

Return Values

NULL

Indicates the end of the table or an error.

x

A pointer to a `protoent` structure.

getservbyname()

getservbyname() — Gets information on the specified service from the services database that is referenced by the TCPIP$SERVICE logical name. If not found there, this function may invoke the BIND resolver to search TCPIP$ETC:SERVICES.DAT.

Format

```
#include <netdb.h>
struct servent *getservbyname (char *name, char *proto);
```

Arguments

name

A pointer to a string containing the name of the service about which information is required.

proto

A pointer to a string containing the name of the protocol (TCP or UDP) for which to search.

Description

This function searches the services database until a matching service name is found or the end of file is encountered. If a protocol name is also supplied, searches must also match the protocol.

This function returns a pointer to a `servent` structure containing the data from the network services database. For information about the `servent` structure, refer to *Section 3.2.11, "servent Structure"*.

All information is contained in a static area, so it must be copied to be saved.

Related Functions

See also `getservbyport()`.

Return Values

NULL

Indicates end of file or an error.

x

A pointer to a `servent` structure.

getservbyport()

getservbyport() — Gets information on the specified port from the services database that is referenced by the TCPIP$SERVICE logical name. If the specified port is not found, this function may invoke the BIND resolver to search TCPIP$ETC:SERVICES.DAT.

Format

```
#include <netdb.h>
struct servent *getservbyport (int port, char *proto);
```

Arguments

port

The port number for which to search. This port number should be specified in network byte order. You can use the `htons()` function to convert the port number to network byte order.

proto

A pointer to a string containing the name of the protocol (TCP or UDP) for which to search.

Description

This function searches the services database until a matching port is found, or until end of file is encountered. If a protocol name is also supplied, searches must also match the protocol.

This function returns a pointer to a `servent` structure containing the broken-out fields of the requested line in the network services database. For information about the `servent` structure, refer to *Section 3.2.11, "servent Structure"*.

All information is contained in a static area, so it must be copied to be saved.

Related Functions

See also `getservbyname()`.

Return Values

NULL

Indicates end of file or an error.

x

A pointer to a `servent` structure.

Errors

EPERM

Not owner. Indicates that the wrong port number was specified.

getservent()

getservent() — Retrieves an entry from the services database file.

Format

```
#include <netdb.h>
struct servent *getservent (void);
```

Description

This function reads the next line of the services database file (TCPIP$ETC:SERVICES.DAT).

An application program can use the `getservent()` function to retrieve information about a service (such as the protocol or the ports it uses) from the services database.

The `getservent()` function returns a `servent` structure that contains information from the services database file. See *Section 3.2.11, "servent Structure"* for a description of the `servent` structure. The `servent` structure is defined in the NETDB.H header file.

The ASCII text services database file remains open after a call by the `getservent()` function. Use the `endservent()` function to close the services database file. Use the `setservent()` function to open the services database file and reset the file marker to the beginning of the file.

The `getservent` function uses a common static area for its return values, so subsequent calls to this function overwrite any existing service entry. To save the services entry, you must make a copy of it.

Related Functions

See also `setservent` and `endservent`.

Return Values

x

A pointer to a `servent` structure.

NULL

Indicates an error or end of file.

getsockname()

getsockname() — Returns the name associated with a socket. The $QIO equivalent is the IO$_SENSEMODE function with the **p3** argument.

Format

```
#include <types.h>
#include <socket.h>
int getsockname (int s, struct sockaddr *name, int *namelen);
(_DECC_V4_SOURCE)
int getsockname (int s, struct sockaddr *name, size_t *namelen);
(not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with the `socket()` function and bound to the socket name with the `bind()` function.

name

A pointer to the buffer in which `getsockname()` should return the socket name.

namelen

A pointer to an integer containing the size of the buffer pointed to by **name**. On return, the integer indicates the actual size, in bytes, of the name returned.

Description

This function returns the current name for the specified socket descriptor. The name is in a format specific to the address family assigned to the socket (AF_INET, or AF_INET6 with BSD 4.4 when _SOCKADDR_LEN is defined).

The `bind()` function, not the `getsockname()` function, makes the association of the name to the socket.

Related Functions

See also `bind()` and `socket()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The descriptor is invalid.

EFAULT

The **name** argument is not a valid part of the user address space.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The operation is not supported for this socket's protocol.

getsockopt()

getsockopt() — Returns the options set on a socket. The $QIO equivalent is the IO$_SENSEMODE function.

Format

```
#include <types.h>
#include <socket.h>
int getsockopt (int s, int level, int optname, char *optval,
int *optlen); (_DECC_V4_SOURCE)
int getsockopt (int s, int level, int optname, void *optval,
size_t *optlen); (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created by the `socket()` function.

level

The protocol level for which the socket options are desired. It can have one of the following values:

SOL_SOCKET	Get the options at the socket level.
p	Any protocol number. Get the options for protocol level specified by *p*. The IPPROTO values are defined in the IN.H header file (for IPv4), or the IN6.H header file (for IPv6).

optname

Interpreted by the protocol specified in the level. Options at each protocol level are documented with the protocol.

For descriptions of the supported socket level options, see the description of `setsockopt()` in this chapter.

optval

Points to a buffer in which the value of the specified option should be placed by `getsockopt()`.

optlen

Points to an integer containing the size of the buffer pointed to by **optval**. On return, the integer is modified to indicate the actual size of the option value returned.

Description

This function gets information on socket options. See the appropriate protocol for information about available options at each protocol level.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EACCES

The calling process does not have appropriate permissions.

EBADF

The socket descriptor is invalid.

EDOM

The send and receive timeout values are too large to fit in the timeout fields of the socket structure.

EFAULT

The address pointed to by the **optval** argument is not in a valid (writable) part of the process space, or the **optlen** argument is not in a valid part of the process address space.

EINVAL

The **optval** or **optlen** argument is invalid; or the socket is shut down.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTSOCK

The socket descriptor is invalid.

ENOPROTOOPT

The option is unknown or the protocol is unsupported.

EOPNOTSUPP

The operation is not supported by the socket protocol.

ENOPROTOOPT

The option is unknown.

ENOTSOCK

The socket descriptor is invalid.

herror()

herror() — Writes a message to standard error explaining `h_error`.

Format

```
#include <netdb.h>
void herror (const char *string);
```

Argument

string

A user-printable string.

Description

This function maps the error number in the external variable `h_errno` to a locale-dependent error message.

hostalias()

hostalias() — Searches for host aliases associated with a name.

Format

```
#include <resolv.h>

char *hostalias (const char *name);
```

Argument

name

Points to the name of the host that you want to retrieve aliases from.

Description

This function searches for the alias associated with the **name** argument. The `HOSTALIASES` logical name can be used to define the name of a file that lists the host aliases, in the form:

```
host    alias
```

Return Values

x

The host alias.

NULL

Indicates an error.

hstrerror()

hstrerror() — Returns an error message string.

Format

```
#include <string.h>
char *hstrerror (int errnum);
```

Arguments

errnum

An error number specifying a value of `h_errno`.

Description

This function maps the error number specified by the **errnum** argument to a location-dependent error message string and returns a pointer to the string. The string pointed to by the return value cannot be modified by the program, but could be overwritten by subsequent calls to this function.

Return Values

x

A pointer to the generated message string.

-1

On error, `errno` might be set, but no return value is reserved to indicate an error.

Errors

If the `hstrerror()` function fails, `errno` is set to EINVAL, indicating the value of the **errnum** argument is an invalid error number.

htonl()

htonl() — Converts longwords from host byte order to network byte order.

Format

```
#include <in.h>
unsigned long int htonl (unsigned long int hostlong);
```

Argument

hostlong

A longword in host byte order (OpenVMS systems).

Description

This function converts 32-bit unsigned integers from host byte order to network byte order.

Data bytes transmitted over the network are expected to be in network byte order. Some hosts, like OpenVMS, have an internal data representation format that is different from the network byte order; this is called the host byte order. Network byte order places the byte with the most significant bits at lower addresses, but OpenVMS host byte order places the most significant bits at the highest address.

This function can be used to convert IP addresses from host byte order to network byte order.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

x

A longword in network byte order.

htons()

htons() — Converts short integers from host byte order to network byte order.

Format

```
#include <in.h>
unsigned short int htons (unsigned short int hostshort);
```

Argument

hostshort

A short integer in host byte order (OpenVMS systems). All short integers on OpenVMS systems are in host byte order unless otherwise specified.

Description

This function converts 16-bit unsigned integers from host byte order to network byte order.

Data bytes transmitted over the network are expected to be in network byte order. Some hosts, like OpenVMS, have an internal data representation format that is different from the network byte order; this is called the host byte order. Network byte order places the byte with the most significant bits at lower addresses, but OpenVMS host byte order places the most significant bits at the highest address.

This function is most often used with ports returned by the `getservent()` function. To convert port numbers from OpenVMS host byte order to network byte order, use the `htons()` function.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

x

A short integer in network byte order. Integers in network byte order cannot be used for arithmetic computation on OpenVMS systems.

if_freenameindex()

if_freenameindex() — Frees dynamic memory allocated by `if_nameindex()` to the array of interface names and indexes

Format

```
#include <if.h>
void if_freenameindex
(struct if_nameindex *ptr);
```

Arguments

ptr

Points to an array of structures returned by the `if_nameindex()` function.

Description

The `if_freenameindex()` function frees dynamic memory allocated to the array of interface names and indexes that the `if_nameindex()` function returned.

if_indextoname()

if_indextoname() — Maps an interface index to its corresponding name.

Format

```
#include <if.h>
char *if_indextoname (unsigned int ifindex, char *ifname);
```

Arguments

ifindex

The interface index.

ifname

Points to a buffer that is IFNAMSIZ bytes in length. (IFNAMSIZ is defined in the IF.H header file.) If an interface name is found, it is returned in the buffer.

Description

This function maps an interface index to its corresponding name.

Return Values

Interface name

If interface name is found, it is returned to the buffer.

NULL

If no interface name corresponds to the specified index, the function returns NULL and sets `errno` to ENXIO.

Errors

ENXIO

No interface name corresponds to the specified index.

System error

A system error.

if_nameindex()

if_nameindex() — Returns an array of all interface names and indexes.

Format

```
#include <if.h>
struct if_nameindex *if_nameindex (void);
```

Description

This function dynamically allocates memory for an array of `if_nameindex` structures, one structure for each interface. A structure with an `if_index` value of 0 and a NULL `if_name` value indicates the end of the array.

The following `if_nameindex` structure must also be defined by including the IF.H header file prior to the call to `if_nameindex()`:

```
struct if_nameindex {
   unsigned int   if_index;
   char           *if_name;
};
```

To free the memory allocated by this function, use the `if_freenameindex()` function. If an error occurs, the function returns a NULL pointer and sets `errno` to an appropriate value.

Return Values

NULL

Indicates an error; `errno` is set to an appropriate value.

if_nametoindex()

if_nametoindex() — Maps an interface name to its corresponding index.

Format

```
#include <if.h>
unsigned int if_nametoindex (const char *ifname);
```

Arguments

ifname

Points to a buffer that contains the interface name.

Description

This function maps an interface name to its corresponding interface index number.

Return Values

0 (zero)

Interface does not exist.

x

Upon successful conversion, the `if_nametoindex()` function returns an interface index number.

inet6_opt_append()

inet6_opt_append() — Returns the length of an IPv6 extension header with a new option and appends the option.

Format

```
#include <in6.h>
int inet6_opt_append (void *extbuf, size_t extlen, int offset,
uint8_t type, size_t len, uint_t align, void **databufp);
```

Arguments

extbuf

Points to a buffer that contains an extension header. This is either a valid pointer or a NULL pointer.

extlen

Specifies the length of the extension header to initialize. Valid values are 0 if **extbuf** equals 0, a value returned by `inet6_opt_finish()`, or any number that is a multiple of 8.

offset

Specifies the length of the existing extension header. Obtain this value from a prior call to `inet6_opt_init()` or `inet6_opt_append()`.

type

Specifies the type of option. Specify a value from 2 to 255, inclusive, excluding 194.

len

Specifies the length of the option data, excluding the option type and option length fields. Specify a value from 0 to 255, inclusive.

align

Specifies the alignment of the option. Specify one of the following values: 1, 2, 4, or 8.

databufp

Points to a buffer that contains the option data.

Description

This function, when called with **extbuf** as a NULL pointer and **extlen** as 0, returns the updated number of bytes in an extension header.

If you specify **extbuf** as a valid pointer and valid **extlen** and **align** arguments, the function returns the same information as in the previous case, but also inserts the pad option, initializes the **type** and **len** fields, and returns a pointer to the location for the option content.

After you call `inet6_opt_append()`, you can then use the data buffer directly or call `inet6_opt_set_val()` to specify the option contents.

Return Values

x

Upon successful completion, the `inet6_opt_append()` function returns the updated number of bytes in an extension header.

-1

Failure

Errors

EBADF

The socket descriptor is invalid.

ECONNABORTED

A connection has been aborted.

EFAULT

The **addr** argument is not in a writable part of the user address space.

EINTR

The `accept()` function was interrupted by a signal before a valid connection arrived.

EINVAL

The socket is not accepting connections.

EMFILE

There are too many open file descriptors.

ENFILE

The maximum number of file descriptors in the system is already open.

ENETDOWN

TCP/IP Services was not started.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system was unable to allocate kernel memory.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The reference socket is not of type `SOCK_STREAM`.

EPROTO

A protocol error occurred.

EWOULDBLOCK

The socket is marked nonblocking, and no connections are present to be accepted.

inet6_opt_find()

inet6_opt_find() — Finds a specific option in an extension header.

Format

```
#include <in6.h>
int inet6_opt_find (void *extbuf, size_t extlen, int offset, uint8_t type,
size_t *lenp, void **databufp);
```

Arguments

extbuf

Points to a buffer that contains an extension header.

extlen

Specifies the length, in bytes, of the extension header.

offset

Specifies the location in the extension header of an option. Valid values are either 0 (zero) for the first option or the length returned from a previous call to either `inet6_opt_next()` or `inet6_opt_find()`.

type

Specifies the type of option to find.

lenp

Points to the length of the option found.

databufp

Points to the option data.

Description

This function searches a received option extension header for an option specified by **type**. If it finds the specified option, it returns the option length and a pointer to the option data. It also returns an offset to the next option, which you can specify in the **offset** argument to subsequent calls to `inet6_opt_next()` in order to search for additional occurrences of the same option type.

Return Values

x

Upon successful completion, the `inet6_opt_find()` function returns an offset from which you can begin the next search in the data buffer.

-1

Failure

inet6_opt_finish()

inet6_opt_finish() — Returns the total length of an IPv6 extension header, including padding, and initializes the option.

Format

```
#include <in6.h>
int inet6_opt_finish (void *extbuf, size_t extlen, int offset);
```

Arguments

extbuf

Points to a buffer that contains an extension header. This is either a valid pointer or a NULL pointer.

extlen

Specifies the length of the extension header to finish initializing. A valid value is any number greater than or equal to 0.

offset

Specifies the length of the existing extension header. Obtain this value from a prior call to `inet6_opt_init()` or `inet6_opt_append()`.

Description

This function, when called with **extbuf** as a NULL pointer and **extlen** as 0, returns the total number of bytes in an extension header, including final padding.

If you specify **extbuf** as a valid pointer and a valid **extlen** argument, the function returns the same information as in the previous case, increments the buffer pointer, and verifies that the buffer is large enough to hold the header.

Return Values

x

Upon successful completion, the `inet6_opt_finish()` function returns the total number of bytes in an extension header, including padding.

-1

Failure

inet6_opt_get_val()

inet6_opt_get_val() — Extracts data items from the data portion of an IPv6 option.

Format

```
#include <in6.h>
int inet6_opt_get_val (void *databuf, size_t offset,
void *val, int vallen);
```

Arguments

databuf

Points to a buffer that contains an extension header. This is a pointer returned by a call to `inet6_opt_find()` or `inet6_opt_next()`.

offset

Specifies the location in the data portion of the option from which to extract the data. You can access the first byte after the option type and length by specifying the offset of 0.

val

Points to a destination for the extracted data.

vallen

Specifies the length of the data, in bytes, to be extracted.

Description

This function copies data items from data buffer **databuf** beginning at **offset** to the location **val**. In addition, it returns the **offset** for the next data field to assist you in extracting option content that has multiple fields.

Make sure that each field is aligned on its natural boundaries.

Return Values

x

Upon successful completion, the `inet6_opt_get_val()` function returns the offset for the next field in the data buffer.

-1

Failure

inet6_opt_init()

inet6_opt_init() — Returns the length of an IPv6 extension header with no options and initializes the header.

Format

```
#include <in6.h>
int inet6_opt_init (void *extbuf, size_t extlen);
```

Arguments

extbuf

Points to a buffer that contains an extension header. This is either a valid pointer or a NULL pointer.

extlen

Specifies the length of the extension header to initialize. Valid values are 0 and any number that is a multiple of 8.

Description

This function, when called with **extbuf** as a NULL pointer and **extlen** as 0, returns the number of bytes in an extension header that has no options.

If you specify **extbuf** as a valid pointer and **extlen** as a number that is a multiple of 8, the function returns the same information as in the previous case, initializes the extension header, and sets the length field.

Return Values

x

Upon successful completion, the `inet6_opt_init()` function returns the number of bytes in an extension header with no options.

-1

Failure

inet6_opt_next()

inet6_opt_next() — Parses received option extension headers.

Format

```
#include <in6.h>
int inet6_opt_next (void *extbuf, size_t extlen, int offset,
uint8_t *typep, size_t *lenp, void **databufp);
```

Arguments

extbuf

Points to a buffer that contains an extension header.

extlen

Specifies the length, in bytes, of the extension header.

offset

Specifies the location in the extension header of an option. Valid values are either 0 for the first option or the length returned from a previous call to either `inet6_opt_next()` or `inet6_opt_find()`.

typep

Points to the type of the option found.

lenp

Points to the length of the option found.

databufp

Points to the option data.

Description

This function parses a received option extension header and returns the next option. In addition, it returns an offset to the next option that you specify in the **offset** parameter to subsequent calls to `inet6_opt_next()`.

This function does not return any PAD1 or PADN options.

Return Values

x

Upon successful completion, the `inet6_opt_next()` function returns the offset for the next option in the data buffer.

-1

Failure

inet6_opt_set_val()

inet6_opt_set_val() — Adds one component of the option content to the options header.

Format

```
#include <in6.h>
int inet6_opt_set_val (void *databuf, size_t offset,
void *val int vallen);
```

Arguments

databuf

Points to a buffer that contains an extension header. This is a pointer returned by a call to `inet6_opt_append()`.

offset

Specifies the location in the data portion of the option into which to insert the data. You can access the first byte after the option type and length by specifying the offset of 0 (zero).

val

Points to the data to be inserted.

vallen

Specifies the length of the data, in bytes, to be inserted.

Description

This function copies data items at the location **val** into a data buffer **databuf** beginning at **offset**. In addition, it returns the offset for the next data field to assist you in composing content that has multiple fields.

Make sure that each field is aligned on its natural boundaries.

Return Values

x

Upon successful completion, the `inet6_opt_set_val()` function returns the offset for the next field in the data buffer.

-1

Failure

inet6_rth_add()

inet6_rth_add() — Adds an IPv6 address to the routing header under construction.

Format

```
#include <in6.h>
int inet6_rth_add (void *bp, const struct in6_addr *addr);
```

Arguments

bp

Points to a buffer that is to contain an IPv6 routing header.

addr

Points to an IPv6 address to add to the routing header.

Description

This function adds an IPv6 address to the end of the routing header under construction. The address pointed to by **addr** cannot be an IPv6 V4-mapped address or an IPv6 multicast address.

The function increments the `ip6r0_segleft` member in the `ip6_rthdr0 structure`. The `ip6_rthdr0` structure is defined in the IP6.H header file.

Only routing header type 0 is supported.

Return Values

x

Upon successful completion, the `inet6_rth_add()` function returns 0 (zero).

-1

Failure

inet6_rth_getaddr()

inet6_rth_getaddr() — Retrieves an address for an index from an IPv6 routing header.

Format

```
#include <in6.h>
struct in6_addr *inet6_rth_getaddr (const void *bp, int index);
```

Arguments

bp

Points to a buffer that contains an IPv6 routing header.

index

Specifies a value that identifies a position in a routing header for a specific address. Valid values range from 0 to the return value from `inet6_rth_segments()` minus 1.

Description

This function uses a specified **index** value and retrieves a pointer to an address in a routing header specified by **bp**. Call `inet6_rth_segments()` before calling this function in order to determine the number of segments (addresses) in the routing header.

Return Values

x

Upon successful completion, the `inet6_rth_getaddr()` function returns a pointer to an address.

NULL pointer

Failure

inet6_rth_init()

inet6_rth_init() — Initializes an IPv6 routing header buffer.

Format

```
#include <in6.h>
void *inet6_rth_init (void *bp, int bp_len, int type, int segments);
```

Arguments

bp

Points to a buffer that is to contain an IPv6 routing header.

bp_len

Specifies the length, in bytes, of the buffer.

type

Specifies the type of routing header. The valid value is `IPV6_RTHDR_TYPE_0` for IPv6 routing header type 0.

segments

Specifies the number of segments or addresses that are to be included in the routing header. The valid value is from 0 to 127, inclusive.

Description

This function initializes a buffer and buffer data for an IPv6 routing header. The function sets the `ip6r0_segleft`, `ip6r0_nxt`, and `ip6r0_reserved` members in the `ip6_rthdr0` structure to zero. In addition, it sets the `ip6r0_type` member to type and sets the `ip6r0_len` member based on the **segments** argument. The `ip6_rthdr0` structure is defined in the IP6.H header file.

The application must allocate the buffer. Use the `inet6_rth_space()` function to determine the buffer size.

Use the returned pointer as the first argument to the `inet6_rth_add()` function.

Return Values

x

Upon successful completion, the `inet6_rth_init()` function returns a pointer to the buffer that is to contain the routing header.

NULL pointer

Failure. If the **type** is not supported, the **bp** is a null, or the number of **bp_len** is invalid.

inet6_rth_reverse()

inet6_rth_reverse() — Reverses the order of addresses in an IPv6 routing header.

Format

```
#include <in6.h>
int inet6_rth_reverse (const void *in, void *out);
```

Arguments

in

Points to a buffer that contains an IPv6 routing header.

out

Points to a buffer that is to contain the routing header with the reversed addresses. This parameter can point to the same buffer specified by the **in** parameter.

Description

This function reads an IPv6 routing header and writes a new routing header, reversing the order of addresses in the new header. The **in** and **out** parameters can point to the same buffer.

The function sets the `ip6r0_segleft` member in the `ip6_rthdr0` structure to the number of segments (addresses) in the new header.

The `ip6_rthdr0` structure is defined in the IP6.H header file.

Return Values

0 (zero)

Success

-1

Failure

inet6_rth_segments()

inet6_rth_segments() — Returns the number of segments (addresses) in an IPv6 routing header.

Format

```
#include <in6.h>
int inet6_rth_segments (const void *bp);
```

Arguments

bp

Points to a buffer that contains an IPv6 routing header.

Description

This function returns the number of segments (or addresses) in an IPv6 routing header.

Return Values

x

Upon successful completion, the `inet6_rth_segments()` function returns the number of segments, 0 (zero) or greater than 0.

-1

Failure

inet6_rth_space()

inet6_rth_space() — Returns the number of bytes required for an IPv6 routing header.

Format

```
#include <in6.h>
size_t inet6_rth_space (int type, int segments);
```

Arguments

type

Specifies the type of routing header. The valid value is `IPV6_RTHDR_TYPE_0` for IPv6 routing header type 0.

segments

Specifies the number of segments or addresses that are to be included in the routing header. The valid value is from 0 to 127, inclusive.

Description

This function determines the amount of space, in bytes, required for a routing header. Although the function returns the amount of space required, it does not allocate buffer space. This enables the application to allocate a larger buffer.

If the application uses ancillary data, it must pass the returned length to `CMSG_LEN()` to determine the amount of memory required for the ancillary data object, including the `cmsghdr` structure.

Note

If an application wants to send other ancillary data objects, it must specify them to `sendmsg()` as a single `msg_control` buffer.

Return Values

x

Upon successful completion, the `inet6_rth_space()` function returns the length, in bytes, of the routing header and the specified number of segments.

0 (zero)

Failure, if the type is not supported or the number of segments is invalid for the type of routing header.

inet_aton()

inet_aton() — Converts an IP address in the standard dotted-decimal format to its numeric binary form, in network byte order. Replaces the `inet_addr()` function.

Format

```
#include <inet.h>
int inet_aton (const char *cp, struct in_addr *in);
```

Argument

cp

A pointer to a null-terminated character string containing an internet address in the standard internet dotted-decimal format.

in

A pointer to a buffer that is to contain the numeric internet address in network byte order.

Description

This function returns a numeric internet address in network byte order that represents the internet address supplied in standard dotted-decimal format as its argument.

Internet addresses specified with the dotted-decimal format take one of the following forms:

```
a.b.c.d
a.b.c
a.b
a
```

When four parts are specified, each is interpreted as a byte of data and assigned, from left to right, to the 4 bytes of an internet address. Note that when an internet address is viewed as a 32-bit integer quantity on an OpenVMS system, the bytes appear in binary as `d.c.b.a`. That is, OpenVMS bytes are ordered from least significant to most significant.

When only one part is given, the value is stored directly in the network address without any byte rearrangement.

All numbers supplied as parts in a dotted-decimal address can be decimal, octal, or hexadecimal, as specified in the C language. (That is, a leading 0x or 0X implies hexadecimal; a leading 0 implies octal; otherwise, the number is interpreted as decimal.)

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

1

Indicates success.

0

Indicates failure.

inet_lnaof()

inet_lnaof() — Returns the local network address portion of an IP address.

Format

```
#include <in.h>
#include <inet.h>
int inet_lnaof (struct in_addr in);
```

Argument

in

An IP address.

Description

This function returns the local network address portion of a full IP address.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

x

The local network address portion of an IP address, in host byte order.

inet_makeaddr()

inet_makeaddr() — Returns an IP address based on a particular local address and a network.

Format

```
#include <in.h>
#include <inet.h>
struct in_addr inet_makeaddr (int net, int lna);
```

Arguments

net

An IP network address in host byte order.

lna

A local network address on network **net** in host byte order.

Description

This function combines the **net** and **lna** arguments into a single IP address.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

x

An IP address in network byte order.

inet_netof()

inet_netof() — Returns the internet network address portion of an IP address.

Format

```
#include <in.h>
#include <inet.h>
int inet_netof (struct in_addr in);
```

Argument

in

An IP address.

Description

This function returns the internet network address (NET) portion of a full IP address.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Value

x

The internet network portion of an IP address, in host byte order.

inet_network()

inet_network() — Converts a null-terminated text string representing an IP address into a network address in local host format.

Format

```
#include <in.h>
#include <inet.h>
int inet_network (const char *cp);
```

Argument

cp

A pointer to an ASCII (null-terminated) character string containing a network address in the dotted-decimal format.

Description

This function returns an internet network address as a local host integer value when an ASCII string representing the address in the internet standard dotted-decimal format is given as its argument.

Note

The 64-bit return from OpenVMS Alpha and I64 systems has zero-extended bits in the high 32 bits of R0.

Return Values

-1

Indicates that **cp** does not point to a proper internet network address.

x

An internet network address, in local host order.

inet_ntoa()

inet_ntoa() — Converts an IP address into a text string representing the address in the standard internet dotted-decimal format.

Format

```
#include <in.h>
#include <inet.h>
char *inet_ntoa (struct in_addr in);
```

Argument

in

An IP address in network byte order.

Description

This function converts an IP address into an ASCII (null-terminated) string that represents the address in standard internet dotted-decimal format.

The string is returned in a static buffer that is overwritten by subsequent calls to `inet_ntoa()`. If you want to save the text string, you should copy it.

Return Value

x

A pointer to a string containing the IP address in dotted-decimal format.

inet_ntop()

inet_ntop() — Converts a numeric address to a text string suitable for presentation.

Format

```
#include <inet.h>
const char *inet_ntop (int af, const void *src, char *dst, size_t size);
```

Arguments

af

Specifies the address family. Valid values are AF_INET for an IPv4 address and AF_INET6 for an IPv6 address.

src

Points to a buffer that contains the numeric IP address.

dst

Points to a buffer that is to contain the text string.

size

Specifies the size of the buffer pointed to by the **dst** parameter. For IPv4 addresses, the minimum buffer size is 16 bytes. For IPv6 addresses, the minimum buffer size is 46 bytes. INET_ADDRSTRLEN constants are defined in the IN.H header file. INET6_ADDRSTRLEN constants are defined in IN6.H.

Description

This function converts a numeric IP address value to a text string.

Return Values

Pointer to the buffer containing the text string

Success

Pointer to the buffer containing NULL

Failure

inet_pton()

inet_pton() — Converts an address in its standard text presentation form into its numeric binary form, in network byte order.

Format

```
#include <inet.h>
int inet_pton (int af, const char *src, void *dst);
```

Arguments

af

Specifies the address family. Valid values are AF_INET for an IPv4 address and AF_INET6 for an IPv6 address.

src

Points to the address text string to be converted.

dst

Points to a buffer that is to contain the numeric address.

Description

This function converts a text string to a numeric value in network byte order.

- If the **af** parameter is AF_INET, the function accepts a string in the standard IPv4 dotted-decimal format:

  ```
  ddd.ddd.ddd.ddd
  ```

  In this format, *ddd* is a one- to three-digit decimal number between 0 and 255.

- If the **af** parameter is AF_INET6, the function accepts a string in the following format:

  ```
  x:x:x:x:x:x:x:x
  ```

  In this format, *x* is the hexadecimal value of a 16-bit piece of the address.

IPv6 addresses can contain long strings of zero (0) bits. To make it easier to write these addresses, you can use double-colon characters (::) one time in an address to represent 1 or more 16-bit groups of zeros.

- For mixed IPv4 and IPv6 environments, the following format is also accepted:

  x:x:x:x:x:x:ddd.ddd.ddd.ddd

  In this format, *x* is the hexadecimal value of a 16-bit piece of the address, and *ddd* is a one- to three-digit decimal value between 0 and 255 that represents the IPv4 address.

The calling application is responsible for ensuring that the buffer referred to by the **dst** parameter is large enough to hold the numeric address. AF_INET addresses require 4 bytes and AF_INET6 addresses require 16 bytes.

Return Values

1

Indicates success.

0

Indicates that the input string is neither a valid IPv4 dotted-decimal string nor a valid IPv6 address string.

-1

Indicates a failure. `errno` is set to the following value.

Errors

EAFNOSUPPORT

The address family specified in the **af** parameter is unknown.

ioctl()

ioctl() — Controls I/O requests to obtain network information.

Format

```
#include <ioctl.h>
int ioctl (int s, int request, ... /* arg */);
```

Argument

s

Specifies the socket descriptor of the requested network device.

request

Specifies the type of `ioctl` command to be performed on the device. The **request** types are grouped as follows:

- Socket operations
- File operations
- Interface operations
- ARP cache operations
- Routing table operations

Refer to *Appendix B, "IOCTL Requests"* for a complete list of supported `IOCTL` commands.

arg

Specifies arguments for this request. The type of **arg** is dependent on the specific `ioctl()` request and device to which the `ioctl()` call is targeted.

Description

This function performs a variety of device-specific functions. The **request** and **arg** arguments are passed to the file designated by the **s** argument and then interpreted by the device driver. The basic I/O functions are performed through the `read()` and `write()` functions.

Encoded in an `ioctl()` request is whether the argument is an “in” argument or an “out” argument, and the size of the **arg** argument in bytes. The macros and definitions used to specify an `ioctl()` request are located in the IOCTL.H header file.

Return Values

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The **s** argument is not a valid socket descriptor.

EINTR

A signal was caught during the `ioctl()` operation.

If an underlying device driver detects an error, `errno` might be set to one of the following values:

EINVAL

Either the **request** or the **arg** argument is not valid.

ENOTTY

Reserved for VSI use. The **s** argument is not associated with a network device, or the specified request does not apply to the specific network device.

ENXIO

The **request** and **arg** arguments are valid for this device driver, but the service requested cannot be performed on the device.

listen()

listen() — Converts an unconnected socket into a passive socket and indicates that the TCP/IP kernel should accept incoming connection requests directed to the socket. The $QIO equivalent is the IO$_SETMODE service.

Format

```
int listen (int s, int backlog);
```

Arguments

s

A socket descriptor of type `SOCK_STREAM` created using the `socket() function`.

backlog

The maximum number of pending connections that can be queued on the socket at any given time. The maximum number of pending connections can be set by specifying the value of the socket subsystem attribute `somaxconn`. (Refer to the *VSI TCP/IP Services for OpenVMS Tuning and Troubleshooting* guide for more information.) The default value for the maximum number of pending connections is 1024.

Description

This function creates a queue for pending connection requests on socket **s** with a maximum size equal to the value of **backlog**. Connections can then be accepted with the `accept()` function.

If a connection request arrives with the queue full (that is, more connections pending than specified by the **backlog** argument), the request is ignored so that TCP retries can succeed. If the backlog has not cleared by the time TCP times out, the `connect()` function fails with an `errno` indication of `ETIMEDOUT`.

Related Functions

See also `accept()`, `connect()`, and `socket()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

EDESTADDRREQ

The socket is not bound to a local address, and the protocol does not support listening on an unbound socket.

EINVAL

The socket is already connected, or the socket is shut down.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The referenced socket is not of a type that supports the operation `listen()`.

ntohl()

ntohl() — Converts longwords from network byte order to host byte order.

Format

```
#include <in.h>
unsigned long ntohl (unsigned long netlong);
```

Argument

netlong

A longword in network byte order. Integers in network byte order cannot be used for arithmetic computation on OpenVMS systems.

Description

This function converts 32-bit unsigned integers from network byte order to host byte order.

Data bytes transmitted over the network are expected to be in network byte order. Some hosts, like OpenVMS, have an internal data representation format that is different from the network byte order; this is called the host byte order. Network byte order places the byte with the most significant bits at lower addresses, but OpenVMS host byte order places the most significant bits at the highest address.

This function can be used to convert IP addresses from network byte order to host byte order.

Return Value

x

A longword in host byte order.

ntohs()

ntohs() — Converts short integers from network byte order to host byte order.

Format

```
#include <in.h>
unsigned short ntohs (unsigned short netshort);
```

Argument

netshort

A short integer in network byte order. Integers in network byte order cannot be used for arithmetic computation on OpenVMS systems.

Description

This function converts 16-bit unsigned integers from network byte order to host byte order.

Data bytes transmitted over the network are expected to be in network byte order. Some hosts, like OpenVMS, have an internal data representation format that is different from the network byte order; this is called the host byte order. Network byte order places the byte with the most significant bits at lower addresses, but OpenVMS host byte order places the most significant bits at the highest address.

This function can be used to convert port numbers returned by `getservent()` from network byte order to host byte order.

Return Value

x

A short integer in host byte order (OpenVMS systems).

poll()

poll() — Monitors conditions on multiple file descriptors.

Format

```
#include <poll.h>
int poll (struct pollfd fds[], nfds_t nfds, int timeout);
```

Arguments

fds

An array of `pollfd` structures, one for each file descriptor of interest. Each `pollfd` structure includes the following members:

`int fd`	The file descriptor
`int events`	The requested conditions
`int revents`	The reported conditions

nfds

The number of `pollfd` structures in the `fds` array.

timeout

The maximum length of time (in milliseconds) to wait for one of the specified events to occur.

Description

This function provides applications with a mechanism for multiplexing input/output over a set of file descriptors. For each member of the array pointed to by **fds**, `poll()` examines the given file descriptor for the events specified in `events`. The number of `pollfd` structures in the **fds** array is specified by **nfds**. The `poll()` function identifies those file descriptors on which an application can read or write data, or on which certain events have occurred.

The **fds** argument specifies the file descriptors to be examined and the events of interest for each file descriptor. It is a pointer to an array with one member for each open file descriptor of interest. The array's members are `pollfd` structures within which `fd` specifies an open file descriptor, and `events` and `revents` are bitmasks constructed by OR-ing a combination of the following event flags:

- POLLIN

  Normal data may be received without blocking.

- POLLRDNORM

  Same as POLLIN.

- POLLRDBAND

  Out-of-band data may be received without blocking.

- POLLPRI

  Same as POLLRDBAND

- POLLOUT

  Normal data may be written without blocking.

- POLLWRNORM

  Same as POLLOUT.

- POLLWRBAND

  Out-of-band data may be written without blocking.

If the value of `fd` is less than 0, `events` is ignored and `revents` is set to 0 in that entry on return from `poll()`. In each `pollfd` structure, `poll()` clears the `revents` member except that where the application requested a report on a condition by setting one of the bits of `events` listed above, `poll()` sets the corresponding bit in `revents` if the requested condition is true.

If none of the defined events have occurred on any selected file descriptor, `poll()` waits at least **timeout** milliseconds for an event to occur on any of the selected file descriptors. If the value of **timeout**

is 0, `poll()` returns immediately. If the value of **timeout** is -1, `poll()` blocks until a specified event occurs or until the call is interrupted.

The `poll()` function is not affected by the O_NONBLOCK flag.

On OpenVMS, the `poll()` function supports sockets only.

Note

VSI recommends using the `select()` function for optimal performance. The `poll()` function is provided to ease the porting of existing applications from other platforms.

Return Values

positive value

Upon successful completion, the total number of file descriptors selected (that is, file descriptors for which the `revents` member is nonzero).

0

Successful completion. The call timed out and no file descriptors were selected.

-1

The `poll()` function failed. The `errno` is set to indicate the error.

Errors

EAGAIN

The allocation of internal data structures failed but a subsequent request may succeed.

EINTR

A signal was caught during the `poll()` function.

read()

read() — Reads data from a socket or file. The $QIO equivalent is the IO$_READVBLK function.

Format

```
#include <unixio.h>
int read(int d, void *buffer, int nbytes);
```

Arguments

d

A descriptor that must refer to a socket or file currently opened for reading.

buffer

The address of a user-provided buffer in which the input data is placed.

nbytes

The maximum number of bytes allowed in the read operation.

Description

This function reads bytes from a socket or file and places them in a user-defined buffer.

If the end of file is not reached, the `read()` function returns **nbytes**. If the end of file occurs during the `read()` function, it returns the number of bytes read.

Upon successful completion, `read()` returns the number of bytes actually read and placed in the buffer.

Related Functions

See also `socket()`.

Return Values

x

The number of bytes read and placed in the buffer.

0

Peer has closed the connection.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EFAULT

The data was specified to be received into a nonexistent or protected part of the process address space.

EINTR

A signal interrupted the `read()` function before any data was available.

EINVAL

The MSG_OOB flag is set and no out-of-band data is available.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system did not have sufficient memory to fulfill the request.

ENOTCONN

A receive is attempted on a connection-oriented socket that is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The specified flags are not supported for this socket type or protocol.

EWOULDBLOCK

The socket is marked nonblocking, and no data is waiting to be received.

recv()

recv() — Receives bytes from a connected socket and places them into a user-provided buffer. The $QIO equivalent is the IO$_READVBLK function.

Format

```
#include <types.h>
#include <socket.h>
int recv (int s, char *buf, int len, int flags); (_DECC_V4_SOURCE)
size_t recv (int s, void *buf, ssize_t len, int flags);
 (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created as the result of a call to `accept()` or `connect()`.

buf

A pointer to a user-provided buffer into which received data will be placed.

len

The size of the buffer pointed to by **buf**.

flags

A bit mask that can contain one or more of the following flags. The mask is built by using a logical OR operation on the appropriate values.

Flag	Description
MSG_OOB	Allows you to receive out-of-band data. If out-of-band data is available, it is read first. If no out-of-band data is available, the MSG_OOB flag is ignored.

Flag	Description
	Use the `send()`, `sendmsg()`, and `sendto()` functions to send out-of-band data.
MSG_PEEK	Allows you to examine data in the receive buffer without removing it from the system's buffers.

Description

This function receives data from a connected socket. To receive data on an unconnected socket, use the `recvfrom()` or `recvmsg()` functions. The received data is placed in the buffer **buf**.

Data is sent by the socket's peer using the `send`, `sendmsg()`, `sendto()`, or `write()` functions.

Use the `select()` function to determine when more data arrives.

If no data is available at the socket, the `recv()` call waits for data to arrive, unless the socket is nonblocking. If the socket is nonblocking, a -1 is returned with the external variable `errno` set to `EWOULDBLOCK`.

Related Functions

See also `read()`, `send()`, `sendmsg()`, `sendto()`, and `socket()`.

Return Values

x

The number of bytes received and placed in **buf**.

0

Peer has closed its send side of the connection.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EFAULT

The data was specified to be received into a nonexistent or protected part of the process address space.

EINTR

A signal interrupted the `recv()` function before any data was available.

EINVAL

The MSG_OOB flag is set and no out-of-band data is available.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system did not have sufficient memory to fulfill the request.

ENOTCONN

A receive is attempted on a connection-oriented socket that is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The specified flags are not supported for this socket type or protocol.

EWOULDBLOCK

The socket is marked nonblocking, and no data is waiting to be received.

recvfrom()

recvfrom() — Receives bytes for a socket from any source.

Format

```
#include <types.h>
#include <socket.h>
int recvfrom (int s, char *buf, int len, int flags, struct sockaddr *from,
int *fromlen) ; (_DECC_V4_SOURCE)
ssize_t recvfrom (int s, void *buf, size_t len, int flags,
struct sockaddr *from, size_t *fromlen) ; (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with the `socket()` function and bound to a name using the `bind()` function or as a result of the `accept()` function.

buf

A pointer to a buffer into which received data is placed.

len

The size of the buffer pointed to by **buf**.

flags

A bit mask that can contain one or more of the following flags. The mask is built by using a logical OR operation on the appropriate values.

Flag	Description
MSG_OOB	Allows you to receive out-of-band data. If out-of-band data is available, it is read first. If no out-of-band data is available, the MSG_OOB flag is ignored. To send out-of-band data, use the `send()`, `sendmsg()`, and `sendto()` functions.
MSG_PEEK	Allows you to examine the data that is next in line to be received without actually removing it from the system's buffers.

from

A buffer that the `recvfrom()` function uses to place the address of the sender who sent the data.

If **from** is non-null, the address is returned. If **from** is null, the address is not returned.

fromlen

Points to an integer containing the size of the buffer pointed to by **from**. On return, the integer is modified to contain the actual length of the socket address structure returned.

Description

This function allows a named, unconnected socket to receive data. The data is placed in the buffer pointed to by **buf**, and the address of the sender of the data is placed in the buffer pointed to by **from** if **from** is non-null. The structure that **from** points to is assumed to be as large as the `sockaddr` structure. See *Section 3.2.12, "sockaddr Structure"* for a description of the `sockaddr` structure.

To receive bytes from any source, the socket does not need to be connected.

You can use the `select()` function to determine if data is available.

If no data is available at the socket, the `recvfrom()` call waits for data to arrive, unless the socket is nonblocking. If the socket is nonblocking, a -1 is returned with the external variable `errno` set to `EWOULDBLOCK`.

Related Functions

See also `read()`, `send()`, `sendmsg()`, `sendto()`, and `socket()`.

Return Values

x

The number of bytes of data received and placed in **buf**.

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EFAULT

A valid message buffer was not specified. Nonexistent or protected address space is specified for the message buffer.

EINTR

A signal interrupted the `recvfrom()` function before any data was available.

EINVAL

The MSG_OOB flag is set, and no out-of-band data is available.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system did not have sufficient memory to fulfill the request.

ENOTCONN

A receive is attempted on a connection-oriented socket that is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The specified flags are not supported for this socket type.

ETIMEDOUT

The connection timed out when trying to establish a connection or when a transmission timed out on an active connection.

EWOULDBLOCK

The NBIO (nonblocking) flag is set for the socket descriptor and the process delayed during the write operation.

recvmsg()

recvmsg() — Receives bytes on a socket and places them into scattered buffers.

Format

```
#include <types.h>
#include <socket.h>
int recvmsg (int s, struct msghdr msg, int flags); (BSD Version 4.4)
int recvmsg (int s, struct omsghdr msg, int flags); (BSD Version 4.3)
```

Arguments

s

A socket descriptor created with the `socket()` function.

msg

A pointer to a `msghdr` structure for receiving the data. See *Section 3.2.8, "msghdr Structure"* for a description of the `msghdr` structure.

flags

A bit mask that can contain one or more of the following flags. The mask is built by using a logical OR operation on the appropriate values.

Flag	Description
MSG_OOB	Allows you to receive out-of-band data. If out-of-band data is available, it is read first. If no out-of-band data is available, the MSG_OOB flag is ignored. Use `send()`, `sendmsg()`, and `sendto()` functions to send out-of-band data.
MSG_PEEK	Allows you to peek at the data that is next in line to be received without actually removing it from the system's buffers.

Description

You can use this function with any socket, whether or not it is in a connected state. It receives data sent by a call to `sendmsg()`, `send()`, or `sendto()`. The message is scattered into several user buffers if such buffers are specified.

To receive data, the socket does not need to be connected to another socket.

When the `ioveciovcnt` array specifies more than one buffer, the input data is scattered into `iovcnt` buffers as specified by the members of the `iovec` array:

```
iov0, iov1, ..., ioviovcnt
```

When a message is received, it is split among the buffers by filling the first buffer in the list, then the second, and so on, until either all of the buffers are full or there is no more data to be placed in the buffers.

You can use the `select()` function to determine when more data arrives.

Related Functions

See also `read()`, `send()`, and `socket()`.

Return Values

x

The number of bytes returned in the `msg_iov` buffers.

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EFAULT

The message argument is not in a readable or writable part of user address space.

EINTR

This function was interrupted by a signal before any data was available.

The MSG_OOB flag is set, and no out-of-band data is available. The value of the `msg_iovlen` member of the `msghdr` structure is less than or equal to zero or is greater than `IOV_MAX`.)

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system did not have sufficient memory to fulfill the request.

ENOTCONN

A receive is attempted on a connection-oriented socket that is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The specified flags are not supported for this socket type.

EWOULDBLOCK

The socket is marked nonblocking, and no data is ready to be received.

select()

select() — Allows you to poll or check a group of sockets for I/O activity. This function indicates which sockets are ready to be read or written, or which sockets have an exception pending.

Format

```
#include <time.h>
int select (int nfds, int *readfds, int *writefds, int *execptfds,
struct timeval *timeout); (_DECC_V4_SOURCE)
int select (int nfds, fd_set *readfds, fd_set *writefds, int *execptfds,
struct timeval *timeout); (not_DECC_V4_SOURCE)
```

Arguments

nfds

The number of open objects that may be ready for reading or writing or that have exceptions pending. The **nfds** argument is normally limited to `FD_SETSIZE`, which is defined in the SOCKET.H header file. Note that a single process can have a maximum of 65535 simultaneous channels (including sockets) on OpenVMS Alpha and I64 systems, and a maximum of 2047 on OpenVMS VAX systems.

readfds

A pointer to an array of bits, organized as integers, that should be examined for read readiness. If bit *n* of the longword is set, socket descriptor *n* is checked to see whether it is ready to be read. All bits set in the bit mask must correspond to the file descriptors of sockets. The `select()` function cannot be used on normal files.

On return, the array to which **readfds** points contains a bit mask of the sockets that are ready for reading. Only bits that were set on entry to the `select()` function can be set on exit.

writefds

A pointer to an array of bits, organized as integers, that should be examined for write readiness. If bit *n* of the longword is set, socket descriptor *n* is checked to see whether it is ready to be written to. All bits set in the bit mask must correspond to socket descriptors.

On return, the array to which **writefds** points contains a bit mask of the sockets that are ready for writing. Only bits that were set on entry to the `select()` function are set on exit.

exceptfds

A pointer to an array of bits, organized as integers, that is examined for exceptions. If bit *n* of the longword is set, socket descriptor *n* is checked to see whether it has any pending exceptions. All bits set in the bit mask must correspond to the file descriptors of sockets.

On return, the array **exceptfds** pointer contains a bit mask of the sockets that have exceptions pending. Only bits that were set on entry to the `select()` function can be set on exit.

timeout

The length of time that the `select()` function should examine the sockets before returning. If one of the sockets specified in the **readfds**, **writefds**, and **exceptfds** bit masks is ready for I/O, the `select()` function returns before the timeout period expires.

The **timeout** argument points to a `timeval` structure. See *Section 3.2.15, "timeval Structure"* for a description of the `timeval` structure.

Description

This function determines the I/O status of the sockets specified in the various mask arguments. It returns when a socket is ready to be read or written, when the timeout period expires, or when exceptions occur. If **timeout** is a non-null pointer, it specifies a maximum interval to wait for the selection to complete.

If the **timeout** argument is null, the `select()` function blocks indefinitely until a selected event occurs. To effect a poll, the value for **timeout** should be non-null, and should point to a zero-value structure.

If a process is blocked on a `select()` function while waiting for input for a socket and the sending process closes the socket, then the `select()` function notes this as an event and unblocks the process. The descriptors are always modified on return if the `select()` function returns because of the timeout.

Note

When the socket option `SO_OOBINLINE` is set on the device socket, the `select()` function on both read and exception events returns the socket mask that is set on both the read and the exception mask. Otherwise, only the exception mask is set.

Related Functions

See also `accept()`, `connect()`, `read()`, `recv()`, `recvfrom()`, `recvmsg()`, `send()`, `sendmsg()`, `sendto()`, and `write()`.

Return Values

n

The number of sockets ready for I/O or pending exceptions. This value matches the number of returned bits that are set in all output masks.

0

The `select()` function timed out before any socket became ready for I/O.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

One or more of the I/O descriptor sets specified an invalid file descriptor.

EINTR

A signal was delivered before the time limit specified by the **timeout** argument expired and before any of the selected events occurred. The time limit specified by the **timeout** argument is invalid.

The **nfds** argument is less than zero, or greater than or equal to `FD_SETSIZE`.)

EAGAIN

Allocation of internal data structures failed. A later call to the `select()` function may complete successfully.

ENETDOWN

TCP/IP Services was not started.

ENOTSOCK

The socket descriptor is invalid.

send()

send() — Sends bytes through a socket to its connected peer. The $QIO equivalent is the IO$_WRITEVBLK function.

Format

```
#include <types.h>
#include <socket.h>
int send (int s, char *msg, int len, int flags); (_DECC_V4_SOURCE)
ssize_t send (int s, const void *msg, size_t len, int flags);
(not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with the `socket()` function that was connected to another socket using the `accept()` or `connect()` function.

msg

A pointer to a buffer containing the data to be sent.

len

The length, in bytes, of the data pointed to by *msg*.

flags

Can be either 0 or MSG_OOB. If it is MSG_OOB, the data is sent out of band. Data can be received before other pending data on the receiving socket if the receiver also specifies `MSG_OOB` in the flag argument of its `recv()` or `recvfrom()` call.

Description

This function sends data to a connected peer.

You can use this function only on connected sockets. To send data on an unconnected socket, use the `sendmsg()` or `sendto()` function. The `send()` function passes data along to its connected peer, which can receive the data by using the `recv()` or `read()` function.

Normally the `send()` function blocks if there is no space for the incoming data in the buffer. It waits until the buffer space becomes available. If the socket is set to nonblocking and there is no space for the data, the `send()` function fails with the `EWOULDBLOCK` error.

If the message is too large to be sent in one piece, and the socket type is `SOCK_DGRAM`, which requires that messages be sent in one piece, `send()` fails with the `EMSGSIZE` error.

If the address specified is an INADDR_BROADCAST address, then the SO_BROADCAST socket option must have been set and the process must have SYSPRV or BYPASS privilege for the I/O operation to succeed.

A success return from the `send()` does not guarantee that the data has been received by the peer. All errors (except `EWOULDBLOCK`) are detected locally. To determine when it is possible to send more data, use the `select()` function.

Related Functions

See also `read()`, `recv()`, `recvmsg()`, `recvfrom()`, `getsockopt()`, and `socket()`.

Return Values

n

The number of bytes sent. This value normally equals **len**.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EDESTADDRREQ

The socket is not connection-oriented, and no peer address is set.

EFAULT

The message argument is not in a readable or writable part of the user address space.

EINTR

A signal interrupted the `send()` before any data was transmitted.

EMSGSIZE

The message is too large to be sent all at once, as the socket requires.

ENETDOWN

The local network connection is not operational.

ENETUNREACH

The destination network is unreachable.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTCONN

The socket is not connected or has not had the peer prespecified.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The socket argument is associated with a socket that does not support one or more of the values set in **flags**.

EWOULDBLOCK

The socket is marked nonblocking, and no space is available for the `send()` function.

sendmsg()

sendmsg() — Sends gathered bytes through a socket to any other socket.

Format

```
#include <types.h>
#include <socket.h>
int sendmsg (int s, struct msghdr *msg, int flags); (BSD Version 4.4)
int sendmsg (int s, struct omsghdr *msg, int flags); (BSD Version 4.3)
```

Arguments

s

A socket descriptor created with the `socket()` function.

msg

A pointer to a `msghdr` structure containing the message to be sent. See *Section 3.2.8, "msghdr Structure"* for a description of the `msghdr` structure.

The `msg_iov` field of the `msghdr` structure is used as a series of buffers from which data is read in order until `msg_iovlen` bytes have been obtained.

flags

Can be either 0 or `MSG_OOB`. If it is equal to `MSG_OOB`, the data is sent out of band. Data can be received before other pending data on the receiving socket if the receiver specifies a flag of `MSG_OOB`.

Description

This function sends the data in a `msghdr` structure to any other socket.

You can use this function on any socket to send data to any named socket. The data in the `msg_iov` field of the `msghdr` structure is sent to the socket whose address is specified in the `msg_name` field of the structure. The receiving socket gets the data using the `read()`, `recv()`, `recvfrom()`, or `recvmsg()` function. When the `iovec` array specifies more than one buffer, the data is gathered from all specified buffers before being sent. See *Section 3.2.6, "iovec Structure"* for a description of the `iovec` structure.

Normally the `sendmsg()` function blocks if there is no space for the incoming data in the buffer. It waits until the buffer space becomes available. If the socket is set to nonblocking and there is no space for the data, the `sendmsg()` function fails with the `EWOULDBLOCK` error.

If the message is too large to be sent in one piece, and the socket type is `SOCK_DGRAM`, which requires that messages be sent in one piece, `sendmsg()` fails with the `EMSGSIZE` error.

If the address specified is an INADDR_BROADCAST address, the SO_BROADCAST socket option must be set and the process must have OPER, SYSPRV, or BYPASS privilege for the I/O operation to succeed.

A success return from `sendmsg()` does not guarantee that the data has been received by the peer. All errors (except `EWOULDBLOCK`) are detected locally. To determine when it is possible to send more data, use the `select()` function.

Related Functions

See also `read()`, `recv()`, `recvfrom()`, `recvmsg()`, `socket()`, and `getsockopt()`.

Return Values

n

The number of bytes sent.

-1

Error; `errno` is set to indicate the error.

Errors

ENOTSOCK

The socket descriptor is invalid.

EFAULT

An invalid user space address is specified for an argument.

EMSGSIZE

The socket requires that messages be sent atomically, but the size of the message to be sent makes this impossible.

EWOULDBLOCK

Blocks if the system does not have enough space for buffering the user data.

sendto()

sendto() — Sends bytes through a socket to any other socket. The $QIO equivalent is the IO$_WRITEVBLK function.

Format

```
#include <types.h>
#include <socket.h>
int sendto (int s, char *msg, int len, int flags,
struct sockaddr *to, int tolen); (_DECC_V4_SOURCE)
ssize_t sendto (int s, const void *msg, size_t len, int flags,
const struct sockaddr *to, size_t tolen); (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created with the `socket()` function.

msg

A pointer to a buffer containing the data to be sent.

len

The length of the data pointed to by the **msg** argument.

flags

Can be either 0 or `MSG_OOB`. If it is `MSG_OOB`, the data is sent out of band. Data can be received before other pending data on the receiving socket if the receiver specifies `MSG_OOB` in the flag argument of its `recv()`, `recvfrom()` or `recvmsg()` call.

to

Points to the address structure of the socket to which the data is to be sent.

tolen

The length of the address pointed to by the **to** argument.

Description

This function can be used on sockets to send data to named sockets. The data in the **msg** buffer is sent to the socket whose address is specified in the **to** argument, and the address of socket **s** is provided to the receiving socket. The receiving socket gets the data using the `read()`, `recv()`, `recvfrom()`, or `recvmsg()` function.

Normally the `sendto()` function blocks if there is no space for the incoming data in the buffer. It waits until the buffer space becomes available. If the socket is set to nonblocking and there is no space for the data, the `sendto()` function fails with the `EWOULDBLOCK` error.

If the message is too large to be sent in one piece, and the socket type is `SOCK_DGRAM`, which requires that messages be sent in one piece, `sendto()` fails with the `EMSGSIZE` error.

If the address specified is a INADDR_BROADCAST address, then the SO_BROADCAST socket option must have been set and the process must have SYSPRV or BYPASS privilege for the I/O operation to succeed.

A success return from the `sendto()` does not guarantee that the data has been received by the peer. All errors (except `EWOULDBLOCK`) are detected locally. To determine when it is possible to send more data, use the `select()` function.

Related Functions

See also `read()`, `recv()`, `recvfrom()`, `recvmsg()`, `socket()`, and `getsockopt()`.

Return Values

n

The number of bytes sent. This value normally equals **len**.

-1

Error; `errno` is set to indicate the error.

Errors

EAFNOSUPPORT

Addresses in the specified address family cannot be used with this socket.

EBADF

The socket descriptor is invalid.

ECONNRESET

A connection was forcibly closed by a peer.

EDESTADDRREQ

You did not specify a destination address for the connectionless socket and no peer address is set.

EFAULT

An invalid user space address is specified for an argument.

EHOSTUNREACH

The destination host is unreachable.

EINTR

A signal interrupted `sendto()` before any data was transmitted.

EINVAL

The **tolen** argument is not a valid size for the specified address family.

EISCONN

The connection-oriented socket for which a destination address was specified is already connected.

EMSGSIZE

The message is too large to be sent all at once, as the socket requires.

ENETDOWN

The local network connection is not operational.

ENETUNREACH

The destination network is unreachable.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system did not have sufficient memory to fulfill the request.

ENOTCONN

The socket is connection-oriented but is not connected.

ENOTSOCK

The socket descriptor is invalid.

EOPNOTSUPP

The socket argument is associated with a socket that does not support one or more of the values set in **flags**.

EPIPE

The socket is shut down for writing or is connection oriented, and the peer is closed or shut down for reading. In the latter case, if the socket is of type `SOCK_STREAM`, the `SIGPIPE` signal is generated to the calling process.

EWOULDBLOCK

The socket is marked nonblocking, and no space is available for the `sendto()` function.

sethostent()

sethostent() — Opens the hosts database file.

Format

```
#include <netdb.h>
void sethostent (int stay_open);
```

Argument

stay_open

Specifies a value used to indicate when to close the hosts database file (TCPIP$ETC:IPNODES.DAT):

- A value of 0 closes the hosts database file after each call to the `gethostbyname()`, `gethostbyaddr()`, or `gethostent()` function.
- A nonzero value keeps the hosts database file open after each call.

Description

This function opens the hosts database file and resets the file marker to the beginning of the file.

Passing a nonzero value to the **stay_open** argument keeps the connection open until the `endhostent()` or `exit()` function is called.

Related Functions

See also `endhostent()`.

setnetent()

setnetent() — Opens the networks database file.

Format

```
#include <netdb.h>
void setnetent (int stay_open);
```

Argument

stay_open

Specifies a value used to indicate when to close the networks database file (TCPIP$SYSTEM:NETWORKS.DAT):

- A value of 0 closes the networks database file after each call to the `getnetent()` function.
- A nonzero value keeps the networks database file open after each call.

Description

This function opens the networks database file and resets the file marker to the beginning of the file.

Passing a nonzero **stay_open** argument keeps the connection open until you call the `endnetent()` or `exit()` function.

Related Functions

See also `endnetent()`, `getnetent()`, and `exit()`.

setprotoent()

setprotoent() — Sets the state of the protocols table.

Format

```
#include <netdb.h>
void setprotoent (int stay_open);
```

Argument

stay_open

Specifies a value used to indicate when to reset the protocols table index:

- A value of 0 resets the protocols table index after each call to the `getprotoent` function.
- A nonzero value does not reset the protocols table index after each call.

Description

This function sets the index marker to the beginning of the protocols table.

Passing a nonzero **stay_open** argument will allow the index to advance until you call the `endprotoent()` or `exit()` function.

Related Functions

See also `endprotoent()`, `exit()`, and `getprotoent()`.

Return Values

1

Indicates success.

0

Indicates an error; unable to access the protocols table.

setservent()

setservent() — Opens the services database file.

Format

```
#include <netdb.h>
```

```
void setservent (int stay_open);
```

Argument

stay_open

Specifies a value used to indicate when to close the services database file (TCPIP$ETC:SERVICES.DAT):

- A value of 0 closes the services database file after each call to the `setservent()` function.
- A nonzero value keeps the services database file open after each call to `setservent()`.

Description

This function opens the services database file and resets the file marker to the beginning of the file.

Passing a nonzero **stay_open** argument keeps the connection open until you call the `endservent()` function or the `exit()` function.

Related Functions

See also `endservent()`, `exit()`, and `getservent()`.

setsockopt()

setsockopt() — Sets options on a socket. The $QIO equivalent is the IO$_SETMODE function.

Format

```
#include <types.h>
#include <socket.h>
int setsockopt (int s, int level, int optname, char *optval,
int optlen); (_DECC_V4_SOURCE)
int setsockopt (int s, int level, int optname, const void *optval,
size_t optlen); (not_DECC_V4_SOURCE)
```

Arguments

s

A socket descriptor created by the `socket()` function.

level

The protocol level for which the socket options are to be modified. It can have one of the following values:

SOL_SOCKET	Set the options at the socket level.
p	Any protocol number. Set the options for protocol level *p*. For IPv4, see the IN.H header file for the IPPROTO values. For IPv6, see the IN6.H header file for the IPPROTO_IPV6 values.

optname

Interpreted by the protocol specified in **level**. Options at each protocol level are documented with the protocol.

Refer to:

- *Table A.1, "Socket Options"* for a list of socket options
- *Table A.2, "TCP Protocol Options"* for a list of TCP options
- *Table A.3, "IP Protocol Options"* for a list of IP options

optval

Points to a buffer containing the arguments of the specified option.

All socket-level options other than `SO_LINGER` should be nonzero if the option is to be enabled, or zero if it is to be disabled.

`SO_LINGER` uses a `linger` structure argument defined in the SOCKET.H header file. This structure specifies the desired state of the option and the linger interval. The option value for the `SO_LINGER` command is the address of a `linger` structure. See *Section 3.2.7, "linger Structure"* for a description of the `linger` structure.

If the socket is type `SOCK_STREAM`, which promises the reliable delivery of data, and `l_onoff` is nonzero, the system blocks the process on the `close()` attempt until it is able to transmit the data or until it decides it is unable to deliver the information. A timeout period, called the linger interval, is specified in `l_linger`.

If `l_onoff` is set to zero and a `close()` is issued, the system processes the close in a manner that allows the process to continue as soon as possible.

optlen

An integer specifying the size of the buffer pointed to by **optval**.

Description

This function manipulates options associated with a socket. Options can exist at multiple protocol levels. They are always present at the uppermost socket level.

When manipulating socket options, specify the level at which the option resides and the name of the option. To manipulate options at the socket level, specify the value of **level** as SOL_SOCKET. To manipulate options at any other level, supply the protocol number of the appropriate protocol controlling the option. For example, to indicate that an option is to be interpreted by TCP, set the value for the **level** argument to the protocol number (IPPROTO_TCP) of TCP.

For IPv4, see the IN.H header file for the various IPPROTO values. For IPv6, see the IN6.H header file for the various IPPROTO_IPV6 values.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EACCES

The calling process does not have appropriate permissions.

EBADF

The descriptor is invalid.

EDOM

The send and receive timeout values are too large to fit in the timeout fields of the socket structure.

EINVAL

The **optlen** argument is invalid.

EISCONN

The socket is already connected; the specified option cannot be set when the socket is in the connected state.

EFAULT

The **optval** argument is not in a readable part of the user address space.

ENOBUFS

The system had insufficient resources to complete the call.

ENOPROTOOPT

The option is unknown.

ENOTSOCK

The socket descriptor is invalid.

EFAULT

The **optname** argument is invalid.

shutdown()

shutdown() — Shuts down all or part of a bidirectional connection on a socket. This function does not allow further receives or sends, or both. The $QIO equivalent is the IO$_DEACCESS function with the IO$M_SHUTDOWN function modifier.

Format

```
#include <socket.h>
int shutdown (int s, int how);
```

Arguments

s

A socket descriptor that is in a connected state as a result of a previous call to either `connect()` or `accept()`.

how

How the socket is to be shut down. Use one of the following values:

0	Do not allow further calls to `recv()` on the socket.
1	Do not allow further calls to `send()` on the socket.
2	Do not allow further calls to both `send()` and `recv()`.

Description

This function allows communications on a socket to be shut down one direction at a time rather than all at once. You can use the `shutdown()` function to shut down one direction in a full-duplex (bidirectional) connection.

Related Functions

See also `connect()` and `socket()`.

Return Values

0

Successful completion.

-1

Error; `errno` is set to indicate the error.

Errors

EBADF

The socket descriptor is invalid.

EINVAL

The **how** argument is invalid.

ENOBUFS

The system has insufficient resources to complete the call.

ENOTCONN

The specified socket is not connected.

ENOTSOCK

The socket descriptor is invalid.

socket()

socket() — Creates an endpoint for communication by returning a special kind of file descriptor called a socket descriptor, which is associated with a TCP/IP Services socket device channel. The $QIO equivalent is the IO$_SETMODE function.

Format

```
#include <types.h>
#include <socket.h>
int socket (int af, int type, int protocol);
```

Arguments

af

The address family used in later references to the socket. Addresses specified in subsequent operations using the socket are interpreted according to this family. Use one of the following:

- `AF_INET` for the IPv4 address family
- `AF_INET6` for the IPv6 address family
- `TCPIP$C_AUXS`

  For a network application server with the `LISTEN` flag enabled, you specify the `TCPIP $C_AUXS` address family to obtain the connected device socket created by the auxiliary server in response to incoming network traffic.

type

The socket types are:

- SOCK_STREAM — Provides sequenced, reliable, two-way, connection-based byte streams with an available out-of-band data transmission mechanism.
- SOCK_DGRAM — Provides datagram transmissions. A datagram is a connectionless, unreliable data transmission mechanism.
- SOCK_RAW — Provides access to internal network interfaces. Available only to users with the SYSPRV privilege.

protocol

The protocol to be used with the socket. Normally, only a single protocol exists to support a particular socket type using a given address format. However, if many protocols exist, a particular protocol must be specified with this argument. Use the protocol number that is specific to the address family.

Description

This function provides the primary mechanism for creating sockets. The type and protocol of the socket affect the way the socket behaves and how it can be used.

The operation of sockets is controlled by socket-level options, which are defined in the SOCKET.H header file and described in the `setsockopt()` function section of this chapter.

Use the `setsockopt()` and `getsockopt()` functions to set and get options. Options take an integer argument that should be nonzero if the option is to be enabled or zero if it is to be disabled. SO_LINGER uses a `linger` structure argument (see *Section 3.2.7, "linger Structure"*).

Related Functions

See also `accept()`, `bind()`, `connect()`, `getsockname()`, `getsockopt()`, `socketpair()`, `listen()`, `read()`, `recv()`, `recvfrom()`, `recvmsg()`, `select()`, `send()`, `sendmsg()`, `sendto()`, `shutdown()`, and `write()`.

Return Values

x

A file descriptor that refers to the socket descriptor.

-1

Error; `errno` is set to indicate the error.

Errors

EACCES

The process does not have sufficient privileges.

EAFNOSUPPORT

The specified address family is not supported in this version of the system.

EMFILE

The per-process descriptor table is full.

ENETDOWN

TCP/IP Services was not started.

ENFILE

No more file descriptors are available for the system.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system was unable to allocate kernel memory to increase the process descriptor table.

EPERM

The process is attempting to open a raw socket and does not have SYSTEM privilege.

EPROTONOSUPPORT

The socket in the specified address family is not supported.

EPROTOTYPE

The socket type is not supported by the protocol.

ESOCKTNOSUPPORT

The specified socket type is not supported in this address family.

socketpair()

socketpair() — Creates a pair of connected sockets.

Format

```
#include <sys/socket.h>
int socketpair (int domain, int type, int protocol, int socket_vector[2]);
```

Arguments

af

The address family in which the sockets are to be created. Use one of the following:

- `AF_INET` for the IPv4 address family
- `AF_INET6` for the IPv6 address family
- `TCPIP$C_AUXS` or a network application server with the `LISTEN` flag enabled. Specify the `TCPIP$C_AUXS` address family to obtain the connected device socket created by the auxiliary server in response to incoming network traffic.

type

Specifies the type of sockets to be created. The socket types are:

- SOCK_STREAM — Provides sequenced, reliable, two-way, connection-based byte streams with an available out-of-band data transmission mechanism.
- SOCK_DGRAM — Supports datagrams (connectionless, unreliable data transmission mechanism).
- SOCK_SEQPACKET — Provides sequenced, reliable, bidirectional, connection-mode transmission paths for records. A record can be sent using one or more output operations and received using one or more input operations, but a single operation never transfers part of more than one record.

  Use the MSG_EOR flag to determine the record boundaries.

protocol

The protocol to be used with the socket. Normally, only a single protocol exists to support a particular socket type using a given address format. However, if many protocols exist, a particular protocol must be specified with this argument. Use the protocol number that is specific to the address family.

If the protocol argument is 0, the function uses the default protocol for the specified socket type.

If the protocol argument is non-zero, the function uses the default protocol for the address family.

socket_vector

A 2-integer array to hold the file descriptors of the created socket pair.

Description

This function creates an unbound pair of connected sockets in a specified address family, of a specified type, under the protocol optionally specified by the **protocol** argument. The two sockets will be identical. The file descriptors used in referencing the created sockets are returned in `socket_vector[0]` and `socket_vector[1]`.

Appropriate privileges are required to use the `socketpair()` function or to create some sockets.

Related Functions

See also `socket()`.

Return Values

0

Successful completion

-1

Error; `errno` is set to indicate the error.

Errors

EACCES

The process does not have sufficient privileges.

EAFNOSUPPORT

The specified address family is not supported in this version of the system.

EMFILE

The per-process descriptor table is full.

ENETDOWN

TCP/IP Services was not started.

ENFILE

No more file descriptors are available for the system.

ENOBUFS

The system has insufficient resources to complete the call.

ENOMEM

The system was unable to allocate kernel memory to increase the process descriptor table.

EPERM

The process is attempting to open a raw socket and does not have SYSTEM privilege.

EPROTONOSUPPORT

The socket in the specified address family is not supported.

EPROTOTYPE

The socket type is not supported by the protocol.

ESOCKTNOSUPPORT

The specified socket type is not supported in this address family.

write()

write() — Writes bytes from a buffer to a file or socket. The $QIO equivalent is the IO$_WRITEVBLK function.

Format

```
#include <unixio.h>
int write(int d, void *buffer, int nbytes);
```

Arguments

d

A descriptor that refers to a socket or file.

buffer

The address of a buffer from which the output data is to be taken.

nbytes

The maximum number of bytes involved in the write operation.

Description

This function attempts to write a buffer of data to a socket or file.

Related Functions

See also `socket()`.

Return Values

x

The number of bytes written to the socket or file.

-1

Error; `errno` is set to indicate the error.

Errors

EPIPE

The socket is shut down for writing or is connection oriented, and the peer is closed or shut down for reading. In the latter case, if the socket is of type `SOCK_STREAM`, the `SIGPIPE` signal is generated to the calling process.

EWOULDBLOCK

The `NBIO` (nonblocking) flag is set for the socket descriptor, and the process is delayed during the write operation.

EINVAL

The **nbytes** argument is a negative value.

EAGAIN

The `O_NONBLOCK` flag is set on this file, and the process is delayed in the write operation.

EBADF

The **d** argument does not specify a valid file descriptor that is open for writing.

EINTR

A `write()` function on a pipe is interrupted by a signal, and no bytes have been transferred through the pipe.

EINVAL

On of the following errors occurred:

- The STREAM or multiplexer referenced by **d** is linked (directly or indirectly) downstream from a multiplexer.
- The file position pointer associated with the **d** argument was a negative value.

EPERM

An attempt was made to write to a socket of type `SOCK_STREAM` that is not connected to a peer socket.

An attempt was made to write to a pipe that has only one end open.

An attempt was made to write to a pipe or `FIFO` that is not opened for reading by any process. A `SIGPIPE` signal is sent to the process.)

ERANGE

An attempt was made to write to a `STREAM` socket where the value of **nbytes** is outside the specified minimum and maximum range, and the minimum value is nonzero.

Chapter 5. Using the $QIO System Service

This chapter describes how to use the $QIO system service and its data structures with TCP/IP Services.

After you create a network pseudodevice (BG:) and assign a channel to it, use the $QIO system service for I/O operations.

5.1. $QIO System Service Variations

The two variations of the $QIO system service are:

- Queue I/O Request ($QIO) — Completes asynchronously. It returns to the caller immediately after queuing the I/O request, without waiting for the I/O operation to complete.
- Queue I/O Request and Wait ($QIOW) — Completes synchronously. It returns to the caller after the I/O operation completes.

The only difference between the $QIO and $QIOW calling sequences is the service name. The system service arguments are the same.

5.2. $QIO Format

The $QIO calling sequence has the following format:

SYS$QIO [*efn*], *chan*, *func*, [*iosb*], [*astadr*], [*astprm*], [*p1*], [*p2*], [*p3*], [*p4*], [*p5*], [*p6*]

Table 5.1, "$QIO Arguments" describes each argument.

Table 5.1. $QIO Arguments

Argument	Description
astadr	AST (asynchronous system trap) service routine
astprm	AST parameter to be passed
chan	I/O channel
efn	Event flag number
func	Network pseudodevice function code and/or function modifier
iosb	I/O status block
p1, p2, p3, p4, p5, p6	Function-specific I/O request parameters

5.2.1. Symbol Definition Files

Table 5.2, "Network Symbol Definition Files" lists the symbol definition files for the $QIO arguments **p1** through **p6**. Use the standard mechanism for the programming language you are using to include the appropriate symbol definition files in your program.

Table 5.2. Network Symbol Definition Files

File Name	Language
TCPIP$INETDEF.H	VSI C
TCPIP$INETDEF.FOR	VAX Fortran
TCPIP$INETDEF.PAS	VAX PASCAL
TCPIP$INETDEF.MAR	MACRO-32
TCPIP$INETDEF.PLI	VAX PL/1
TCPIP$INETDEF.R32	BLISS-32
TCPIP$INETDEF.ADA	VAX Ada
TCPIP$INETDEF.BAS	VAX BASIC

5.3. $QIO Functions

Table 5.3, "$QIO Function Codes" lists the $QIO function codes commonly used in a network application.

Note

The IO$_SETMODE and IO$_SETCHAR function codes are identical. All references to the IO $_SETMODE function code, its arguments, options, function modifiers, and condition values returned also apply to the IO$_SETCHAR function code, which is not explicitly described in this manual.

The IO$_SENSEMODE and IO$_SENSECHAR function codes are identical. All references to the IO$_SENSEMODE function code, its arguments, options, function modifiers, and condition values returned also apply to the IO$_SENSECHAR function code, which is not explicitly described in this manual.

Table 5.3. $QIO Function Codes

Function	Description
$QIO(IO$_SETMODE) $QIO(IO$_SETCHAR)	Creates the socket by setting the internet domain, protocol (socket) type, and protocol of the socket. Binds a name (local address and port) to the socket. Defines a network pseudodevice as a listener on a TCP/IP server. Specifies socket options.
$QIO(IO$_ACCESS)	Initiates a connection request from a client to a remote host using TCP. Specifies the peer where you can send datagrams. Accepts a connection request from a TCP/IP client when used with the IO$M_ACCEPT function modifier.

Function	Description
$QIO(IO$_WRITEVBLK)	Writes data (virtual block) from the local host to the remote host for stream sockets, datagrams, and raw IP.
$QIO(IO$_READVBLK)	Reads data (virtual block) from the remote host to the local host for stream sockets, datagrams, and raw IP.
$QIO(IO$_DEACCESS)	Disconnects the link established between two communication agents through an IO $_DEACCESS function. Shuts down the communication link when used with the IO$M_SHUTDOWN function modifier. You can shut down the receive or transmit portion of the link, or both.
$QIO(IO$_SENSECHAR) $QIO(IO$_SENSEMODE)	Obtains socket information.

5.4. $QIO Arguments

You pass two types of arguments with the $QIO system service: function-independent arguments and function-dependent arguments. The following sections provide information about $QIO system service arguments.

5.4.1. $QIO Function-Independent Arguments

Table 5.4, "$QIO Function-Independent Arguments" describes the $QIO function-independent arguments.

Table 5.4. $QIO Function-Independent Arguments

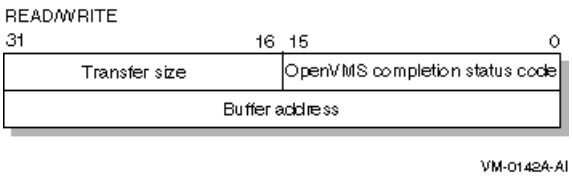
Argument	Description
astadr	Address of the asynchronous system trap (AST) routine to be executed when the I/O operation is completed.
astprm	A quadword (Alpha and I64) or longword (VAX) containing the value to be passed to the AST routine.
chan	A longword value that contains the number of the I/O channel. The $QIO system service uses only the low-order word.
efn	A longword value of the event flag number that the $QIO system service sets when the I/O operation completes. The $QIO system service uses only the low-order byte.
func	A longword value that specifies the network pseudodevice function code and function modifiers that specify the operation to be performed. Function modifiers affect the operation of a specified function code. In MACRO-32, you use the exclamation point (!) to logically OR the function code and its modifier.

Argument	Description
	In VSI C, you use the vertical bar (|). This manual uses the vertical bar (|) in text.
iosb	The I/O status block that receives the final status message for the I/O operation. The **iosb** argument is the address of the quadword I/O status block. (For the format of the I/O status block, see *Section 5.4.2, "I/O Status Block"*.)

5.4.2. I/O Status Block

The system returns the status of a $QIO operation in the I/O status block (IOSB) supplied as an argument to the $QIO call. In the case of a successful IO$_READVBLK or IO$_WRITEVBLK operation, the second word of the I/O status block contains the number of bytes transferred during the operation (see *Figure 5.1, "I/O Status Block for a Successful READ or WRITE Operation"*).

Figure 5.1. I/O Status Block for a Successful READ or WRITE Operation



With an unsuccessful IO$_READVBLK or IO$_WRITEVBLK operation, in most cases, the system returns a UNIX error code in the second word of the I/O status block.

For C programs, the OpenVMS completion codes are defined in the SSDEF.H header file. The UNIX error codes are defined in the ERRNO.H header file and in the TCPIP$INETDEF.H header file. For other language variants, see *Table 5.2, "Network Symbol Definition Files"*.

5.4.3. $QIO Function-Dependent Arguments

Arguments **p1**, **p2**, **p3**, **p4**, **p5**, and **p6** to the $QIO system service are used to pass function-dependent arguments. *Table 5.5, "$QIO Function-Dependent Arguments"* lists arguments **p1** through **p6** for the $QIO system service and indicates whether the parameter is passed by value, by reference, or by descriptor.

Table 5.5. $QIO Function-Dependent Arguments

$QIO	p1	p2	p3	p4	p5	p6
IO$_ACCESS	Not used	Not used	Remote socket name [4]	Not used	Not used	Not used
IO$_ACCESS \| IO$M_ACCEPT	Not used	Not used	Remote socket name [5]	Channel number [2]	Not used	Not used
IO$_ACPCONTROL	Sub function code [3]	Input parameter [3]	Buffer length [2]	Buffer [3]	Not used	Not used
IO$_DEACCESS	Not used	Not used	Not used	Not used	Not used	Not used

$QIO	p1	p2	p3	p4	p5	p6
IO$_DEACCESS | IO $M_SHUTDOWN	Not used	Not used	Not used	Shutdown flags [1]	Not used	Not used
IO$_READVBLK	Buffer [2]	Buffer size [1]	Remote socket name [5]	Flags [1]	Not used	Output buffer list [3]
IO$_READVBLK | IO $M_INTERRUPT	Buffer [2]	Buffer size [1]	Not used	Not used	Not used	Not used
IO$_WRITEVBLK	Buffer [2]	Buffer size [1]	Remote socket name [4]	Flags [1]	Input buffer list [3]	Not used
IO$_WRITEVBLK | IO $M_INTERRUPT	Buffer [2]	Buffer size [1]	Not used	Not used	Not used	Not used
IO$_SETMODE	Socket char [2]	Not used	Local socket name [4]	Backlog limit [1]	Input parameter list [4]	Not used
IO$_SETMODE \| IO$_OUTBAND	AST procedure [2]	User argument [1]	Access mode [1]	Not used	Not used	Not used
IO$_SETMODE | IO $_READATTN	AST procedure [2]	User argument [1]	Access mode [1]	Not used	Not used	Not used
IO$_SETMODE \| IO$WRTATTN	AST procedure [2]	User argument [1]	Access mode [1]	Not used	Not used	Not used
IO$_SENSEMODE	Not used	Not used	Local socket name [5]	Remote socket name [5]	Not used	Output parameter list [4]

[4]By item_list_2 descriptor.

[5]By item_list_3 descriptor.

[2]By reference.

[3]By descriptor.

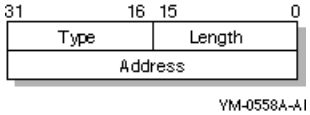
[1]By value.

5.5. Passing Arguments by Descriptor

In addition to OpenVMS argument descriptors, I/O functions specific to TCP/IP Services also pass arguments by using `item_list_2` and `item_list_3` argument descriptors. The format of these argument descriptors is unique to TCP/IP Services, and they supplement argument descriptors defined in the OpenVMS Calling Standard.

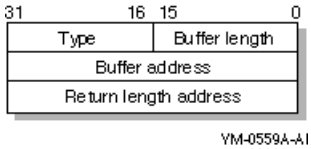
Use of an `item_list_2` or `item_list_3` argument descriptor is indicated when the argument's passing mechanism is specified as an `item_list_2` descriptor or an `item_list_3` descriptor. To determine an argument's passing mechanism, refer to the argument's description in *Chapter 6, "OpenVMS System Services Reference"*.

The `item_list_2` argument descriptors describe the size, data type, and starting address of a service parameter. An `item_list_2` argument descriptor contains three fields, as depicted in the following diagram:



The first field is a word containing the length (in bytes) of the parameter being described. The second field is a word containing a symbolic code specifying the data type of the parameter. The third field is a longword containing the starting address of the parameter.

The `item_list_3` argument descriptors describe the size, data type, and address of a buffer in which a service writes parameter information returned from a get operation. An `item_list_3` argument descriptor contains four fields, as depicted in the following diagram:



The first field is a word containing the length (in bytes) of the buffer in which a service writes information. The length of the buffer needed depends on the data type specified in the type field. If the value of buffer length is too small, the service truncates the data. The second field is a word containing a symbolic code specifying the type of information that a service is to return. The third field is a longword containing the address of the buffer in which a service writes the information. The fourth field is a longword containing the address of a longword in which a service writes the length (in bytes) of the information it actually returned.

Note

When a parameter specified as a descriptor is described as “read-only”, the descriptor itself is only read, and TCP/IP Services does not modify the memory described. However, system service postprocessing requires that the described memory must be both readable and writable.

5.5.1. Specifying an Input Parameter List

Use the **p5** argument with the IO$_SETMODE function to specify input parameter lists. The **p5** argument specifies the address of a `item_list_2` descriptor that points to and identifies the type of input parameter list.

To initialize an `item_list_2` descriptor, you need to:

1. Set the descriptor's type field to one of the following symbolic codes to specify the type of input parameter list:

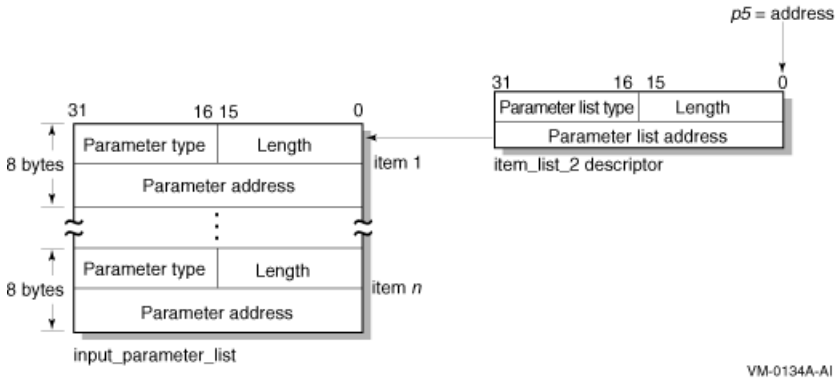
Symbolic Name	Input Parameter List Type
TCPIP$C_SOCKOPT	Socket options
TCPIP$C_TCPOPT	TCP protocol options
TCPIP$C_IPOPT	IP protocol options
TCPIP$C_IOCTL	I/O control commands

2. Set the descriptor's length field to specify the length of the input parameter list.

3. Set the descriptor's address field to specify the starting address of the input parameter list.

Figure 5.2, "Specifying an Input Parameter List" illustrates how the **p5** argument specifies an input parameter list.

Figure 5.2. Specifying an Input Parameter List



As the name implies, input parameter lists consist of one or more contiguous `item_list_2` or `ioctl_comm` structures. The length of a input parameter list is determined solely from the length field of its associated argument descriptor. Input parameter lists are never terminated by a longword containing a zero.

Each `item_list_2` structure that appears in an input parameter list describes an individual parameter or item to set. Such items include socket or protocol options as identified by the item's type field.

To initialize an `item_list_2` descriptor, you need to:

1. Set the item's type field to one of the symbolic codes found in the following tables:

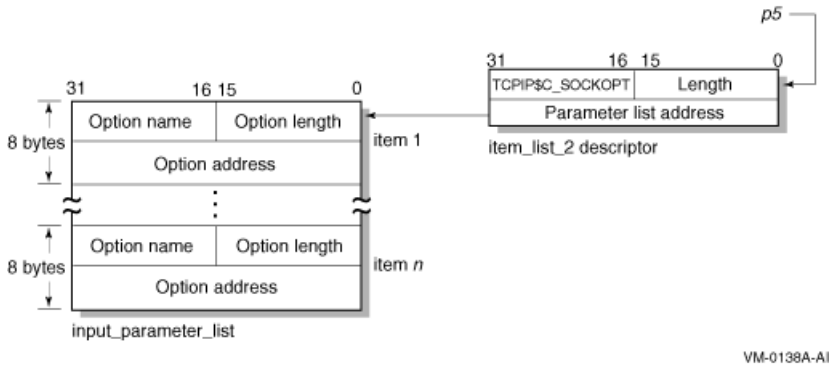
   Table A.1, "Socket Options"
   Table A.2, "TCP Protocol Options"
   Table A.3, "IP Protocol Options"

2. Set the item's length field to specify the length of the item.

3. Set the item's address field to specify the starting address of its data.

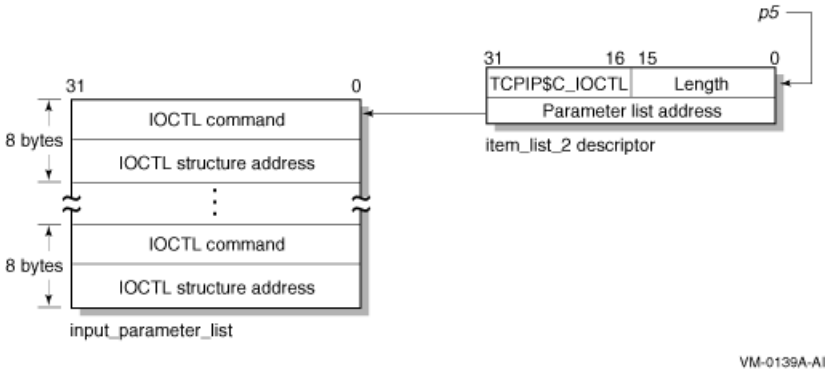
Figure 5.3, "Setting Socket Options" illustrates how to specify setting socket options.

Figure 5.3. Setting Socket Options



Each `ioctl_comm` structure appearing in an input parameter list contains an I/O control command – the IOCTL request code (as defined by $SIOCDEF) and its associated IOCTL structure address. *Figure 5.4, "Setting IOCTL Parameters"* illustrates how to specify (set) I/O control (IOCTL) commands.

Figure 5.4. Setting IOCTL Parameters



5.5.2. Specifying an Output Parameter List

Use the **p6** argument with the IO$_SENSEMODE function to specify output parameter lists. The **p6** argument specifies the address of an `item_list_2` descriptor that points to and identifies the type of output parameter list.

To initialize an `item_list_2` descriptor, you need to:

1. Set the descriptor's type field to one of the following symbolic codes to specify the type of output parameter list:

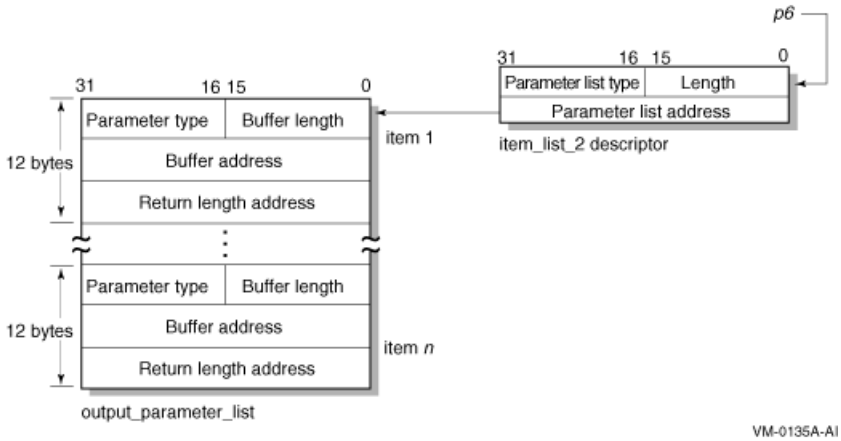
Symbolic Name	Output Parameter List Type
TCPIP$C_SOCKOPT	Socket options
TCPIP$C_TCPOPT	TCP protocol options
TCPIP$C_IPOPT	IP protocol options
TCPIP$C_IOCTL	I/O control commands

2. Set the descriptor's length field to specify the length of the output parameter list.

3. Set the descriptor's address field to specify the starting address of the output parameter list.

Figure 5.5, "Specifying an Output Parameter List" illustrates how the **p6** argument specifies an output parameter list.

Figure 5.5. Specifying an Output Parameter List



As the name implies, output parameter lists consist of one or more contiguous `item_list_3` or `ioctl_comm` structures. The length of an output parameter list is determined solely from the length field of its associated argument descriptor. Output parameter lists are never terminated by a longword containing a zero.

Each `item_list_3` structure that appears in an output parameter list describes an individual parameter or item to return. Such items include socket or protocol options as identified by the item's type field.

To initialize an `item_list_3` structure, you need to:

1. Set the item's type field to one of symbolic codes found in the following tables:

   Table A.1, "Socket Options"
   Table A.2, "TCP Protocol Options"
   Table A.3, "IP Protocol Options"

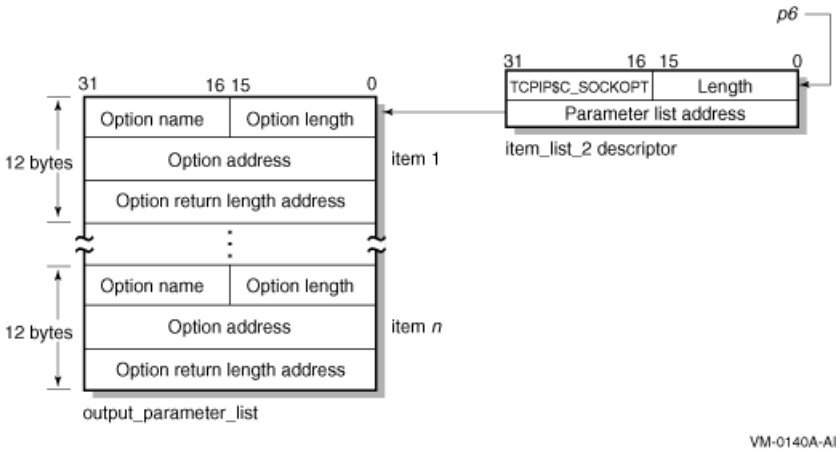
2. Set the item's buffer length field to specify the length of its buffer.

3. Set the item's buffer address field to specify the starting address of its buffer.

4. Set the item's returned length address field to specify the address of a longword to receive the length in bytes of the information actually returned for this item.

Figure 5.6, "Getting Socket Options" illustrates how to specify getting socket options.

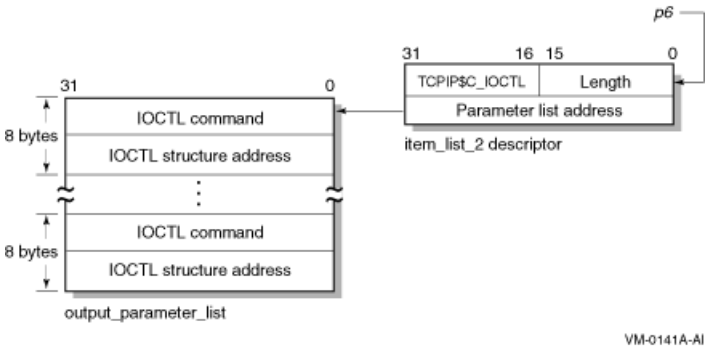
Figure 5.6. Getting Socket Options



Each `ioctl_comm` structure appearing in a output parameter list contains an I/O control command – the IOCTL request code (as defined by `$SIOCDEF`) and its associated IOCTL structure address. For more information about IOCTL requests, see *Appendix B, "IOCTL Requests"*.

Figure 5.7, "Getting IOCTL Parameters" illustrates how to specify (get) I/O control (IOCTL) commands.

Figure 5.7. Getting IOCTL Parameters



5.5.3. Specifying a Socket Name

Use the **p3** or **p4** argument with the IO$_ACCESS, IO$_READVBLK, IO$_SENSEMODE, IO $_SETMODE, and IO$_WRITEVBLK functions to specify a socket name. The **p3** and **p4** arguments specify the address of an `item_list_2` or `item_list_3` descriptor that points to a socket name structure. The socket name structure contains (among other things), the address domain, port number, and host internet address.

Note

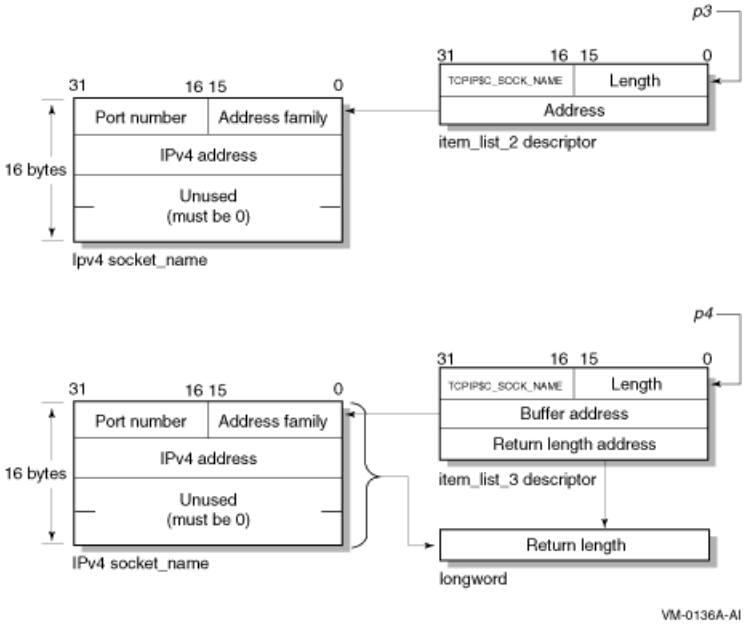
Port numbers 1 to 1023 require SYSPRV and BYPASS privileges when assigned. If you specify 0 when binding a socket name, the system assigns an available port.

Use an `item_list_2` argument descriptor with the IO$_ACCESS, IO$_WRITEVBLK, and IO $_SETMODE functions to specify (set) a socket name. The descriptor's parameter type is TCPIP $C_SOCK_NAME.

Use an `item_list_3` argument descriptor with the IO$_ACCESS |IO$M_ACCEPT, IO $_READVBLK, and IO$_SENSEMODE functions to specify (get) a socket name. The descriptor's parameter type is TCPIP$C_SOCK_NAME.

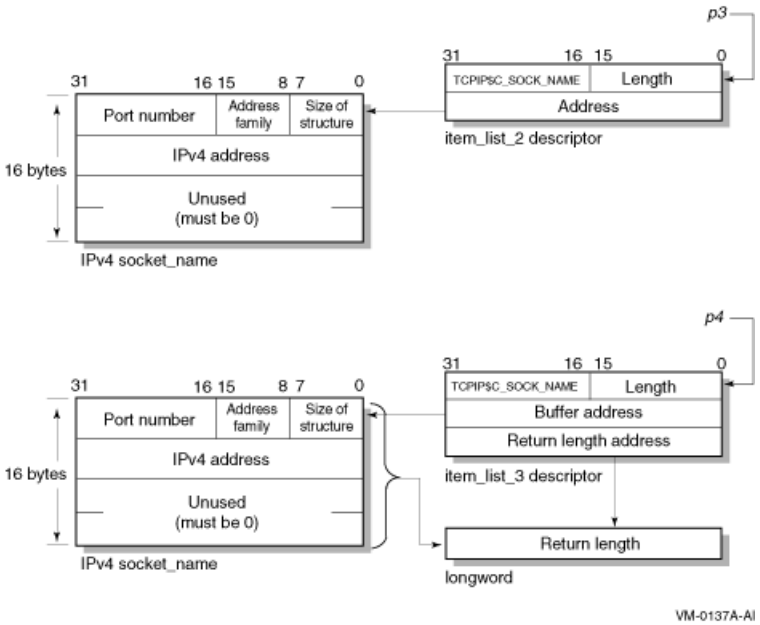
With BSD Version 4.3, specify IPv4 socket names as illustrated in *Figure 5.8, "Specifying IPv4 Socket Names (BSD Version 4.3)"*.

Figure 5.8. Specifying IPv4 Socket Names (BSD Version 4.3)



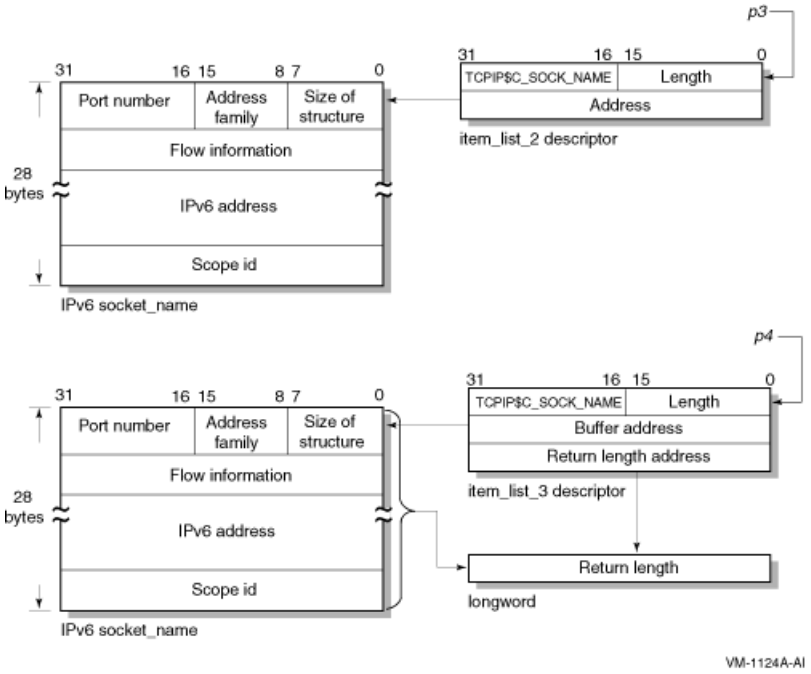
With BSD Version 4.4, specify IPv4 socket names as illustrated in *Figure 5.9, "Specifying IPv4 Socket Names (BSD Version 4.4)"*.

Figure 5.9. Specifying IPv4 Socket Names (BSD Version 4.4)



Specify IPv6 socket names as illustrated in *Figure 5.10, "Specifying IPv6 Socket Names (BSD Version 4.4)"*.

Figure 5.10. Specifying IPv6 Socket Names (BSD Version 4.4)



Note that the first byte in the socket name is the length field. To accommodate this field, use the IO $M_EXTEND function modifier for all I/O functions that take a socket name as an output argument (IO $_ACCESS |IO$M_ACCEPT, IO$_READVBLK, and IO$_SENSEMODE). Always use a buffer large enough to accept IPv6 socket names when you use the IO$M_EXTEND function modifier.

5.5.4. Specifying a Buffer List

Use the **p5** argument with the IO$_WRITEVBLK function to specify input buffer lists. The **p5** argument specifies the address of a 32- or 64-bit fixed-length descriptor (on Alpha and I64 systems) or a 32-bit fixed-length descriptor (on VAX systems) pointing to an input buffer list.

Use the **p6** argument with the IO$_READVBLK function to specify output buffer lists. The **p6** argument specifies the address of a 32- or 64-bit fixed-length descriptor (on Alpha and I64 systems) or a 32-bit fixed-length descriptor (on VAX systems) pointing to an output buffer list.

To initialize a **p5** or **p6** argument descriptor, you need to:

1. Set the descriptor's data-type code (the DTYPE field) to DSC$K_DTYPE_DSC to specify a buffer list containing one or more descriptors defining the length and starting address of user buffers.

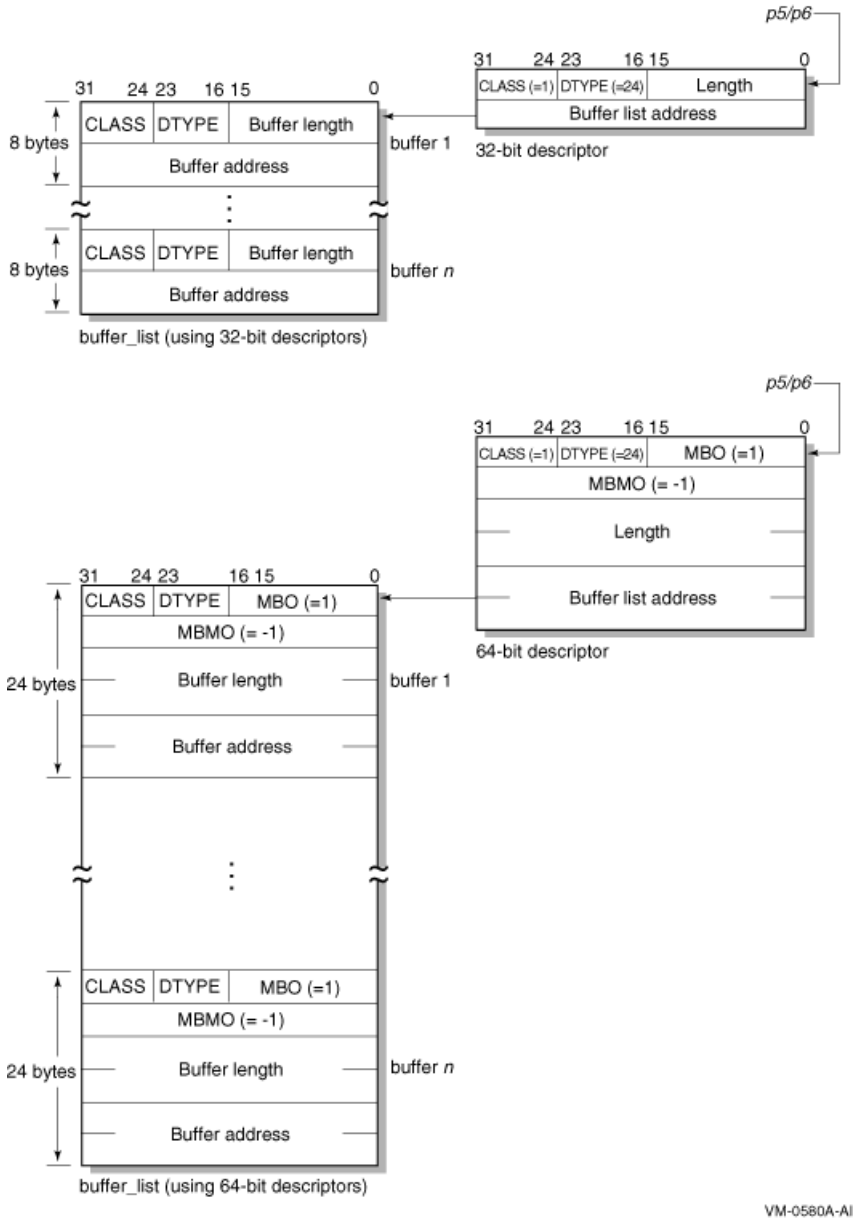
2. Set the descriptor's class code (the CLASS field) to DSC$K_CLASS_S.

3. Set the descriptor's length field to specify the length of the buffer list.

4. Set the descriptor's MBO field to 1 and the MBMO field to all 1s if this is a 64-bit argument descriptor.

Figure 5.11, "Specifying a Buffer List" illustrates how to specify a buffer list.

Figure 5.11. Specifying a Buffer List



Buffer lists, as the name implies, consist of one or more contiguous 32- or 64-bit fixed-length descriptors (on Alpha and I64 systems) or 32-bit fixed-length descriptors (on VAX systems).

Each 32- or 64-bit descriptor that appears in a buffer list describes one user buffer. Initialize each descriptor by setting its data type, class, length, and address fields as appropriate for 32- and 64-bit descriptors.

For more information about using 32-bit and 64-bit descriptors, refer to the OpenVMS Calling Standard.

Chapter 6. OpenVMS System Services Reference

This chapter provides detailed information about the OpenVMS system services for writing network applications. The chapter also describes the network pseudodevice driver and TELNET port driver I/O functions used with the $QIO system service.

The descriptions of the system services and I/O function codes are targeted specifically for network application programmers. For a general description of these system services and I/O function codes, see the *VSI OpenVMS System Services Reference Manual* manuals.

Table 6.1, "OpenVMS System Service and Equivalent Sockets API Function" lists the equivalent Sockets API function for each system service and $QIO I/O function code in this chapter. See *Chapter 4, "Sockets API Reference"* for descriptions of the Sockets API functions.

Table 6.1. OpenVMS System Service and Equivalent Sockets API Function

OpenVMS System Service	**Sockets API Function or Description**
$ASSIGN	`socket()`
$CANCEL	`close()`
$DASSGN	`close()`
$QIO	
Network Pseudodevice I/O Function Codes:	
IO$_ACCESS	`connect()`
IO$_ACCESS\|IO$M_ACCEPT	`accept()`
IO$_ACPCONTROL	`gethostbyname()`, `gethostbyaddr()`, `getnetbyname()`, `getnetbyaddr()`
IO$_DEACCESS	`close()`
IO$_DEACCESS\|IO$M_SHUTDOWN	`shutdown()`
IO$_READVBLK	`read()`, `recv()`, `recvfrom()`, `recvmsg()`
IO$_SENSEMODE	`getsockopt()`, `ioctl()`, `getpeername()`, `getsockname()`
IO$_SENSECHAR	`getsockopt()`, `ioctl()`, `getpeername()`, `getsockname()`
IO$_SETMODE	`socket()`, `bind()`, `listen()`, `setsockopt()`, `ioctl()`
IO$_SETCHAR	`socket()`, `bind()`, `listen()`, `setsockopt()`, `ioctl()`
IO$_WRITEVBLK	`send()`, `sendto()`, `sendmsg()`, `write()`
TELNET Port Driver I/O Function Codes:	
IO$_TTY_PORT	
IO$M_TN_STARTUP	Binds a socket to a TELNET terminal device.
IO$M_TN_SHUTDOWN	Breaks a previously bound socket terminal connection.

OpenVMS System Service	Sockets API Function or Description
IO$_TTY_PORT_BUFIO	
IO$M_TN_SENSEMODE	Reads parameters associated with the device.
IO$M_TN_SETMODE	Writes parameters associated with the device.

6.1. System Service Descriptions

This section describes the OpenVMS system services used to write network applications.

Detailed information about each argument is listed for each I/O function. 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

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 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.

To determine the correct syntax of the data type you are using, refer to the appropriate language implementation table in *Appendix C, "Data Types"*.

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.

Assign I/O Channel

Assign I/O Channel — Provides a calling process with an I/O channel, thereby allowing the calling process to perform I/O operations on the network pseudodevice. On Alpha and I64 systems, this service accepts 64-bit addresses.

Format

```
SYS$ASSIGN devnam, chan, [acmode], [mbxnam], [flags]
```

C Prototype

```
int sys$assign(void *devnam, unsigned short int *chan, unsigned int acmode,
 void *mbxnam,...);
```

Returns

OpenVMS usage:	cond_value

type:	longword (unsigned)
access:	write only
mechanism:	by value

Longword condition value. All system services return (by immediate value) a condition value in R0. Condition values that can be returned by this service are listed under Condition Values Returned.

Arguments

devnam

OpenVMS usage:	device_name
type:	character-coded text string
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit descriptor-fixed-length string descriptor (VAX) by 32-bit descriptor-fixed-length string descriptor

Name of the device to which $ASSIGN is to assign a channel. The **devnam** argument is the address of a character string descriptor pointing to the network pseudodevice name string (either TCPIP$DEVICE: or SYS$NET:).

chan

OpenVMS usage:	channel
type:	word (unsigned)
access:	write only
mechanism:	(Alpha and I64) by 32- or 64-bit reference (VAX) by 32-bit reference

Number of the channel that is assigned. The **chan** argument is the address of a word into which $ASSIGN writes the channel number.

acmode

OpenVMS usage:	access_mode
type:	longword (unsigned)
access:	read only
mechanism:	by value

Access mode to be associated with the channel. I/O operations on the channel can be performed only from equal or more privileged access modes. The $PSLDEF macro defines the following symbols for the four access modes:

Symbol	Access Mode	Numeric Value
PSL$C_KERNEL	Kernel	0
PSL$C_EXEC	Executive	1
PSL$C_SUPER	Supervisor	2

Symbol	Access Mode	Numeric Value
PSL$C_USER	User	3

mbxnam

OpenVMS usage:	device_name
type:	character-coded text string
access:	read only
mechanism:	(Alpha and I64) by 32-bit or 64-bit descriptor-fixed-length string descriptor (VAX) by 32-bit descriptor-fixed-length string descriptor

This argument is not used.

flags

OpenVMS usage:	mask_longword
type:	longword (unsigned)
access:	read only
mechanism:	by value

An optional device-specific argument. The **flags** argument is a longword bit mask. For more information about the applicability of the **flags** argument for a particular device, refer to the *OpenVMS I/O User's Reference Manual*.

Description

The $ASSIGN system service establishes a path to a device but does not check whether the calling process has the capability to do I/O operations to the device. The device drivers may apply privilege and protection restrictions. The calling process must have NETMBX privilege to assign a channel.

System dynamic memory is required for the target device, and the I/O byte limit quota from the process buffer is used.

When a channel is assigned to the TCPIP$DEVICE: network pseudodevice, the network software creates a new device called BG*n*, where *n* is a unique unit number. The corresponding channel number is used in any subsequent operation requests for that device.

When the auxiliary server creates a process for a service with the LISTEN flag set, the server creates a device socket. In order for your application to receive the device socket, assign a channel to SYS $NET, which is the logical name of a network pseudodevice, and perform an appropriate $QIO(IO $_SETMODE) operation.

Channels remain assigned either until they are explicitly deassigned with the Deassign I/O Channel ($DASSGN) service or, if they are user-mode channels, until the image that assigned the channel exits.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ACCVIO

The caller cannot read the device string or string descriptor, or the caller cannot write the channel number.

SS$_DEVALLOC

The device is allocated to another process.

SS$_DEVLSTFULL

The system maximum number of BG: device units has been reached.

SS$_EXQUOTA

The process has exceeded its buffered I/O byte limit (BIOLM) quota.

SS$_IVDEVNAM

No device name was specified, the logical name translation failed, or the device name string contains invalid characters.

SS$_IVLOGNAM

The device name string has a length of zero or has more than 63 characters.

SS$_NOIOCHAN

No I/O channel is available for assignment.

SS$_NOPRIV

The specified channel is not assigned or was assigned from a more privileged access mode.

SS$_NOSUCHDEV

The specified device does not exist.

Cancel I/O on Channel

Cancel I/O on Channel — Cancels all pending I/O requests on a specified channel.

Related Functions

The equivalent Sockets API function is `close()`.

Format

`SYS$CANCEL` *chan*

C Prototype

```
int sys$cancel(unsigned short int chan);
```

Returns

OpenVMS usage:	cond_value

type:	longword (unsigned)
access:	write only
mechanism:	by value

Longword condition value. All system services return (by immediate value) a condition value in R0. Condition values that can be returned by this service are listed under Condition Values Returned.

Arguments

chan

OpenVMS usage:	channel
type:	word (unsigned)
access:	read only
mechanism:	by value

I/O channel on which I/O is to be canceled. The **chan** argument is a word containing the channel number.

Description

To cancel I/O on a channel, the access mode of the calling process must be equal to or more privileged than the access mode of the process that made the original channel assignment.

The $CANCEL service requires system dynamic memory and uses the process's buffered I/O limit (BIOLM) quota.

When a request currently in progress is canceled, the driver is notified immediately. Actual cancellation may or may not occur immediately, depending on the logical state of the driver. When cancellation does occur, the action taken for I/O in progress is similar to that taken for queued requests. For example:

- The specified event flag is set.
- The first word of the I/O status block, if specified, is set to SS$_CANCEL if the I/O request is queued, or to SS$_ABORT if the I/O operation is in progress.
- If the asynchronous system trap (AST) is specified, it is queued.

For proper synchronization between this service and the actual canceling of I/O requests to take place, the issuing process must wait for the I/O process to complete normally. Note that the I/O has been canceled. Outstanding I/O requests are canceled automatically at image exit.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ABORT

A physical line went down during a network connect operation.

SS$_CANCEL

The I/O operation was canceled by executing a $CANCEL system service.

SS$_EXQUOTA

The process has exceeded its buffered I/O limit (BIOLM) quota.

SS$_INSFMEM

Insufficient system dynamic memory to cancel the I/O.

SS$_IVCHAN

An invalid channel was specified (that is, a channel number of 0 or a number larger than the number of channels available).

SS$_NOPRIV

The specified channel is not assigned or was assigned from a more privileged access mode.

Deassign I/O Channel

Deassign I/O Channel — Deassigns (releases) an I/O channel previously acquired using the Assign I/O Channel ($ASSIGN) service.

Related Functions

The equivalent Sockets API function is `close()`.

Format

`SYS$DASSGN` *`chan`*

C Prototype

```
int sys$dassgn(unsigned short int chan);
```

Returns

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

Longword condition value. All system services return (by immediate value) a condition value in R0. Condition values that can be returned by this service are listed under Condition Values Returned.

Arguments

chan

OpenVMS usage:	channel

type:	word (unsigned)
access:	read only
mechanism:	by value

Number of the I/O channel to be deassigned. The **chan** argument is a word containing this number.

Description

After all communication is completed, use the $DASSGN system service to free an I/O channel. A $DASSGN operation executed on a channel associated with a network pseudodevice does the following:

- Ends all pending operations to send or receive data at $QIO level ($CANCEL system service).
- Clears the port associated with the channel. When executing the $DASSGN system service for TCP sockets, the socket remains until the connection is closed on both the local and remote sides.
- Ends all communications with the network pseudodevice that the I/O channel identifies.
- Frees the channel associated with the network pseudodevice. An I/O channel can be deassigned only from an access mode equal to or more privileged than the access mode from which the original channel assignment was made.

I/O channels assigned from user mode are automatically deassigned at image exit.

Note

Even after a $DASSGN has been issued, a TCP socket may remain until the TCP close timeout interval expires. The default and maximum timeout interval is either 10 minutes if the peer host is not responding or 30 seconds after acknowledging the socket close. Although the TCP socket is open, you cannot make a reference to that socket after issuing a $DASSGN.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_IVCHAN

An invalid channel number was specified (that is, a channel number of zero or a number larger than the number of channels available).

SS$_NOPRIV

The specified channel is not assigned or is assigned from a more privileged access mode.

Queue I/O Request

Queue I/O Request — Queues an I/O request to a channel associated with a network pseudodevice. The $QIO service is completed asynchronously; that is, it returns to the caller immediately after queuing the I/O request, without waiting for the I/O operation to be completed. For synchronous completion,

use the Queue I/O Request and Wait ($QIOW) service. The $QIOW service is identical to the $QIO service, except the $QIOW returns to the caller after the I/O operation has completed. On Alpha and I64 systems, this service accepts 64-bit addresses.

Format

```
SYS$QIO [efn],chan,func, [iosb],[astadr],[astprm], [p1],[p2],[p3],[p4],
 [p5],[p6]
```

C Prototype

```
int sys$qio(unsigned int efn, unsigned short int chan, unsigned int func,
 struct _iosb *iosb, void (*astadr)(__unknown_params), __int64 astprm, void
 *p1, __int64 p2, __int64 p3, __int64 p4, __int64 p5, __int64 p6);
```

Returns

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

Longword condition value. All system services return (by immediate value) a condition value in R0. Condition values that can be returned by this service are listed under Condition Values Returned.

Arguments

efn

OpenVMS usage:	ef_number
type:	longword (unsigned)
access:	read only
mechanism:	by value

Event flag that $QIO sets when the I/O operation completes. The **efn** argument is a longword value containing the number of the event flag; however, $QIO uses only the low-order byte.

If **efn** is not specified, event flag 0 is set.

The specified event flag is set if the service terminates without queuing an I/O request.

chan

OpenVMS usage:	channel
type:	word (unsigned)
access:	read only
mechanism:	by value

I/O channel that is assigned to the device to which the request is directed. The **chan** argument is a word value containing the number of the I/O channel.

func

OpenVMS usage:	function_code
type:	longword (unsigned)
access:	read only
mechanism:	by value

Function codes and function modifiers specifying the operation to be performed. The **func** argument is a longword containing the function code.

For information about the network pseudodevice and TELNET device function codes and modifiers, see *Section 6.2, "Network Pseudodevice Driver I/O Functions"* and *Section 6.4, "TELNET Port Driver I/O Function Codes"*.

iosb

OpenVMS usage:	io_status_block
type:	quadword (unsigned)
access:	write only
mechanism:	(Alpha and I64) by 32-bit reference or 64-bit reference
	(VAX) by 32-bit reference

I/O status block to receive the final completion status of the I/O operation. The **iosb** is the address of the quadword I/O status block. See *Figure 5.1, "I/O Status Block for a Successful READ or WRITE Operation"* for a description of the general structure of the I/O status block.

When the $QIO begins executing, it clears the event flag. The $QIO also clears the quadword I/O status block if the **iosb** argument is specified.

Although the **iosb** argument is optional, VSI strongly recommends that you specify it, for the following reasons:

- If you are using an event flag to signal the completion of the service, you can test the I/O status block for a condition value to be sure that the event flag was not set by an event other than service completion.
- If you are using the $SYNCH service to synchronize completion of the service, the I/O status block is a required argument for $SYNCH.
- The condition value returned in R0 and the condition value returned in the I/O status block provide information about different aspects of the call to the $QIO service. The condition value returned in R0 provides information about the success or failure of the service call itself; the condition values returned in the I/O status block give information on the success or failure of the service operation. Therefore, to determine the success or failure of the $QIO call, check the condition values returned in both the R0 and the I/O status block.

astadr

OpenVMS usage:	ast_procedure
type:	procedure value

access:	call without stack unwinding
mechanism:	(Alpha and I64) by 32- or 64-bit reference
	(VAX) by 32-bit reference

AST service routine to be executed when the I/O completes. The **astadr** argument is the address of the AST routine.

The AST routine executes at the access mode of the caller of $QIO.

astprm

OpenVMS usage:	user_arg
type:	quadword unsigned (Alpha and I64); longword unsigned (VAX)
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit value
	(VAX) by 32-bit value

AST parameter to be passed to the AST service routine. On Alpha and I64 systems, the **astprm** argument is a quadword value containing the AST parameter. On VAX systems, the **astprm** argument is a longword value containing the AST parameter.

p1 to p6

OpenVMS usage:	varying_arg
type:	quadword unsigned (Alpha and I64); longword unsigned (VAX)
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit reference or by 64-bit value depending on the I/O function
	(VAX) by 32-bit reference or by 32-bit value depending on the I/O function

Optional device- and function-specific I/O request arguments. The parameter values contained in these arguments vary according to the function for which they are used. See *Table 6.2, "Network Pseudodevice Driver I/O Functions"* for descriptions of the network pseudodevice driver I/O function codes; see *Table 6.7, "List Codes for the **p5** Item"* through *Table 6.10, "Service Type Codes"* for related TELNET device driver I/O function codes.

Description

The Queue I/O Request service operates only on assigned I/O channels and only from access modes that are equal to or more privileged than the access mode from which the original channel assignment was made.

For TCP/IP Services, $QIO uses the following system resources:

- The process's AST limit (ASTLM) quota, if an AST service routine is specified.
- System dynamic memory, which is required to queue the I/O request. System dynamic memory requirements are protocol specific.

- Additional memory, on a device-dependent basis.

For $QIO, completion can be synchronized as follows:

- By specifying the **astadr** argument to have an AST routine execute when the I/O is completed.
- By calling the $SYNCH synchronize service to await completion of the I/O operation. (If you want your I/O operation to complete synchronously, use the $QIOW system service instead.)

Condition Values Returned

Each function used with $QIO has its own error codes. See the error codes listed under the individual descriptions of the I/O function code in the remainder of this chapter.

6.2. Network Pseudodevice Driver I/O Functions

The network pseudodevice allows physical, logical, and virtual I/O functions. The physical and logical I/O functions are used only with the IP layer. *Table 6.2, "Network Pseudodevice Driver I/O Functions"* lists the basic I/O functions and their modifiers. The sections that follow describe in greater detail the operation of these I/O functions.

Table 6.2. Network Pseudodevice Driver I/O Functions

Function Code and Arguments	Function Modifier	Description
IO$_ACCESS **p3,p4**	IO$M_ACCEPT IO$M_EXTEND IO$M_NOW	Opens a connection.
IO$_ACPCONTROL **p1, p2, p3, p4**		Performs an ACP (ancillary control process) operation.
IO$_DEACCESS **p4**	IO$M_NOW IO$M_SHUTDOWN	Aborts or closes a connection.
IO$_READVBLK **p1,p2,p3,p4,p6**	IO$M_EXTEND IO$M_INTERRUPT	Reads a virtual block.
	IO$M_LOCKBUF IO$M_PURGE	Controls the buffer operations.
IO$_SENSEMODE **p2**, **p3,p4,p6**		Reads the network pseudodevice characteristics.
IO$_SENSECHAR **p2**, **p3,p4,p6**		Reads the network pseudodevice characteristics.
IO$_SETMODE **p1**, **p2**, **p3,p4,p5**	IO$M_OUTBAND IO$M_READATTN IO$M_WRTATTN	Sets the network pseudodevice characteristics for subsequent operations.

Function Code and Arguments	Function Modifier	Description
IO$_SETCHAR **p1**, **p2**, **p3,p4,p5**	IO$M_OUTBAND IO$M_READATTN IO$M_WRTEATTN	Sets the network pseudodevice characteristics for subsequent operations.
IO$_WRITEVBLK **p1,p2,p3,p4,p5**	IO$M_INTERRUPT	Writes a virtual block.

Table 5.2, "Network Symbol Definition Files" lists the file names of the symbol definition files. These files specify $QIO arguments (**p1,p2,...p6**) for applications written in the corresponding programming languages. You must invoke the symbol definition by using the appropriate statement in your application.

6.3. Network Pseudodevice Driver I/O Function Codes

IO$_ACCESS

IO$_ACCESS — When using a connection-oriented protocol, such as TCP, the IO$_ACCESS function initiates a connection and specifies a remote port number and IP address. When using a connectionless protocol, such as UDP, the IO$_ACCESS function sets the remote port number and IP address. For TCP, a connection request times out at a specified interval (75 seconds is the default). This interval can be changed by setting the inet subsystem parameter `tcp_keepinit`. The program can also set a specific timeout interval for a socket that it has created, as described in *Table A.2, "TCP Protocol Options"*. If a connection fails, you must deallocate the socket and then create a new socket before trying to reconnect.

Related Functions

The equivalent Sockets API function is `connect()`.

Arguments

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_2` descriptor

The remote port number and IP address of the host to connect. The **p3** argument is the address of an `item_list_2` descriptor that points to the socket address structure containing the remote port number and IP address.

Function Modifiers

IO$M_NOW

Regardless of a $QIO or $QIOW, if the system detects a condition that would cause the operation to block, the system completes the I/O operation and returns the SS$_SUSPENDED status code.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_BADPARAM

Programming error that occurred for one of the following reasons:

- $QIO system service was specified without a socket.
- An IO$_ACCESS function was specified without the address of a remote socket name (**p3** was null).

SS$_BUGCHECK

Inconsistent state. Report the problem to your VSI support representative.

SS$_CANCEL

The I/O operation was canceled by a $CANCEL system service.

SS$_CONNECFAIL

The connection to a network object timed out or failed.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_DUPLNAM

A network configuration error. No ports were available for new connections.

SS$_EXQUOTA

The process has exceeded a process quota.

SS$_FILALRACC

The specified socket name is already in use by one of the following:

- On a raw socket, the remote IP address was already specified on a previous IO$_ACCESS call.
- On a datagram, the remote IP address was already specified on a previous IO$_ACCESS call.
- On a stream socket, the IO$_ACCESS function targeted a stream socket that was already connected.

SS$_ILLCNTRFUNC

Illegal function.

SS$_INSFMEM

Insufficient system dynamic memory to complete the service.

SS$_IVADDR

The specified IP address was not found, or an invalid port number and IP address combination was specified with the IO$_ACCESS function. Port 0 is not allowed with the IO$_ACCESS function.

SS$_IVBUFLEN

The size of the socket name structure specified with the IO$_ACCESS function was invalid.

SS$_LINKABORT

The remote socket closed the connection.

SS$_NOLICENSE

The TCP/IP Services license is not present.

SS$_PROTOCOL

A network protocol error occurred. The address family specified in the socket address structure is not supported.

SS$_REJECT

The network connection is rejected for one of the following reasons:

- An attempt was made to connect to a remote socket that is already connected.
- An error was encountered while establishing the connection
- The peer socket refused the connection request or is closing the connection.

SS$_SHUT

The local or remote node is no longer accepting connections.

SS$_SUSPENDED

The system detected a condition that might cause the operation to block.

SS$_TIMEOUT

A TCP connection timed out before the connection could be established.

SS$_UNREACHABLE

The remote node is currently unreachable.

IO$_ACCESS|IO$M_ACCEPT

IO$_ACCESS|IO$M_ACCEPT — This function is used with a connection-based protocol, such as TCP, to accept a new connection on a passive socket. This function completes the first connection on the queue of pending connections.

Related Functions

The equivalent Sockets API function is `accept()`.

Arguments

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_3` descriptor

The remote port number and IP address of a new connection. The **p3** argument is the address of an `item_list_3` descriptor that points to the socket address structure into which the remote port number and IP address of the new connection is written.

p4

OpenVMS usage:	channel
type:	word (unsigned)
access:	write only
mechanism:	by reference

The I/O channel number assigned to a new connection. The **p4** argument is the address of a word into which the new connection's channel number is written.

Function Modifiers

IO$M_EXTEND

Allows the usage of BSD Version 4.4 formatted socket address structures. Use this modifier to operate in the IPv6 environment.

IO$M_NOW

Regardless of a $QIO or $QIOW, if the system detects a condition that would cause the operation to block, the system completes the I/O operation and returns the SS$_SUSPENDED status code.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_BADPARAM

Programming error that occurred for one of the following reasons:

- $QIO system service was specified without a socket.
- A IO$_ACCESS|IO$M_ACCEPT function was specified without the address of the channel for the new connection (**p4** was null or invalid).

SS$_BUGCHECK

Inconsistent state. Report the problem to your VSI support representative.

SS$_CANCEL

The I/O operation was canceled by a $CANCEL system service.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_EXQUOTA

The process has exceeded a process quota.

SS$_FILALRACC

The specified socket name is already in use by one of the following:

- On a raw socket, the remote IP address was already specified on a previous IO$_ACCESS call.
- On a datagram, the remote IP address was already specified on a previous IO$_ACCESS call.
- On a stream socket, the IO$_ACCESS function targeted a stream socket that was already connected.

SS$_ILLCNTRFUNC

Illegal function.

SS$_INSFMEM

Insufficient system dynamic memory to complete the service.

SS$_IVADDR

The specified IP address was not found, or an invalid port number and IP address combination was specified with the IO$_ACCESS function. Port 0 is not allowed with the IO$_ACCESS function.

SS$_IVBUFLEN

The size of the socket name structure specified with the IO$_ACCESS function was invalid.

SS$_LINKABORT

The remote socket closed the connection.

SS$_NOLICENSE

The TCP/IP Services license is not present.

SS$_PROTOCOL

A network protocol error occurred. The address family specified in the socket address structure is not supported.

The network connection is rejected for one of the following reasons:

- An attempt was made to connect to a remote socket that is already connected.
- An error was encountered while establishing the connection
- The peer socket refused the connection request or is closing the connection.)

SS$_SHUT

The local or remote node is no longer accepting connections.

SS$_SUSPENDED

The system detected a condition that might cause the operation to block.

SS$_TIMEOUT

A TCP connection timed out before the connection could be established.

SS$_UNREACHABLE

The remote node is currently unreachable.

IO$_ACPCONTROL

IO$_ACPCONTROL — The IO$_ACPCONTROL function accesses the network ACP to retrieve information from the host and the network database files.

Related Functions

The equivalent Sockets API functions are `gethostbyaddr()`, `gethostbyname()`, `getnetbyaddr()`, and `getnetbyname()`.

Arguments

p1

OpenVMS usage:	subfunction_code
type:	longword (unsigned)
access:	read only
mechanism:	by descriptor-fixed-length descriptor

A longword identifying the network ACP operation to perform. The **p1** argument is the address of a descriptor pointing to this longword.

To specify the network ACP operation to perform, select a subfunction code from *Table 6.3, "Subfunction Codes"* and a call code from *Table 6.4, "Call Codes"*.

Table 6.3, "Subfunction Codes" defines subfunction codes for network ACP operations.

Table 6.3. Subfunction Codes

Subfunction Code	Description
INETACP_FUNC$C_GETHOSTBYADDR	Get the host name of the specified IP address from the hosts database.[1]
INETACP_FUNC$C_GETHOSTBYNAME	Get the IP address of the specified host from the hosts database.[1]
INETACP_FUNC$C_GETNETBYADDR	Get the network name of the specified IP address from the network database.
INETACP_FUNC$C_GETNETBYNAME	Get the IP address of the specified network from the network database.

[1]You can limit the maximum amount of time spent obtaining host names and addresses by entering the command TCPIP SET NAME_SERVICE/TIMEOUT=1/RETRY=1

Table 6.4, "Call Codes" defines call codes for network ACP operations.

Table 6.4. Call Codes

Call Code	Description
INETACP$C_ALIASES	Returns the list of alias names associated with the specified host or network from the internet hosts or network database.
INETACP$C_TRANS	Returns the IP address associated with the specified host or network as a 32-bit value in network byte order.
INETACPC$C_HOSTENT_OFFSET	Returns full host information in a modified `hostent` structure. In the modified structure, pointers are replaced with offsets from the beginning of the structure.
INETACP$C_NETENT_OFFSET	Returns full network information in a modified `netent` structure. In the modified structure, pointers are replaced with offsets from the beginning of the structure.

IO$_ACPCONTROL searches the local hosts database for the host's name. If a matching host name is not found in the local hosts database, IO$_ACPCONTROL then searches the BIND database if the BIND resolver is enabled.

p2

OpenVMS usage:	char_string
type:	character-coded text string
access:	read only
mechanism:	by descriptor-fixed-length string descriptor

Input string for the network ACP operation containing one of the following: host IP address, host name, network IP address, or network name. The **p2** argument is the address of a string descriptor pointing to the input string. The input string must be in an area of memory that is capable of being read and written to.

All IP addresses are specified in dotted-decimal notation.

p3

OpenVMS usage:	word_unsigned
type:	word (unsigned)
access:	write only
mechanism:	by reference

Length in bytes of the output buffer returned by IO$_ACPCONTROL. The **p3** argument is the address of a word in which the length of the output buffer is written.

p4

OpenVMS usage:	buffer
type:	vector byte (unsigned)
access:	write only
mechanism:	by descriptor-fixed-length descriptor

Buffer into which IO$_ACPCONTROL writes its output data. The **p4** argument is the address of a descriptor pointing to the output buffer.

The format of the data returned in the output buffer is dictated by the call code specified by the **p1** argument.

- Strings returned by IO$_ACPCONTROL with a call code of INETACP$C_ALIASES consist of one of the following: host IP address, host name, network IP address, or network name. All IP addresses are formatted using dotted-decimal notation. Alias names are separated by a null character (0). The length of the returned string includes all null characters that separate alias names.
- IP addresses returned by IO$_ACPCONTROL with a call code of INETACP$C_TRANS are 32-bit values in network byte order.
- All `hostent` and `netent` structures returned by IO$_ACPCONTROL with a call code of INETACP$C_HOSTENT_OFFSET or INETACP$C_NETENT_OFFSET are modified; pointers are replaced with offsets from the beginning of the structure.

Condition Values Returned

SS$_NORMAL

The service completed successfully

SS$_ABORT

An error was detected while performing an ACP function.

SS$_BADPARAM

Programming or internal error. A bad parameter (name or address) was specified in the call.

SS$_BUFFEROVF

Programming error. There was not enough space for returning all alias names in the call.

SS$_ENDOFFILE

The information requested is not in the database.

SS$_ILLCNTRFUNC

Illegal function.

SS$_NOPRIV

The privilege level was insufficient for the execution of an ACP function.

SS$_RESULTOVF

The ACP overflowed the buffer in returning a parameter.

SS$_SHUT

The local or remote node is no longer accepting connections.

IO$_DEACCESS

IO$_DEACCESS — The IO$_DEACCESS function closes a connection and deletes a socket. Any pending messages queued for transmission are sent before tearing down the connection. When used with the IO$M_SHUTDOWN function modifier, the IO$_DEACCESS function shuts down all or part of a bidirectional connection on a socket. Use the **p4** argument to specify the disposition of pending I/O operations on the socket. You can specify a wait time or time-to-linger socket parameter (TCPIP$C_LINGER option) for transmission completion before disconnecting the connection. Use the IO$_SETMODE function to set and clear the TCPIP$C_LINGER option. If you set the TCPIP $C_LINGER option, a $QIO call that uses the IO$_DEACCESS function allows data queued to the socket to arrive at the destination. The system is blocked until data arrives at the remote socket. The socket data structure remains open for the duration of the TCP idle time interval. If you do not set the TCPIP$C_LINGER option (option is set to 0), a $QIO call that uses the IO$_DEACCESS function discards any data queued to the socket and deallocates the socket data structure. For compatibility with UNIX, TCP/IP Services forces a time to linger of 2 minutes on TCP stream sockets.

Related Functions

The equivalent Sockets API functions are `close()` and `shutdown()`.

Arguments

p4

OpenVMS usage:	mask_longword
type:	longword (unsigned)
access:	read only
mechanism:	by value

Longword of shutdown flags to specify the disposition of pending I/O operations on the socket. The **p4** argument is used only with the IO$M_SHUTDOWN function modifier. The following table lists available shutdown flags.

Shutdown Flag	Description
TCPIP$C_DSC_RCV	Discards messages from the receive queue and disallows further receiving. Pending messages in the receive queue for this connection are discarded.
TCPIP$C_DSC_SND	Discards messages from the send queue and disallows sending new messages. Pending messages in the transmit queue for this connection are discarded.
TCPIP$C_DSC_ALL	Discards all messages and disallows both sending and receiving. All pending messages are discarded. Specifying this flag has the same effect as issuing a $CANCEL QIO followed by an IO$_DEACCESS QIO without specifying any flags.

Function Modifiers

IO$M_SHUTDOWN

Causes all or part of a full-duplex connection on a socket to be shut down.

IO$M_NOW

Regardless of a $QIO or $QIOW, if the system detects a condition that would cause the operation to block, the system completes the I/O operation and returns the SS$_SUSPENDED status code.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_BADPARAM

The IO$_DEACCESS operation failed to specify a socket.

SS$_CANCEL

The I/O operation was canceled by a $CANCEL system service.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_NOLINKS

The specified socket was not connected.

SS$_SHUT

The local or remote node is no longer accepting connections.

SS$_SUSPENDED

The system detected a condition that might cause the operation to block.

IO$_READVBLK

IO$_READVBLK — The IO$_READVBLK function transfers data received from an internet host to the specified user buffers. Use both **p1** and **p2** arguments to specify a single user buffer. Use the **p6** argument to specify multiple buffers. For connection-oriented protocols, such as TCP, data is buffered in system space as a stream of bytes. The IO$_READVBLK function completes when one of the following occurs: there is no more data buffered in system space for this socket; there is no more available space in the user buffer. Data that is buffered in system space but did not fit in the user buffer is available to the user in subsequent $QIOs. For connectionless protocols, datagram and raw socket data is buffered in system space as a chain of records. The user buffer specified with a IO$_READVBLK function is filled with data that is buffered in one record. Each IO$_READVBLK reads data from one record. The IO$_READVBLK function completes when one of the following occurs: all data from a record is transferred to the user buffer; there is no more available space in the user buffer, any data remaining in the current record that did not fit in the user buffer is discarded, a subsequent $QIO reads data from the next record buffered in system space. Use the TCP/IP management command SHOW DEVICE_SOCKET/FULL to display counters related to read operations.

Related Functions

The equivalent Sockets API functions are `read()`, `recv()`, `recvfrom()`, and `recvmsg()`.

Arguments

p1

OpenVMS usage:	buffer
type:	vector byte (unsigned)
access:	read only
mechanism:	(Alpha and I64) by 64-bit reference

The address of the buffer to receive the incoming data. The length of this buffer is specified by the **p2** argument.

p2

OpenVMS usage:	buffer_length
type:	
access:	quadword unsigned (Alpha and I64); longword unsigned (VAX)
mechanism:	read only
OpenVMS usage	(Alpha and I64) by 64-bit value
	(VAX) by 32-bit value

The length (in bytes) of the buffer available to hold the incoming data. The address of this buffer is specified by the **p1** argument.

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_3` descriptor

The remote port number and IP address of the source of the datagram or raw IP message (not TCP). The **p3** argument is the address of an `item_list_3` descriptor that points to the socket address structure into which the remote port number and IP address of the message source is written.

p4

OpenVMS usage:	mask_longword
type:	longword (unsigned)
access:	read only
mechanism:	by value

Longword of flags to specify attributes for the read operations. *Table 6.5, "Read Flags"* lists the available read flags.

Table 6.5. Read Flags

Read Flag	Description
TCPIP$C_MSG_OOB	Reads an out-of-band byte.
TCPIP$C_MSG_PEEK	Reads a message but leaves the message in the queue.
TCPIP$C_MSG_NBIO	Does not block the I/O operation if the receive queue is empty (similar to using IO$M_NOWAIT).
TCPIP$C_MSG_PURGE	Flushes data from the queue (similar to using IO $M_PURGE).
TCPIP$C_MSG_BLOCKALL	Blocks the completion of the operation until the buffer is filled completely or until the connection is closed (similar to using IO$M_LOCKBUF).

p6

OpenVMS usage:	buffer_list
type:	vector byte (unsigned)
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit descriptor-fixed-length descriptor (VAX) by 32-bit descriptor-fixed-length descriptor

Output buffer list describing one or more buffers to hold the incoming data. The **p6** argument is the 32- or 64-bit address (on Alpha and I64 systems) or the 32-bit address (on VAX systems) of a descriptor that points to a output buffer list. Buffers are filled in the order specified by the output buffer list. The transfer-length value returned in the I/O status block is the total number of bytes transferred to all buffers.

If you use the **p1** and **p2** arguments, do not use the **p6** argument; they are mutually exclusive.

Function Modifiers

IO$_READVBLK

Specifies the format of the socket address structure to return when used with the **p3** argument.

When specified, a BSD Version 4.4 formatted socket address structure is returned that identifies the source of the received UDP datagram or raw IP message.

To operate in an IPv6 environment, you must set the IO$M_EXTEND modifier.

IO$M_INTERRUPT

Reads an out-of-band (OOB) message. This has the same effect as specifying the TCPIP $C_MSG_OOB flag in the **p4** argument.

On receiving an OOB character, TCP/IP stores the pointer in the received stream with the character that precedes the OOB character.

A read operation with a user-buffer size larger than the size of the received stream up to the OOB character completes and returns to the user the received stream up to, but not including, the OOB character.

To determine whether the socket must issue more read $QIOs before getting all the characters from the stream preceding an OOB character, poll the socket. To do this, issue a $QIO with the $IO_SENSEMODE function, and the TCPIP$C_IOCTL subfunction that specifies the SIOCATMARK command. The SIOCATMARK values are as follows:

- 0 = Issue more read $QIOs to read more data before reading the OOB.
- 1 = The next read $QIO will return the OOB character.

Polling a socket is particularly useful when the OOBINLINE socket option is set. When the OOBINLINE is set, TCP/IP reads the OOB character with the characters in the stream (IO $_READVBLK), but not before reading the preceding characters. Use this polling mechanism to determine whether the first character in the user buffer on the next read is an OOB character.

On a socket without the OOBINLINE option set, a received OOB character will always be read by issuing a $QIO with either the IO$_READVBLK|IO$M_INTERRUPT or IO$_READVBLK and the TCPIP$C_MSG_OOB flag set. This can occur regardless of how many preceding characters in the stream have been returned to the user.)

IO$M_LOCKBUF

Blocks the completion of the I/O operation until the user buffer is completely filled or until the connection is closed. This is particularly useful when you want to minimize the number of $QIO service calls issued to read a data stream of a set size. This function modifier supports only stream protocols.

IO$M_NOWAIT

Regardless of a $QIO or $QIOW, if the system detects a condition that would cause the operation to block, the system completes the I/O operation and returns the SS$_SUSPENDED status code.

IO$M_PURGE

Flushes data from the socket receive queue (discards data). If the user buffer is larger than the amount of data in the queue, all data is flushed.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ABORT

Programming error, INET management error, or hardware error. The execution of the I/O was aborted.

SS$_ACCVIO

Access to an invalid memory location or buffer occurred.

SS$_BADPARAM

One of the following methods was used to specify a $QIO function with an invalid parameter:

- An I/O function executed without specifying a device socket. First issue a $QIO with the IO $_SETMODE function and the proper parameters to create the device socket.
- An IO$_READVBLK function that does not specify a correct buffer address (**p1** or **p6** is null).
- An IO$_READVBLK function specified an invalid vectored buffer (**p6** is an invalid descriptor).
- The socket has the OOBINLINE option set, or there is no OOB character in the socket's OOB queue because the character was either already read or never received. This condition happens only if you use the IO$M_INTERRUPT modifier or set the TCPIP$C_MSG_OOB flag with IO $_READVBLK.

SS$_CANCEL

The I/O operation was canceled by a $CANCEL system service.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_INSFMEM

INET management or programming error. There is not enough buffer space for allocation. The INET software needs more buffer space. You should set a higher quota for the dynamic buffer space, or shut down and restart TCP/IP Services with a larger static buffer space.

Programming error occurred for one of the following reasons:

- The size of the buffer for an I/O function is insufficient.

- An IO$_READVBLK specified a correct buffer address (**p1** valid), but does not specify a buffer length (**p2** is null).)

SS$_LINKDISCON

A virtual circuit (TCP/IP) was closed at the initiative of the peer.

SS$_NOLINKS

Programming error. Read attempt on unconnected TCP socket.

SS$_SHUT

The network is being shut down.

SS$_SUSPENDED

The operation is blocked for one of the following reasons:

- No messages were received, so the receive operation cannot complete. The socket is marked as nonblocking.
- The socket has the OOBINLINE option clear, and the OOB character has already been read.

SS$_TIMEOUT

This applies to a socket that has KEEPALIVE set. The connection was idle for longer than the timeout interval (10 minutes is the default). For more information, see *Table A.2, "TCP Protocol Options"*.

SS$_UNREACHABLE

Communication status. The remote host or network is unreachable.

IO$_SENSEMODE/IO$_SENSECHAR

IO$_SENSEMODE/IO$_SENSECHAR — The IO$_SENSEMODE and IO$_SENSECHAR functions return one or more parameters (characteristics) pertaining to the network driver. Socket names (local and remote peer) are returned by using IO$_SENSEMODE's **p3** and **p4** arguments. Other parameters such as socket and protocol options, are specified in an output parameter list using the IO$_SENSEMODE **p6** argument. IO$_SENSEMODE **p3** and **p4** arguments can be used with the **p6** argument in a single $QIO system service to return socket names as well as socket and protocol options. IO$_SENSEMODE processes arguments in this order: **p3**, **p4**, **p6**. If IO$_SENSEMODE detects an error, the I/O status block (IOSB) contains the error and argument address or the value that was at fault. Refer to individual argument descriptions for details about specifying the type and format of output parameters.

Arguments

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_3` descriptor

The port number and IP address of the local name associated with the socket. The **p3** argument is the address of an `item_list_3` descriptor that points to the socket address structure into which the local name is written.

The equivalent Sockets API function is `getsockname()`.

p4

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_3` descriptor

The port number and IP address of the remote name associated with the socket's peer. The **p4** argument is the address of an `item_list_3` descriptor that points to the socket address structure into which the peer name is written.

The equivalent Sockets API function is `getpeername()`.

p6

OpenVMS usage:	output_parameter_list
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_2` descriptor

Output parameter list describing one or more parameters to return. The **p6** argument is the address of an `item_list_2` descriptor that points to and identifies the type of output parameter list.

The equivalent Sockets API functions are `getsockopt()` and `ioctl()`.

Function Modifiers

IO$M_EXTEND

Specifies the format of the socket address structure to return when used with the **p3** or **p4** arguments.

When specified, a BSD Version 4.4 formatted socket address structure is returned.

Specify the IO$M_EXTEND modifier to operate in an IPv6 environment.)

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ACCVIO

The service cannot access a buffer specified by one or more arguments.

SS$_BADPARAM

Programming error occurred for one of the following reasons:

- $QIO system service was specified without a socket.
- Error occurred processing a socket or protocol option.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_ILLCNTRFUNC

Programming error. The operation is unsupported for one of the following reasons:

- An invalid IO$_SENSEMODE function for the interface was specified. The interface does not have an IOCTL routine.
- An IO$_SENSEMODE function that requires a socket was specified, but the device did not have one. Create a socket and then issue the function.
- An unsupported operation was performed on at least one of the following protocols: raw IP, datagram, or stream sockets.

SS$_INSFMEM

Insufficient system dynamic memory to complete the service.

SS$_IVBUFLEN

The size of a socket option buffer specified with the IO$_SENSEMODE function was invalid.

SS$_NOSUCHDEV

Programming error or INET management error. An INET address is not in the Address Resolution Protocol (ARP) table. An attempt to show or delete an ARP table entry failed.

SS$_NOLINKS

The specified socket was not connected.

SS$_NOOPER

Programming error. An attempt to get ARP information occurred without OPER privilege.

SS$_PROTOCOL

A network protocol error occurred. The address family specified in the socket address structure is not supported.

SS$_SHUT

The local or remote node is no longer accepting connections.

SS$_UNREACHABLE

The remote node is currently unreachable.

IO$_SETMODE/IO$_SETCHAR

IO$_SETMODE/IO$_SETCHAR — The IO$_SETMODE and IO$_SETCHAR functions set one or more parameters (characteristics) pertaining to the network driver. Sockets are created using the IO $_SETMODE **p1** argument. Names are assigned to sockets using the IO$_SETMODE **p3** argument. Active sockets are converted to passive sockets using the IO$_SETMODE **p4** argument. Other parameters, such as socket and protocol options, are specified in an input parameter list using the IO $_SETMODE **p5** argument. The IO$_SETMODE **p1**, **p3**, and **p4** arguments can be used with the **p5** argument in a single $QIO system service to set socket names as well as socket and protocol options. IO $_SETMODE processes arguments in this order: **p1**, **p3**, **p4**, **p5**. If IO$_SETMODE detects an error, the I/O status block (IOSB) contains the error and argument address or the value that was at fault. Refer to individual argument descriptions for details about specifying the type and format of input parameters.

Arguments

p1

OpenVMS usage:	socket_characteristics
type:	longword (unsigned)
access:	read only
mechanism:	by reference

Longword specifying the protocol, socket type, and address family of a new socket. The **p1** argument is the address of the longword containing the socket characteristics.

The newly created socket is marked privileged if the image that creates a socket runs in a process that has BYPASS, OPER, or SYSPRV privilege.

The following table shows protocol codes:

Protocol	Description
TCPIP$C_TCP	TCP/IP protocol
TCPIP$C_UDP	UDP/IP protocol
TCPIP$C_RAW_IP	IP protocol

Table 6.6, "Socket Types" lists the socket types.

Table 6.6. Socket Types

Socket Type	Description
TCPIP$C_STREAM	Permits bidirectional, reliable, sequenced, and unduplicated data flow without record boundaries.
TCPIP$C_DGRAM	Permits bidirectional data flow with record boundaries. No provisions for sequencing, reliability, or unduplicated messages.
TCPIP$C_RAW	Permits access to the IP layer; used to develop new protocols that are layered upon the IP layer.

The following table shows address family codes:

Address Family	Description
TCPIP$C_AF_INET	IPv4 Internet domain (default).
TCPIP$C_AF_INET6	IPv6 Internet domain.
TCPIP$C_AUXS	Accept hand-off of a socket already created and initialized by the auxiliary server.

The equivalent Sockets API function is `socket()`.

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_2` descriptor

The local name (that is, port number and IP address) to assign to the socket. The **p3** argument is the address of an `item_list_2` descriptor that points to the socket address structure containing the local name.

The equivalent Sockets API function is `bind()`.

p4

OpenVMS usage:	connection_backlog
type:	byte (unsigned)
access:	read only
mechanism:	by value

Maximum limit of outstanding connection requests for a socket that is connection oriented. If more connection requests are received than are specified, the additional requests are ignored so that TCP retries can succeed.

The equivalent Sockets API function is `listen()`.

p5

OpenVMS usage:	input_parameter_list
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_2` descriptor

Input parameter list describing one or more parameters to set. The **p5** argument is the address of an `item_list_2` descriptor that points to and identifies the type of input parameter list.

The equivalent Sockets API functions are `setsockopt()` and `ioctl()`.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ACCVIO

The service cannot access a buffer specified by one or more arguments.

SS$_BADPARAM

Programming error that occurred for one of the following reasons:

- $QIO system service was specified without a socket.
- Error occurred processing a socket or protocol option.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_DUPLNAM

Programming error. The port being bound is already in use. An attempt to bind the socket to an address and port failed.

SS$_FILALRACC

Programming error. The IP address is already in use. An attempt to bind the socket to an address and port failed.

SS$_ILLCNTRFUNC

Programming error. An attempt to perform an IO$_SETMODE function required a socket, but the device did not have one. Create a socket before issuing the function.

SS$_IVADDR

Programming error. The IP address you specified using the IO$_SETMODE function was not placed into the system. This resulted in an invalid port number or IP address combination. The IP address was invalid for one of the following reasons:

- An attempt was made to exceed the limit of allowable permanent entries in the ARP table.
- An attempt was made to bind a raw IP socket when there are no interfaces defined in the system.
- An attempt was made to bind a raw IP socket to a null Internet address.

SS$_INSFMEM

Insufficient system dynamic memory to complete the service.

SS$_IVBUFLEN

The size of a socket option buffer specified with the IO$_SETMODE function was invalid.

SS$_NOLICENSE

Programming or system management error. A TCP/IP Services license is not present.

SS$_NOOPER

Programming or INET management error. An attempt to was made to execute an I/O function that needs the OPER privilege.

SS$_NOPRIV

Programming or INET management error. There are not enough privileges for the attempted operation for one of the following reasons:

- An attempt was made to broadcast an IP datagram on a process without SYSPRV, BYPASS, or OPER privilege.
- An attempt was made to use a reserved port number lower than 1024.
- An attempt was made to access a process that requires SYSPRV or BYPASS privilege.
- An attempt was made to use raw IP on a privileged socket that requires the SYSPRV or BYPASS privilege.

SS$_NOSUCHDEV

Programming error or INET management error. An attempt was made to show or delete an ARP table entry failed because the IP address is not found.

SS$_NOSUCHNODE

Programming error or INET management error. An attempt was made to delete a route from the routing table failed because the entry was not found.

SS$_PROTOCOL

Programming error. A specified protocol or address family caused an error for one of the following reasons:

- An invalid protocol type was specified at socket creation.
- An unsupported protocol was specified.
- The address family is unsupported for one of the following reasons:
  - An unsupported address family was specified. Instead, specify the address family (TCPIP $C_AF_INET, TCPIP$C_AF_INET6, or TCPIP$C_UNSPEC).
  - An unsupported address family for the local IP address was specified. Instead, specify the address family (TCPIP$C_AF_INET or TCPIP$C_AF_INET6).
  - An unsupported address family for the IP address of the routing module was specified. Instead, specify the address family (TCPIP$C_AF_INET or TCPIP$C_AF_INET6).

SS$_SHUT

The local or remote node is no longer accepting connections.

IO$_SETMODE|IO$M_OUTBAND

IO$_SETMODE|IO$M_OUTBAND — The IO$_SETMODE|IO$M_OUTBAND function/modifier combination requests that the asynchronous system trap (AST) for an out-of-band (OOB) character

be delivered to the requesting process. This is to be done only when an OOB character is received on the socket and there is no waiting read request. The socket must be a TCP (stream) socket. The Enable OOB character AST function allows an Attention AST to be delivered to the requesting process only once. After the AST occurs, the function must explicitly reenable AST delivery before a new AST can be delivered. This function is subject to AST quotas.

Arguments

p1

OpenVMS usage:	ast_procedure
type:	procedure value
access:	call without stack unwinding
mechanism:	by reference

To enable the AST, the **p1** argument is the address of the OOB character AST routine. To disable the AST, **p1** equals 0.

p2

OpenVMS usage:	user_arg
type:	longword (unsigned)
access:	read only
mechanism:	by value

AST parameter to be delivered to the AST routine specified by the **p1** argument.

p3

OpenVMS usage:	access_mode
type:	longword (unsigned)
access:	read only
mechanism:	by value

Access mode to deliver the AST.

Condition Values Returned

SS$_NORMAL

The service completed successfully.

SS$_ABORT

Programming, INET management, or hardware error.

SS$_ACCVIO

Programming error. An attempt to access an invalid memory location or buffer occurred.

Programming error. A $QIO service with an invalid parameter occurred for one of the following reasons:

- An attempt was made to execute an IO$_SETMODE function (all functions except socket creation) without specifying a device socket. Instead, create a device socket by issuing a $QIO with the IO$_SETMODE function and correct parameters.
- A socket option was specified incorrectly.)

SS$_DEVACTIVE

INET management error. An attempt to change the static parameters occurred. If new parameters are needed, restart TCP/IP Services.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded but the INET_ACP is not currently available for use.

SS$_DUPLNAM

Programming error. An attempt to bind a port that is already in use occurred. An attempt to bind the socket to an address and port failed.

SS$_FILALRACC

Programming error. IP address is already in use. An attempt to bind the socket to an address and port failed.

SS$_INSFMEM

Programming or system management error: Not enough resources to allocate new socket.

Programming error. Operation is not supported because of one of the following reasons:

- Invalid IO$_SETMODE (IOCTL) function was used for the interface. The interface does not have an IOCTL routine.
- An attempt was made to perform an IO$_SETMODE (IOCTL) function that required a socket, but the device did not have one. Create a socket and issue the IOCTL function.)

SS$_IVADDR

The specified IP address was not found, or an invalid port number and IP address combination was specified. Port 0 is not allowed with this function.

SS$_IVBUFLEN

Programming error. The socket option buffer has an invalid size.

SS$_NOLICENSE

Programming or system management error. The TCP/IP Services license is not present.

SS$_NOOPER

Programming or INET management error. An attempt was made to execute an I/O function that needs the OPER privilege.

SS$_NOPRIV

Programming or INET management error. Not enough privileges for the attempted operation for one of the following reasons:

- Broadcasting an IP datagram was denied because the process does not have SYSPRV, BYPASS, or OPER privilege.
- An attempt was made to use a reserved port number lower than 1024.
- An operation accesses only processes that have SYSPRV or BYPASS privilege.
- Raw IP protocol can be used only on privileged sockets. The process must have a SYSPRV or BYPASS privilege.

SS$_NOSUCHDEV

Programming error or INET management error. An INET address is not in the ARP table. An attempt to show or delete an ARP table entry failed.

SS$_NOSUCHNODE

Programming or INET management error. An attempt to delete a route from the routing table failed because a route entry was not found.

SS$_PROTOCOL

Programming error. The specified protocol type is not supported.

SS$_SHUT

The local or remote node is no longer accepting connections.

IO$_SETMODE|IO$M_READATTN

IO$_SETMODE|IO$M_READATTN — The IO$_SETMODE|IO$M_READATTN function/modifier combination requests that an Attention AST be delivered to the requesting process when a data packet is received on the socket and there is no waiting read request.

Description

The Enable Read Attention AST function enables an Attention AST to be delivered to the requesting process only once. After the AST occurs, the function must explicitly reenable AST delivery before the AST can occur again. The function is subject to AST quotas.

Consider the following when using IO$M_READATTN:

- There is a one-to-one correspondence between the number of times you enable an Attention AST and the number of times the AST is delivered. For each enabled AST, one AST is delivered. If you enable an Attention AST several times, several ASTs are delivered for one event when an event occurs.
- If an out-of-band (OOB) Attention AST is enabled, the OOB AST is delivered, regardless of the following:

- An enabled Read Attention AST
- The TCPIP$C_OOBINLINE socket option
- A READ $QIO waiting for completion on the socket

If the TCPIP$C_OOBINLINE option is set, then a waiting READ $QIO is completed and the OOB character is returned in the data stream.

- If both an OOB AST and a Read Attention AST are enabled, only the OOB AST is delivered when an OOB character is received.
- If a Read Attention AST is enabled and the TCPIP$C_OOBINLINE socket option is set, a waiting READ $QIO completes and the OOB character is returned in the data stream.
- If a Read Attention AST is enabled and the TCPIP$C_OOBINLINE socket option is not set (clear), the Read Attention AST is delivered when an OOB character is received, regardless of whether a READ $QIO is waiting for completion. In this case, the OOB character is not returned in the data stream. Therefore, if the OOB character is the only character received, the READ $QIO does not complete.

Arguments

p1

OpenVMS usage:	ast_procedure
type:	procedure value
access:	call without stack unwinding
mechanism:	by reference

To enable the AST, the **p1** argument is the address of the Read Attention AST routine. To disable the AST, set **p1** to 0.

p2

OpenVMS usage:	user_arg
type:	longword (unsigned)
access:	read only
mechanism:	by value

AST parameter to be delivered to the AST routine.

p3

OpenVMS usage:	access_mode
type:	longword (unsigned)
access:	read only
mechanism:	by value

Access mode in which the AST is delivered.

Condition Values Returned

SS$_ABORT

Programming, INET management, or hardware error. The route entry already exists, so the attempt to add a route entry using the IO$_SETMODE function failed.

SS$_ACCVIO

Programming error. An attempt to access an invalid memory location or buffer occurred.

SS$_BADPARAM

Programming error. The parameter specified for a $QIO function was invalid for one of the following reasons:

- An attempt to execute the IO$_SETMODE functions without specifying a device socket occurred. Instead, create a device socket by issuing a $QIO with the IO$_SETMODE function and the proper parameters.
- A socket option was specified incorrectly.

SS$_DEVACTIVE

INET management error. An attempt to change a static parameter was unsuccessful. If you need new parameters, restart TCP/IP Services.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded but the INET_ACP is not currently available for use.

SS$_DUPLNAM

Programming error. An attempt to bind a port already in use occurred so the operation to bind the socket to the address and port failed.

SS$_FILALRACC

Programming error. An attempt to bind the socket to an address that is already in use occurred and the operation failed.

SS$_INSFMEM

Programming or system management error. The system does not have enough resources to allocate new socket.

SS$_ILLCNTRFUNC

Programming error. Operation is not supported.

- Invalid IO$_SETMODE (IOCTL) function was used for the interface. The interface does not have an IOCTL routine.

- An attempt was made to perform an IO$_SETMODE (IOCTL) function that required a socket, but the device did not have one. Create a socket and issue the IOCTL function.

SS$_IVADDR

Programming error. The specified IP address is not in the system, and an invalid port number or an invalid IP address combination was specified with an IO$_SETMODE function (a bind).

- An attempt to bind the address failed because the IP address is not in the system, Port 0 and IP address 0 are not allowed, or Port 0 is not allowed when using an IO$_ACCESS function.
- An attempt was made to make a permanent entry in the ARP table failed because of lack of space. Too many permanent entries.
- An attempt was made to bind an IP socket (raw IP) when there are no interfaces defined in the system.
- An attempt was made to bind an IP socket (raw IP) to a null INET address.

SS$_IVBUFLEN

Programming error. The socket option buffer has an invalid size.

SS$_NOLICENSE

Programming or system management error. The TCP/IP Services license is not present.

SS$_NOOPER

Programming or INET management error. An attempt was made to execute an I/O function that needs the OPER privilege.

SS$_NOPRIV

Programming or INET management error. Not enough privileges for the attempted operation.

- Broadcasting an IP datagram was denied because the process does not have SYSPRV, BYPASS, or OPER privilege.
- An attempt was made to use a reserved port number lower than 1024.
- An operation accesses only processes that have SYSPRV or BYPASS privilege.
- Raw IP protocol can be used only on privileged sockets. The process must have a SYSPRV or BYPASS privilege.

SS$_NOSUCHDEV

Programming error or INET management error. An Internet address is not in the ARP table. An attempt to show or delete an ARP table entry failed.

SS$_NOSUCHNODE

Programming error or INET management error. An attempt to delete a route from the routing table failed because a route entry was not found.

SS$_PROTOCOL

Programming error. The specified protocol type is not supported.

SS$_SHUT

The local or remote node is no longer accepting connections.

IO$_SETMODE|IO$M_WRTATTN

IO$_SETMODE|IO$M_WRTATTN — The IO$_SETMODE|IO$M_WRTATTN function/modifier combination (IO$M_WRTATTN is Enable Write Attention AST) requests that an Attention AST be delivered to the requesting process when a data packet can be queued to the socket. For TCP sockets, this occurs when space becomes available in the TCP transmit queue. The Enable Write Attention AST function enables an Attention AST to be delivered to the requesting process only once. After the AST occurs, the function must explicitly reenable AST delivery before the AST can occur again. The function is subject to AST quotas. There is a one-to-one correspondence between the number of times you enable an Attention AST and the number of times the AST is delivered. For example, for each enabled AST, one AST is delivered. If you enable an Attention AST several times, several ASTs are delivered for one event when the event occurs. You can use the TCP/IP management command SHOW DEVICE_SOCKET to display information about the socket's characteristics, options, and state.

Arguments

p1

OpenVMS usage:	ast_procedure
type:	procedure value
access:	call without stack unwinding
mechanism:	by reference

To enable the AST, the **p1** argument is the address of the Write Attention AST routine. To disable the AST, **p1** is set to 0.

p2

OpenVMS usage:	user_arg
type:	longword (unsigned)
access:	read only
mechanism:	by value

AST parameter to be delivered to the AST routine.

p3

OpenVMS usage:	access_mode
type:	longword (unsigned)
access:	read only
mechanism:	by value

Access mode in which the AST is delivered.

Condition Values Returned

SS$_ABORT

Programming error, INET management error, or hardware error. The route specified with the IO $_SETMODE function already exists. Therefore, the operation failed.

SS$_ACCVIO

Programming error. An attempt to access an invalid memory location or buffer occurred.

SS$_BADPARAM

Programming error. The parameter specified for the $QIO I/O function was invalid for one of the following reasons:

- An attempt was made to execute the IO$_SETMODE functions without specifying a device socket. Instead, create a device socket by issuing a $QIO with the IO$_SETMODE function and the proper parameters.
- A socket option was specified incorrectly.

SS$_DEVACTIVE

INET management error. You attempted to change the static parameters. If you need new parameters, restart TCP/IP Services.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded but the INET_ACP is not currently available for use.

SS$_DUPLNAM

Programming error. Port that is being bound is already in use. An attempt to bind the socket to an address and port failed.

SS$_FILALRACC

Programming error. Because the IP address is already in use, an attempt to bind the socket to an address and port failed.

SS$_INSFMEM

Programming or system management error. There are not enough resources to allocate a new socket.

SS$_ILLCNTRFUNC

Programming error. An attempt was made to execute an IO$_SETMODE function that required a socket, but the device did not have one. Instead, create a socket and issue the function.

SS$_IVADDR

Programming error. An invalid port number and IP address combination was specified with the IO $_SETMODE bind function. This caused the operation to fail for one of the following reasons:

- An illegal combination of Port 0 and IP address 0 was specified.
- An attempt was made to make a permanent entry in the ARP table and the operation failed because of lack of space. There are too many permanent entries.
- An attempt was made to bind a raw IP socket when there were no interfaces defined in the system.
- An attempt was made to bind a raw IP socket to a null IP address.

SS$_IVBUFLEN

Programming error. An invalid size was specified for the socket option buffer.

SS$_NOLICENSE

Programming or system management error. The TCP/IP Services license is not present.

SS$_NOOPER

Programming or INET management error. An attempt was made to execute an I/O function that needs the OPER privilege.

SS$_NOPRIV

Programming or INET management error. The operation failed for one of the following reasons:

- An attempt was made to broadcast an IP datagram for a process without having SYSPRV, BYPASS, or OPER privilege.
- An attempt was made to use a reserved port number lower than 1024.
- An attempt was made to access a process without having SYSPRV or BYPASS privilege.
- An attempt was made to use raw IP on a socket that is not a privileged socket. To do this, the process must have SYSPRV or BYPASS privilege.

SS$_NOSUCHDEV

Programming error or INET management error. An attempt was made to show or delete an entry in the ARP table. However, because the IP address was not in the ARP table, the operation failed.

SS$_NOSUCHNODE

Programming error or INET management error. An attempt was made to delete a route from the routing information table (RIT). However, because the route was not found in the RIT, the operation failed.

SS$_PROTOCOL

Programming error. The specified protocol is not supported.

SS$_SHUT

The local or remote node is no longer accepting connections.

IO$_WRITEVBLK

IO$_WRITEVBLK — The IO$_WRITEVBLK function transmits data from the specified user buffers to an Internet host. Use both **p1** and **p2** arguments to specify a single user buffer. Use the **p5** argument to specify multiple buffers. For connection-oriented protocols, such as TCP, if the socket transmit buffer is full, the IO$_WRITEVBLK function is blocked until the socket transmit buffer has room for the user data. For connectionless-oriented protocols, such as UDP and raw IP, the user data is transmitted in one datagram. If the user data is greater than the socket's transmit quota, the error code (SS$_TOOMUCHDATA) is returned.

Related Functions

The equivalent Sockets API functions are `send()`, `sendto()`, `sendmsg()`, and `write()`.

Arguments

p1

OpenVMS usage:	buffer
type:	vector byte (unsigned)
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit reference
	(VAX) by 32-bit reference

The address of the buffer containing the data to be transmitted. The length of this buffer is specified by the **p2** argument.

p2

OpenVMS usage:	buffer_length
type:	quadword unsigned (Alpha and I64); longword unsigned (VAX)
access:	read only
mechanism:	(Alpha and I64) by 64-bit value
	(VAX) by 32-bit value

The length (in bytes) of the buffer containing data to be transmitted. The address of this buffer is specified by the **p1** argument.

p3

OpenVMS usage:	socket_name
type:	vector byte (unsigned)
access:	read only
mechanism:	by `item_list_2` descriptor

The remote port number and IP address of the message destination. The **p3** argument is the address of an `item_list_2` descriptor pointing to the socket address structure containing the remote port number and IP address.

p4

OpenVMS usage:	mask_longword
type:	longword (unsigned)
access:	read only
mechanism:	by value

Longword of flags to specify attributes for this write operation. The following table lists the available write flags:

Write Flag	Description
TCPIP$C_MSG_OOB	Writes an out-of-band (OOB) byte.
TCPIP$C_MSG_DONTROUTE	Sends message directly without routing.
TCPIP$C_MSG_NBIO	Completes the I/O operation and returns an error if a condition arises that would cause the I/O operation to be blocked. (Similar to using IO $M_NOWAIT.)

p5

OpenVMS usage:	buffer_list
type:	vector byte (unsigned)
access:	read only
mechanism:	(Alpha and I64) by 32- or 64-bit descriptor-fixed-length descriptor (VAX) by 32-bit descriptor-fixed-length descriptor

Input buffer list describing one or more buffers containing the data to be transmitted. The **p5** argument is the address of a descriptor pointing to a input buffer list. Buffers are transmitted in the order specified by the input buffer list. The transfer-length value returned in the I/O status block is the total number of bytes transferred from all buffers.

If you use the **p1** and **p2** arguments, do not use the **p5** argument; they are mutually exclusive.

Function Modifiers

IO$M_EXTEND

Allows the use of extended modifiers with BSD Version 4.4. Valid only for datagram sockets (UDP or raw IP); ignored for TCP.

IO$M_INTERRUPT

Sends an OOB message.

IO$M_NOWAIT

Regardless of a $QIO or $QIOW, if the system detects a condition that would cause the operation to block, the system completes the I/O operation and returns the SS$_SUSPENDED status code. When using this function modified, always check the message length in the IOSB to ensure that all data is transferred. IO$_WRITEVBLK returns a success status even if data is only partially transferred.

Condition Values Returned

SS$_ABORT

Programming error, INET management error, or hardware error. The execution of the I/O was aborted.

SS$_ACCVIO

Programming error. An attempt was made to access an invalid memory location or buffer.

SS$_BADPARAM

Programming error. An I/O operation was specified using an invalid parameter.

- An attempt was made to execute an IO$_WRITEVBLK function without specifying a device socket. First create a device socket by issuing an IO$_SETMODE function and the proper arguments.
- An attempt was made to issue an IO$_WRITEVBLK function that did not specify a correct buffer address (**p1** or **p5** is null).
- An attempt was made to issue an IO$_WRITEVBLK that specifies an invalid vectored buffer (**p5** specifies an invalid address descriptor).

SS$_CANCEL

The I/O operation was canceled by the $CANCEL system service.

SS$_DEVINTACT

The network driver was not started.

SS$_DEVNOTMOUNT

The network driver is loaded, but the INETACP is not currently available for use.

SS$_EXQUOTA

Returned when process resource mode wait is disabled. There is no Internet request packet (IRP) available for completing the request. Increase the buffered I/O quota.

SS$_FILALRACC

Programming error.

- IP address is already in use. An attempt was made to bind the socket to an address but the port failed.
- IP protocol (raw socket). An attempt was made to specify a remote socket address with an IO $_WRITEVBLK function, while an IP address was already specified with an IO$_ACCESS function.
- UDP/IP protocol. An attempt was made to specify a remote socket address with an IO $_WRITEVBLK function, while an IP address was already specified with the IO$_ACCESS function.

SS$_ILLCNTRFUNC

Programming error. Unsupported operation on the protocol (UDP or TCP).

SS$_INSFMEM

Insufficient system dynamic memory to complete the operation.

SS$_IVADDR

Programming error. The specified IP address is not in the system, and an invalid port number or an IP address combination was specified with an IO$_WRITEVBLK operation.

- An attempt to bind the socket failed because the INET address is not in the system, Port 0 and IP address 0 are not allowed, or Port 0 is not allowed with an IO$_WRITEVBLK function.
- An attempt to get an interface IP address, broadcast mask, or network mask failed.
- A send request was made on a datagram-oriented protocol, but the destination address is unknown or not specified.

SS$_IVBUFLEN

Programming error.

- The size of the buffer for an I/O function is insufficient.
- An attempt was made to issue an IO$_WRITEVBLK function that specifies a correct buffer address (**p1** valid) but does not specify a buffer length (**p2** is null).

SS$_LINKDISCON

Notification. Connection completion return code. The virtual circuit (TCP/IP) was closed at the initiative of the peer. The application must stop sending data and must either shut down or close the socket.

SS$_PROTOCOL

Programming error. The address family of the remote address specified with an IO$_WRITEVBLK function is not supported (UDP or TCP). The address family should be either the TCPIP $C_AF_INET or the TCPIP$C_AF_INET6 address family.

SS$_NOLINKS

Programming error. The socket was not connected (TCP), or an INET port and address were not specified with an IO$_ACCESS (UDP).

- An IO$_WRITEVBLK with no remote INET socket address was issued on a socket that was not the object of an IO$_ACCESS function (raw IP).
- An IO$_WRITEVBLK with no remote INET socket address was issued on a socket that was not the object of an IO$_ACCESS function (UDP).
- An attempt was made to disconnect a socket that is not connected, or an attempt was made to issue an IO$_WRITEVBLK function on an unconnected socket (TCP).

SS$_SHUT

The local or remote node is no longer accepting connections.

SS$_SUSPENDED

The system detected a condition that might cause the operation to block.

SS$_TIMEOUT

Programming error, INET management error, or hardware error.

- A TCP/IP connection timed out after several unsuccessful retransmissions.
- On a TCP socket where KEEPALIVE is set, the connection was idle for longer than the timeout interval. The default is 10 minutes.

SS$_TOOMUCHDATA

Programming or INET management error. The message size was too large.

- An IP packet that is broadcast cannot be fragmented.
- The Not Fragment IP flag was set and the IP datagram was too large to be sent without being fragmented.
- Internal error. The length of the Ethernet datagram does not allow enough space for the minimum IP header.
- The message to be sent on a UDP or raw IP socket is larger than the socket buffer high water allows. For more information, see *Appendix B, "IOCTL Requests"*.
- An attempt was made to send or receive more than 16 buffers specified with the **p5** argument.

SS$_UNREACHABLE

Communication status. The remote host is currently unreachable.

This indicates a hardware error. The data link adapter detected an error and shut itself off. The TCP/IP Services software is waiting for the adapter to come back on line.

6.4. TELNET Port Driver I/O Function Codes

The TELNET port driver (TNDRIVER) provides terminal session support for TCP streaming connections using the RAW, NVT, RLOGIN, and TELNET protocols. Either a remote device or an application can be present at the remote endpoint of the connection.

A user program can manage a TELNET connection with the standard OpenVMS $QIO system service by using the IO$_TTY_PORT and IO$_TTY_PORT_BUFIO I/O function codes. This section describes these I/O function codes and their associated arguments.

6.4.1. Interface Definition

The following definitions are used by the interface. The symbols are defined in SYS $LIBRARY:TNIODEF.H.

6.4.1.1. Item List Codes

*Table 6.7, "List Codes for the **p5** Item"* describes the symbols used with the **p5** parameter.

Table 6.7. List Codes for the p5 Item

Item Code	Maximum Size	Description
TN$_ACCPORNAM	64	Access port name string. When written, the string's length is determined by the item_length field. The value of `item_length` should not be more than 63 bytes. When read, the string is returned in ASCIC format (the first byte contains the string's length), so a size of 64 is appropriate.
TN$_CHARACTERISTICS	4	Characteristics mask. This longword contains a bit mask of the device's characteristics read or to be written. (See *Table 6.8, "Characteristic Mask Bits"*.)
TN $_CONNECTION_ATTEMPTS	4	Reconnection attempts. This item is the number of unsuccessful reconnection attempts which have been made on a reconnectable device. The value will be reinitialized when a successful connection is made. This item is read only.
TN $_CONNECTION_INTERVAL	4	Minimum time (in seconds) before reconnection attempts.
TN $_CONNECTION_TIMEOUT	4	Current time (in seconds) since the last reconnection attempt. This item is read only.
TN$_DATA_HIGH	4	Maximum amount of output data (in bytes) buffered at the network port. This number does not affect the amount of data buffered within the socket.
TN$_DEVICE_UNIT	4	Terminal device unit number. When written, this value must be between 1 and 9999.
TN$_IDLE_INTERVAL	4	Maximum idle time (in seconds) allowed before a connection is to be broken. Connections are not broken if the device is stalled.
TN$_IDLE_TIMEOUT	4	Current time (in seconds) since last output on the terminal. This item is read only.

Item Code	Maximum Size	Description
TN$_LOCAL_ADDRESS	32	Local `sockaddr` of the active connection. When written, the value of `item_length` determines the size of the `sockaddr`. Note that the `sockaddr` is in BSD Version 4.4 format, which includes a `sockaddr` size field. (C programs should be compiled with the _SOCKADDR_LEN symbol defined.) This item is read only.
TN $_NETWORK_DEVICE_NAME	64	Name of the network pseudodevice currently bound to the terminal. When read, the data is returned in ASCIC format (the first byte contains the string's length). This item is read only.
TN$_PROTOCOL	4	Session protocol. (See *Table 6.9, "Protocol Type Codes"*.)
TN$_REMOTE_ADDRESS	32	Remote peer's `sockaddr` of the active connection. Note that the `sockaddr` is in BSD Version 4.4 format, which includes a `sockaddr` size field. The size of the `sockaddr` should be determined from this field. This item is read only.
TN$_SERVICE_TYPE	4	Class of terminal service. (See *Table 6.10, "Service Type Codes"*.)
TN$_STATUS	4	Current device and session status. This item is read only.

6.4.1.2. Characteristic Mask Bits

Table 6.8, "Characteristic Mask Bits" describes the characteristic mask bits used with the **p5** parameter.

Table 6.8. Characteristic Mask Bits

Characteristic	Description
TN$M_AUTOCONNECT	The device supports automatic connect/reconnect.
TN$M_LOGIN_ON_DASSGN	Initiate a login when the TELNET device is deassigned. This characteristic requires the BYPASS or SYSNAM privilege or executive or kernel mode calls.
TN$M_LOGIN_TIMER	Used in conjunction with TN $M_LOGIN_ON_DASSGN, this bit indicates that the login completion timer applies. If the

Characteristic	Description
	TN device fails to login within 60 seconds, the connection will be broken and the device deallocated. This characteristic requires the BYPASS or SYSNAM privileges or executive or kernel mode calls.
TN$M_PERMANENT_UCB	The TELNET device is to remain until explicitly deleted.
TN$M_RETAIN_ON_DASSGN	The TELNET device is not to be deleted upon the deassignment of the last channel to this device. This condition is cleared on this last deassignment, so that a subsequent assign and deassign will result in the device being deleted.
TN$M_VIRTUAL_TERMINAL	When logging in under this device, a virtual terminal is to be created by TTDRIVER.

6.4.1.3. Protocol Types

Table 6.9, "Protocol Type Codes" describes the protocol types used with the **p5** parameter.

Table 6.9. Protocol Type Codes

Protocol Type	Description
TN$K_PROTOCOL_UNDEFINED	There is no explicit protocol for this session. Data is transmitted and received on the socket without any interpretation. This is a raw connection.
TN$K_PROTOCOL_NVT	Network Virtual Terminal (NVT) protocol. The protocol understands basic session control but does not include the options negotiation present in the TELNET protocol.
TN$K_PROTOCOL_RLOGIN	BSD Remote Login protocol. This simple protocol provides some special control character support but lacks the architecture independence of the NVT and TELNET protocols.
TN$K_PROTOCOL_TELNET	TELNET protocol. Including the basic NVT protocol, TELNET adds support for options negotiation. This can provide an enhanced terminal session depending upon the client and server involved.

6.4.1.4. Service Types

Table 6.10, "Service Type Codes" describes the service type codes used with the **p5** parameter.

Table 6.10. Service Type Codes

Service Type	Description
TN$K_SERVICE_NONE	The service type is not currently known.
TN$K_SERVICE_INCOMING	The service is an incoming connection.
TN$K_SERVICE_OUTGOING	The service is an outgoing connection.

6.4.2. Passing Parameters to the TELNET Port Driver

The IO$_TTY_PORT function is used to pass $QIO parameters through the terminal driver to the TELNET port driver. The actual subfunction is encoded as an option mask and may be:

- IO$M_TN_STARTUP — Bind socket to a TELNET terminal.
- IO$M_TN_SHUTDOWN — Unbind socket from a TELNET terminal.

6.5. TELNET Port Driver I/O Function Codes

IO$_TTY_PORT|IO$M_TN_STARTUP

IO$_TTY_PORT|IO$M_TN_STARTUP — Bind socket to a TELNET terminal. This subfunction will bind a created (connected) socket to a TELNET terminal device.

Arguments

p1

OpenVMS usage:	channel
type:	word (unsigned)
access:	read only
mechanism:	by value

The **p1** argument contains the channel number of the socket over which the TELNET session is to be established.

p2

OpenVMS usage:	protocol_number
type:	longword (unsigned)
access:	read only
mechanism:	by value

The **p2** argument contains the protocol selection.

p3

OpenVMS usage:	characteristics_mask
type:	longword (unsigned)
access:	read only
mechanism:	by value

The **p3** argument specifies a mask of characteristics to apply against the connection. See *Table 6.8, "Characteristic Mask Bits"* for possible values.

Description

The IO$M_TN_STARTUP subfunction allows the application to communicate over a socket using the terminal driver QIO interface. Note that incoming and outgoing data is processed by the terminal driver,

and that the terminal's characteristics may affect the format of the data. Be aware that by default, the terminal will echo incoming data back to the sender.

Once the subfunction completes, the application is free to perform all terminal QIO functions on the connection. While the socket is bound to a terminal device, it will process neither the IO$_READ*x*BLK nor the IO$_WRITE*x*BLK function, and will return the error SS$_DEVINUSE.

Condition Values Returned

SS$_IVCHAN

Programming error. The specified channel is not valid.

SS$_IVMODE

Programming error. The access mode of the channel is more privileged than the access mode of the terminal's channel.

SS$_NOPRIV

Programming error. The TN$M_LOGIN_ON_DASSGN characteristic was specified in a characteristics mask from a $QIO in USER or SUPERVISOR mode without either the BYPASS or SYSPRV privilege.

SS$_NOTNETDEV

Programming error. The specified channel is an assignment to a non-BG device.

SS$_PROTOCOL

Programming error. The specified protocol number is not valid, or the network is not available.

IO$_TTY_PORT|IO$M_TN_SHUTDOWN

IO$_TTY_PORT|IO$M_TN_SHUTDOWN — Unbind socket from a TELNET terminal. This subfunction will unbind a previously bound socket-terminal connection.

Arguments

p1

OpenVMS usage:	channel
type:	word (unsigned)
access:	read only
mechanism:	by value

The **p1** argument contains the channel number of the socket to establish the TELNET session.

Description

The IO$M_TN_SHUTDOWN subfunction allows the application to break a previously bound socket-terminal connection (created with IO$M_TN_STARTUP). The channel must be from an assignment to the same network pseudodevice in the socket-terminal connection.

Upon completion, the application retains the assignments to the connection and the TELNET terminal, but they are no longer related. Any subsequent IO$_READ*x*BLK or IO$_WRITE*x*BLK function on the socket channel will no longer return the error SS$_DEVINUSE.

Condition Values Returned

SS$_IVCHAN

Programming error. The specified channel is not valid.

SS$_IVMODE

Programming error. The access mode of the channel is more privileged than the access mode of the terminal's channel.

SS$_NOTNETDEV

Programming error. The specified channel is an assignment to a non-BG device.

SS$_DEVREQERR

Programming error. The device on the channel does not match the device in the socket-terminal connection.

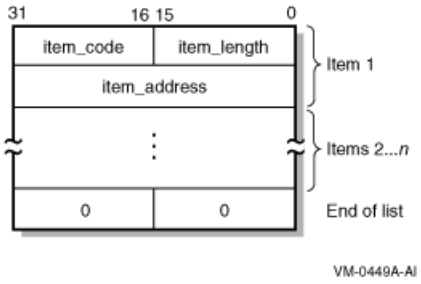
6.6. Buffered Reading and Writing of Item Lists

The IO$_TTY_PORT_BUFIO function is used to pass $QIO parameters through the terminal driver to the TELNET port driver. IO$_TTY_PORT_BUFIO differs from IO$_TTY_PORT in that certain subfunctions accept buffered item lists for reading or writing parameters to the terminal device.

- IO$M_TN_SENSEMODE — Read device parameters.
- IO$M_TN_SETMODE — Write device parameters.

The subfunctions of IO$_TTY_PORT_BUFIO accept an item list for input or output. *Figure 6.1, "Subfunction Item List"* shows the format of this item list.

Figure 6.1. Subfunction Item List



The item list is terminated with an `item_code` and `item_length`, both of which are zero.

The subfunctions of IO$_TTY_PORT_BUFIO can be combined into a single $QIO. For example, the IO $M_TN_SETMODE and IO$M_TN_CONNECT can be combined to set the device's parameters and then to attempt to make a connection.

The subfunctions are performed in the following order:

1. IO$M_TN_SETMODE
2. IO$M_TN_CONNECT
3. IO$M_TN_SENSEMODE
4. IO$M_TN_DISCON

Note

Certain items are read only (IO$M_TN_SENSEMODE) and cannot be written (IO $M_TN_SETMODE). Normally, attempting to write such items would result in the error SS$_BADATTRIB. However, if a combination operation (IO$M_TN_SENSEMODE|IO $M_TN_SETMODE) is being performed, these items will *not* result in an error. Rather, the items will be ignored in the IO$M_TN_SETMODE processing, and the $QIO will continue with IO $M_TN_SENSEMODE processing, returning the information that the item specifies.

6.7. TELNET Port Driver I/O Function Codes

IO$_TTY_PORT_BUFIO|IO$M_TN_SENSEMODE

IO$_TTY_PORT_BUFIO|IO$M_TN_SENSEMODE — Read device parameters.

Arguments

p5

OpenVMS usage:	item_list_2
type:	vector byte (unsigned)
access:	read only
mechanism:	by reference

The **p5** argument is the address of an item list that contains a summary of information to be read from the device.

Description

The IO$M_TN_SENSEMODE subfunction of IO$_TTY_PORT_BUFIO is used to read the parameters associated with a device.

Condition Values Returned

SS$_BADATTRIB

Programming error. The item code within the list is not valid. This could be because of its code, an attempt to write a read-only parameter, or inappropriate size. The address of the item's buffer is returned in the second longword of the I/O status block.

SS$_IVBUFLEN

Programming error. The length of the specified item is not acceptable. The address of the item's buffer is returned in the second longword of the I/O status block.

SS$_NOPRIV

Programming error. An item that requires a privilege which the requestor does not have is present in the item list. The address of the item's buffer is returned in the second longword of the I/O status block.

IO$_TTY_PORT_BUFIO|IO$M_TN_SETMODE

IO$_TTY_PORT_BUFIO|IO$M_TN_SETMODE — Write device parameters.

Arguments

p5

OpenVMS usage:	item_list_2
type:	vector (byte unsigned)
access:	read only
mechanism:	by reference

The **p5** argument is the address of an item list that contains a summary of information to be written to the device.

Description

The IO$M_TN_SETMODE subfunction of IO$_TTY_PORT_BUFIO is used to write the parameters associated with a device.

Condition Values Returned

SS$_BADATTRIB

Programming error. The item code within the list is not valid. This could be because of its code, an attempt to write a read-only parameter, or inappropriate size. The address of the item's buffer is returned in the second longword of the I/O status block.

SS$_DUPLNAM

Programming error. An attempt to set the device's unit number via the TN$_DEVICE_UNIT item has failed because that specified unit number was already present.

SS$_IVBUFLEN

Programming error. The length of the specified item is not acceptable. The address of the item's buffer is returned in the second longword of the I/O status block.

SS$_NOPRIV

Programming error. An item that requires a privilege which the requester does not have is present in the item list. The address of the item's buffer is returned in the second longword of the I/O status block.

Appendix A. Socket Options

This appendix describes the socket options that you can set with the Sockets API `setsockopt()` function and the $QIO system service IO$_SETMODE and IO$_SETCHAR I/O function codes. You can query the value of these socket options using the Sockets API `getstockopt()` function or the $QIO system service IO$_SENSEMODE or IO$_SENSECHAR I/O function code.

The following tables list:

- *Table A.1, "Socket Options"*
- *Table A.2, "TCP Protocol Options"*
- *Table A.3, "IP Protocol Options"*
- *Table A.4, "IPv6 Socket Options"*

Table A.1, "Socket Options" lists the socket options that are set at the SOL_SOCKET level and their Sockets API and system service symbol names.

Table A.1. Socket Options

Sockets API Symbol	System Service Symbol	Description
SO_BROADCAST	TCPIP$C_BROADCAST	Permits the sending of broadcast messages. Requires an integer parameter and SYSPRV, BYPASS, or OPER privilege. Optional for a connectionless datagram. If the `inet` subsystem attribute `ovms_nobroadcastcheck` is not zero, any nonprivileged application can send broadcast messages.
SO_DONTROUTE	TCPIP$C_DONTROUTE	Indicates that outgoing messages should bypass the standard routing facilities. Instead, the messages are directed to the appropriate network interface according to the network portion of the destination address.
SO_ERROR	TCPIP$C_ERROR	Obtains the socket error status and clears the error on the socket.
SO_FULL_DUPLEX_CLOSE	TCPIP $C_FULL_DUPLEX_CLOSE	When set, if the remote application closes the connection, the next transmit operation will return an error.
SO_KEEPALIVE	TCPIP$C_KEEPALIVE	Keeps connections active. Enables the periodic transmission of keepalive probes to the remote system. If the remote system

Sockets API Symbol	System Service Symbol	Description
		fails to respond to the keepalive probes, the connection is broken. If the SO_KEEPALIVE option is enabled, the values of TCP_KEEPCNT, TCP_KEEPINTVL and TCP_KEEPIDLE affect TCP behavior on the socket.
SO_LINGER	TCPIP$C_LINGER	Lingers on a `close()` function if data is present. Controls the action taken when unsent messages queue on a socket and a `close()` function is performed. Uses a `linger` structure parameter defined in SOCKET.H to specify the state of the option and the linger interval. If SO_LINGER is specified, the system blocks the process during the `close()` function until it can transmit the data or until the time expires. If the option is not specified and a `close()` function is issued, the system allows the process to resume as soon as possible.
SO_OOBINLINE	TCPIP$C_OOBINLINE	When this option is set, out-of-band data is placed in the normal input queue. When `SO_OOBINLINE` is set, the `MSG_OOB` flag to the receive functions cannot be used to read the out-of-band data. A value of 0 disables the option, and a nonzero value enables the option.
SO_RCVBUF	TCPIP$C_RCVBUF	Sets the receive buffer size, in bytes. Requires an integer parameter and SYSPRV, BYPASS, or OPER privileges.
SO_RCVTIMEO	TCPIP$C_RCVTIMEO	For VSI use only. Sets the timeout value for a `recv()` operation. The argument is a pointer to a `timeval` structure containing an integer value specified in seconds.
SO_REUSEADDR	TCPIP$C_REUSEADDR	Specifies that the rules used in validating addresses supplied

Sockets API Symbol	System Service Symbol	Description
		by a `bind()` function should allow reuse of local addresses. A value of 0 disables the option, and a non-zero value enables the option. The SO_REUSEPORT option is automatically set when an application sets SO_REUSEADDR.
SO_REUSEPORT	TCPIP$C_REUSEPORT	Allows more than one process to receive UDP datagrams destined for the same port. The `bind()` call that binds a process to the port must be preceded by a `setsockopt()` call specifying this option. SO_REUSEPORT is automatically set when an application sets the SO_REUSEADDR option.
SO_SHARE	TCPIP$C_SHARE	Allows multiple processes to share the socket.
SO_SNDBUF	TCPIP$C_SNDBUF	Sets the send buffer size in bytes. Takes an integer parameter and requires SYSPRV, BYPASS, or OPER privileges. Optional for a connectionless datagram.
SO_SNDLOWAT	TCPIP$C_SNDLOWAT	Sets the low-water mark for a `send()` operation. The send low-water mark is the amount of space that must exist in the socket send buffer for `select()` to return writeable. Takes an integer value specified in bytes.
SO_SNDTIMEO	TCPIP$C_SNDTIMEO	For VSI use only. Sets the timeout value for a `send()` operation. The argument is a pointer to a `timeval` structure containing an integer value specified in seconds.
SO_TYPE	TCPIP$C_TYPE	Obtains the socket type.
SO_USELOOPBACK	TCPIP$C_USELOOPBACK	For VSI use only. This option applies only to sockets in the routing domain (AF_ROUTE), When you enable this option, the socket receives a copy of everything sent on the socket.

Table A.2, "TCP Protocol Options" lists the TCP protocol options that are set at the IPPROTO_TCP level and their Sockets API and system service symbol names. You must use the TCP.H header file to specify the TCP protocol options.

Table A.2. TCP Protocol Options

Sockets API Symbol	System Service Symbol	Description
TCP_KEEPCNT	TCPIP$C_TCP_KEEPCNT	When the SO_KEEPALIVE option is enabled, TCP sends probes to the remote system of a connection that has been idle for a period of time. The TCP_KEEPCNT option specifies the maximum number of keepalive probes to be sent. To display the values of the `inet` subsystem attributes, enter the following command at the system prompt: `$ TCPIP sysconfig -q inet` The default value for TCP_KEEPCNT is 8.
TCP_KEEPIDLE	TCPIP$C_TCP_KEEPIDLE	When the SO_KEEPALIVE option is enabled, TCP sends probes to the remote system of a connection that has been idle for a period of time. TCP_KEEPIDLE specifies the number of seconds before TCP will send the initial keepalive probe. To display the values of the `inet` subsystem attributes, enter the following command at the system prompt: `$ TCPIP sysconfig -q inet` The default value for TCP_KEEPIDLE is 75 seconds[1].
TCP_KEEPINIT	TCPIP$C_TCP_KEEPINIT	If a TCP connection cannot be established within a period of time, TCP will time out the connection attempt. The default timeout value for this initial connection establishment is 75 seconds. The TCP_KEEPINIT option specifies the number of seconds to wait before the connection attempt times out. For passive connections, the

Sockets API Symbol	System Service Symbol	Description
		TCP_KEEPINIT option value is inherited from the listening socket. To display the values of the `inet` subsystem attributes, enter the following command at the system prompt: `$ TCPIP sysconfig -q inet` The default value for TCP_KEEPINIT is 75 seconds[1]. TCP_KEEPINIT option does not require the SO_KEEPALIVE option to be enabled.
TCP_KEEPINTVL	TCPIP$C_TCP_KEEPINTVL	When the SO_KEEPALIVE option is enabled, TCP sends probes to the remote system on a connection that has been idle for a period of time. The TCP_KEEPINTVL option specifies the number of seconds to wait before retransmitting a keepalive probe. The default value for this retransmit interval is 75 seconds[1]. To display the values of the `inet` subsystem attributes, enter the following command at the system prompt: `$ TCPIP sysconfig -q inet`
TCP_NODELAY	TCPIP$C_TCP_NODELAY	Specifies that the `send()` operation not be delayed to merge packets. Under most circumstances, TCP sends data when it is presented. When outstanding data has not yet been acknowledged, TCP gathers small amounts of the data into a single packet and sends it when an acknowledgment is received. This functionality can cause significant delays for some clients that do not expect replies (such as windowing

Sockets API Symbol	System Service Symbol	Description
		systems that send a stream of events from the mouse). The TCP_NODELAY option disables the Nagle algorithm, which reduces the number of small packets on a wide area network.
TCP_MAXSEG	TCPIP$C_TCP_MAXSEG	Sets the maximum transmission unit (MTU) of a TCP segment to a specified integer value from 1 to 65535. The default is 576 bytes. Can only be set before a `listen()` or `connect()` operation on the socket. For passive connections, the value is obtained from the listening socket. Note that TCP does not use an MTU value that is less than 32 or greater than the local network's MTU. Setting the option to zero results in the default behavior.
TCP_NODELACK	TCPIP$C_TCP_NODELACK	When specified, disables the algorithm that gathers outstanding data that has not been acknowledged and sends it in a single packet when acknowledgment is received. Takes an integer value.
TCP_PAWS	TCPIP$C_TCP_PAWS	When specified, the receiver rejects any old duplicate segments it receives. This option is used on synchronized TCP connections only, and requires that the TCP_TSOPTENA option be enabled also.
TCP_SACKENA	TCPIP$C_TCP_SACKENA	When specified, the receiver can inform the sender about all segments that arrive successfully. This allows the sender to retransmit only those segments that have actually been lost. This option is useful in cases where multiple segments are dropped.
TCP_TSOPTENA	TCPIP$C_TSOPTENA	When specified, the sender places a timestamp in each data segment. The receiver, if configured to accept them, sends these times back in the

Sockets API Symbol	System Service Symbol	Description
		acknowledgement (ACK) segments. This allows the sender to measure the round-trip communication time.
TCP protocol options that are obsolete but provided for backward compatibility		
TCP_DROP_IDLE	TCPIP$C_TCP_DROP_IDLE	When the TCP_KEEPALIVE option is enabled, the TCP_DROP_IDLE option specifies the time interval after which a connection is dropped. The value of TCP_DROP_IDLE is an integer specified in seconds. When the TCP_DROP_IDLE option is set, the value of the TCP_KEEPCNT option is calculated as the value of TCP_DROP_IDLE divided by the value of TCP_KEEPINTVL. A call to `getsockopt()` function specifying the TCP_DROP_IDLE option returns the result of multiplying the values of TCP_KEEPCNT and TCP_KEEPINTVL.
TCP_PROBE_IDLE	TCPIP$C_TCP_PROBE_IDLE	When the TCP_KEEPALIVE option is enabled, the TCP_PROBE_IDLE option specifies the time interval between the keepalive probes and for the connections establishing the timeout. The value of TCP_PROBE_IDLE is an integer specified in seconds. When this option is set, TCP_KEEPINTVL, TCP_KEEPIDLE and TCP_KEEPINIT are set to the value specified for TCP_PROBE_IDLE. A call to the `getsockopt()` function specifying the TCP_PROBE_IDLE option returns the value of TCP_KEEPINTVL.

[1]The value of this option is stored internally as half-seconds. When setting or retrieving the value of the systemwide parameter, the value is expressed as half-seconds. When setting or retrieving the value of the socket option, the value is expressed as seconds.

Table A.3, "IP Protocol Options" lists options that are set at the IPPROTO_IP level and their Sockets API and system service symbol names.

Table A.3. IP Protocol Options

Sockets API Symbol	System Service Symbol	Description
IP_ADD_MEMBERSHIP	TCPIP $C_IP_ADD_MEMBERSHIP	Adds the host to the membership of a multicast group. A host must become a member of a multicast group before it can receive datagrams sent to the group. Membership is associated with a single interface; programs running on multihomed hosts may need to join the same group on more than one interface. Up to IP_MAX_MEMBERSHIPS (currently 20) memberships may be added on a single socket.
IP_DROP_MEMBERSHIP	TCPIP $C_IP_DROP_MEMBERSHIP	Removes the host from the membership of a multicast group.
IP_HDRINCL	TCPIP$C_IP_HDRINCL	If specified for a raw IP socket, you must build the IP header for all datagrams sent on the raw socket.
IP_MULTICAST_IF	TCPIP$C_IP_MULTICAST_IF	Specifies the interface for outgoing multicast datagrams sent on this socket. The interface is specified as an `in_addr` structure.
IP_MULTICAST_LOOP	TCPIP $C_IP_MULTICAST_LOOP	Disables loopback of local delivery. If a multicast datagram is sent to a group which the sending host is a member, a copy of the datagram is looped back by the IP layer for local delivery (the default). To disable the loopback delivery, specify a value of 0.
IP_MULTICAST_TTL	TCPIP$C_IP_MULTICAST_TTL	Specifies the time-to-live (TTL) value for outgoing multicast datagrams. Takes an integer value between 0 and 255:

Value	Action
0	Restricts distribution to applications running on the local host.
1	Forwards the multicast datagram to hosts on the local subnet.

Sockets API Symbol	System Service Symbol	Description	
		2 - 255	With a multicast router attached to the sending host's network, forwards multicast datagrams beyond the local subnet. Multicast routers forward the datagram to known networks that have hosts belonging to the specified multicast group. The TTL value is decremented by each multicast router in the path. When the TTL value is decremented to zero, the datagram is no longer forwarded.
IP_OPTIONS	TCPIP$C_IP_OPTIONS	Provides IP options to be transmitted in the IP header of each outgoing packet.	
IP_RECVDSTADDR	TCPIP$C_IP_RECVDSTADDR	Enables a SOCK_DGRAM socket to receive the destination IP address for a UDP datagram.	
IP_RECVOPTS	TCPIP$C_IP_RECVOPTS	Enables a SOCK_DGRAM socket to receive IP options.	
IP_TTL	TCPIP$C_IP_TTL	Time to live (TTL) for a datagram.	
IP_TOS	TCPIP$C_IP_TOS	Type of service (1-byte value).	

Table A.4, "IPv6 Socket Options" describes the socket options supporting IPv6. The IPv6 socket options do not have system service symbols.

Table A.4. IPv6 Socket Options

Sockets API Symbol	Description
IPV6_RECVPKTINFO	Source and destination IPv6 address, and sending and receiving interface.
IPV6_RECVHOPLIMIT	Hop limit.
IPV6_RECVRTHDR	Routing header.
IPV6_RECVHOPOPTS	Hop-by-hop options.
IPV6_RECVDSTOPTS	Destination options.
IPV6_CHECKSUM	For raw IPv6 sockets other than ICMPv6 raw sockets, causes the kernel to compute and store

Sockets API Symbol	Description
	checksum for output and to verify the received checksum on input. Discards the packet if the checksum is in error.
IPV6_ICMP6_FILTER	Fetches and stores the filter associated with the ICMPv6 raw socket using the `getsockopt()` function and `setsockopt()` functions.
IPV6_UNICAST_HOPS	Sets the hop limit for all subsequent unicast packets sent on a socket. You can also use this option with the `getsockopt()` function to determine the current hop limit for a socket.
IPV6_MULTICAST_IF	Sets the interface to use for outgoing multicast packets.
IPV6_MULTICAST_HOPS	Sets the hop limit for outgoing multicast packets.
IPV6_MULTICAST_LOOP	Controls whether to deliver outgoing multicast packets back to the local application.
IPV6_JOIN_GROUP	Joins a multicast group on the specified interface.
IPV6_LEAVE_GROUP	Leaves a multicast group on the specified interface.

Appendix B. IOCTL Requests

The `ioctl()` Sockets API function and the IO$_SENSEMODE and IO$_SETMODE function codes used with the $QIO system service perform I/O control functions on a network pseudodevice (BG:).

The following tables list the IOCTL requests supported by TCP/IP Services, their data types, the equivalent $QIO system services, and descriptions of their operations:

- *Table B.1, "Terminal Compatibility Operations"* describes the terminal compatibility options.
- *Table B.2, "Socket Operations"* describes the socket operations.
- *Table B.3, "Interface Operations"* describes the interface operations. These request types are defined in the IF.H header file.
- *Table B.4, "Routing Table Operations"* describes the routing operations. These request types are defined in the ROUTE.H header file.
- *Table B.5, "ARP Cache Operations"* describes the ARP cache operations. These request types are defined in the IF_ARP.H header file.

Table B.1. Terminal Compatibility Operations

Operation	Data Type	$QIO Function Code	Description
FIONREAD	int	IO$_SENSEMODE	Get number of bytes to read.
FIONBIO	int	IO$_SETMODE	Set/clear non-blocking I/O.
FIOASYNC	int	IO$_SETMODE	Set/clear asynchronous I/O.
FIOSETOWN	int	IO$_SETMODE	Set owner.
FIOGETOWN	int	IO$_SENSEMODE	Get owner.
FIOPIPESTAT	int	IO$_SENSEMODE	Pipe first-in, first out statistics.
FIOFATTACH	int	IO$_SETMODE	Internal: fattach.
FIOFDETACH	int	IO$_SETMODE	Internal: fdetach.

Table B.2. Socket Operations

Operation	Data Type	$QIO Function Code	Description
SIOCSHIWAT	int	IO$_SETMODE	Set high watermark.
SIOCGHIWAT	int	IO$_SENSEMODE	Get high watermark.
SIOCSLOWAT	int	IO$_SETMODE	Set low watermark.
SIOCGLOWAT	int	IO$_SENSEMODE	Get low watermark.
SIOCATMARK	int	IO$_SENSEMODE	Determines whether you are at the out-of-band character mark. The operation returns a nonzero value if the socket's read pointer

Operation	Data Type	$QIO Function Code	Description
			is currently at the end-of-band mark or a zero value if the read pointer is not at the out-of-band mark. The value is returned in the integer pointed to by the third argument of the `ioct()` call. For more information, see *Section 2.11.2, "Reading OOB Data (System Services)"*.

Table B.3. Interface Operations

Operation	Data Type	$QIO Function Code	Description
SIOCSIFADDR	struct ifreq	IO$_SETMODE	Sets the interface address from the `ifr_addr` member. The initialization function for the interface is also called.
SIOCSIFDSTADDR	struct ifreq	IO$_SETMODE	Sets the point-to-point address from the `ifr_dstaddr` member.
SIOCSIFFLAGS	struct ifreq	IO$_SETMODE	Sets the interface flags from the `ifr_flags` member.
SIOCGIFFLAGS	struct ifreq	IO$_SENSEMODE	Returns the interface flags in the `ifr_flags` member. The flags indicate whether the interface is up (`IFF_UP`), is a point-to-point interface (`IFF_POINTOPOINT`), supports broadcasts (`IFF_BROADCAST`), and other flags.
SIOCSIFBRDADDR	struct ifreq	IO$_SETMODE	Sets the broadcast address from the `ifr_broadaddr` member.
SIOCSIFNETMASK	struct ifreq	IO$_SETMODE	Sets the subnet address mask from the `ifr_addr` member.
SIOCGIFMETRIC	struct ifreq	IO$_SENSEMODE	Returns the interface routing metric in the

Operation	Data Type	$QIO Function Code	Description
			`ifr_metric` member. The interface metric is maintained by the kernel for each interface but is used by the routing software (ROUTED). The interface metric is added to the hop count (to make an interface less favorable).
SIOCSIFMETRIC	struct ifreq	IO$_SETMODE	Sets the interface routing metric from the `ifr_metric` member.
SIOCDIFADDR	struct ifreq	IO$_SETMODE	Deletes an interface address
SIOCAIFADDR	struct ifaliasreq	IO$_SETMODE	Adds or changes an interface alias.
SIOCPIFADDR	struct ifaliasreq	IO$_SETMODE	Sets the primary interface address.
SIOCADDMULTI	struct ifreq	IO$_SETMODE	Adds a multicast address.
SIOCDELMULTI	struct ifreq	IO$_SETMODE	Deletes a multicast address.
SIOCENABLBACK	struct ifreq	IO$_SETMODE	Enables the loopback interface.
SIOCDISABLBACK	struct ifreq	IO$_SETMODE	Disables the loopback interface.
SIOCSIPMTU	struct ifreq	IO$_SETMODE	Sets the interface IP MTU value.
SIOCRIPMTU	struct ifreq	IO$_SENSEMODE	Returns the interface IP MTU value.
SIOCGIFINDEX	struct ifreq	IO$_SENSEMODE	Returns the IF index value.
SIOCGMEDIAMTU	struct ifreq	IO$_SENSEMODE	Returns the value of the media MTU.
SIOCGIFTYPE	struct ifreq	IO$_SENSEMODE	Returns the interface type.
SIOCGIFADDR	struct ifreq	IO$_SENSEMODE	Returns the interface address.
SIOCGIFDSTADDR	struct ifreq	IO$_SENSEMODE	Returns the point-to-point interface address.
SIOCGIFBRDADDR	struct ifreq	IO$_SENSEMODE	Returns the interface broadcast address.
SIOCGIFCONF	struct ifconf	IO$_SENSEMODE	Returns the interface list.

Operation	Data Type	$QIO Function Code	Description
SIOCGIFNETMASK	struct ifreq	IO$_SENSEMODE	Returns the interface subnet address mask.

Table B.4. Routing Table Operations

Operation	Data Type	$QIO Function Code	Description
SIOCADDRT	struct ortentry	IO$_SETMODE	Adds an entry to the routing table.
SIOCDELRT	struct ortentry	IO$_SETMODE	Deletes an entry from the routing table.

Table B.5. ARP Cache Operations

Operation	Data Type	$QIO Function Code	Description
SIOCSARP	struct arpreq	IO$_SETMODE	Adds a new entry to or modifies an existing entry in the ARP table.
SIOCDARP	struct arpreq	IO$_SETMODE	Deletes an entry from the ARP table.
SIOCGARP	struct arpreq	IO$_SENSEMODE	Returns an ARP table entry.

Appendix C. Data Types

As part of the OpenVMS common language environment, the TCP/IP system services data types provide compatibility between procedure calls that support many different high-level languages. Specifically, the OpenVMS data types apply to Alpha, I64, and VAX architectures as the mechanism for passing argument data between procedures. This appendix describes the context and structure of the TCP/IP system services data types and identifies the associated declarations to each of the specific high-level language implementations.

C.1. OpenVMS Data Types

In *Chapter 6, "OpenVMS System Services Reference"*, the OpenVMS usage entry in the TCP/IP Services documentation format for system services 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 C.1, "TCP/IP Services Usage Data Type Entries"* and read its definition.
2. Find the same OpenVMS data type in the C and C++ language implementation table (*Table C.2, "C and C++ Implementations"*) 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.
4. For all other OpenVMS data types, refer to the *VSI OpenVMS Programming Concepts Manual, Volume II* manual.

Table C.1, "TCP/IP Services Usage Data Type Entries" lists and describes OpenVMS data type declarations for the OpenVMS usage entry of system services unique to TCP/IP Services.

Table C.1. TCP/IP Services Usage Data Type Entries

Data Type	Definition
`buffer_list`	Structure that consists of one or more descriptors defining the length and starting address of user buffers. On Alpha and I64 systems, each descriptor can be a 32- or 64-bit fixed-length descriptor. On VAX systems, each descriptor is a 32-bit fixed-length descriptor. For more information concerning descriptors, see the OpenVMS Calling Standard.

Data Type	Definition
`input_parameter_list`	Structure that consists of one or more `item_list_2` or `ioctl_comm` structures. Each `item_list_2` structure describes an individual parameter that can be set by a service. Such parameters include socket or protocol options as identified by the item's type field. Each `ioctl_comm` structure describes an IOCTL command; its encoded request code and address of its associated argument.
`ioctl_comm`	Quadword structure that describes an IOCTL command's encoded request code and address of its associated argument. It contains two longword fields, as depicted in the following diagram: The first field is a longword containing the IOCTL encoded request code specifying the type of I/O control operation to be performed. The second field is a longword containing the address of a variable or a data structure targeted by this IOCTL command.
`item_list_2`	Quadword structure that describes the size, data type, and starting address of a user-supplied data item. It contains three fields, as depicted in the following diagram: The first field is a word containing the length (in bytes) of the user-supplied data item being described. The second field is a word containing a symbolic code specifying the data type of the user-supplied data item. The third field is a longword containing the starting address of the user-supplied data item.
`item_list_2 descriptor`	An `item_list_2` structure, used as an argument descriptor and containing structural information about the argument's type and the address of a data item. This data item is associated with the argument. The format of this descriptor is unique to TCP/IP Services and supplements argument descriptors defined in the OpenVMS Calling Standard.
`item_list_3`	A 12-byte structure that describes the size, data type, and address of a buffer in which a service writes information. It contains four fields, as depicted in the following diagram:

Data Type	Definition
	The first field is a word containing the length (in bytes) of the buffer in which a service writes information. The length of the buffer needed depends on the data type specified in the type field. If the value of buffer length is too small, the service truncates the data. The second field is a word containing a symbolic code and specifies the type of information that a service is to return. The third field is a longword containing the address of the buffer in which a service writes the information. The fourth field is a longword containing the address of a longword in which a service writes the length in bytes of the information it actually returned.
`item_list_3 descriptor`	An `item_list_3` structure, used as an argument descriptor and containing structural information about the argument's type and the address of a buffer used to return service information. This buffer is associated with the argument. The format of this descriptor is unique to TCP/IP Services and supplements argument descriptors defined in the OpenVMS Calling Standard.
`output_parameter_list`	Structure that consists of one or more `item_list_3` or `ioctl_comm` structures. Each `item_list_3` structure describes an individual parameter that can be returned by a service. Such parameters include socket or protocol options as identified by the item's type field. Each `ioctl_comm` structure describes an IOCTL command, its encoded request code, and the address of its associated argument.
`socket_name`	Internet domain socket address structure that consists of an Internet address and a port number. The layouts of socket address structures of BSD Version 4.3 and BSD Version 4.4 are different. BSD Version 4.3 specifies a 16-byte IPv4 socket address structure. It contains four fields, as depicted in the following diagram:

Data Type	Definition
	The first field is a word identifying a socket address structure as belonging to the internet domain (always a value of 2). The second field is a word containing a 16-bit port number (stored in network byte order) used to demultiplex transport-level messages. The third field is a longword containing a 32-bit IPv4 internet address (stored in network byte order). The fourth field is a quadword. It is unused but must be initialized to all zeros. BSD Version 4.4 specifies a 16-byte IPv4 socket address structure. It contains five fields, as depicted in the following diagram: The first field is a byte containing the size of this socket address structure (always a value of 16). The second field is a byte identifying a socket address structure as belonging to the internet domain (always a value of 2). The third field is a word containing a 16-bit port number (stored in network byte order) used to demultiplex transport-level messages. The fourth field is a longword containing a 32-bit IPv4 internet address (stored in network byte order). The fifth field is a quadword. It is unused but must be initialized to all zeros. BSD Version 4.4 also specifies a 28-byte IPv6 socket address structure. It contains six fields, as depicted in the following diagram: The first field is a byte containing the size of this socket address structure (always a value of 28). The second field is a byte identifying a socket address structure as belonging to the IPv6 internet domain (always a value of 28). The third field is a word containing the 16-bit port number (stored in network byte order) used to demultiplex transport-level messages.

Data Type	Definition
	The fourth field is a longword containing priority and flow label information (stored in network byte order). The fifth field is an octaword (16 bytes) containing a 128-bit IPv6 Internet address (stored in network byte order). The sixth field is a longword containing the scope id (stored in network byte order).
`subfunction_code`	Longword structure specifying the exact operation an IO$_ACPCONTROL function is to perform. This structure has three fields, as depicted in the following diagram: The first field is a byte specifying the network ACP operation. The second field is a byte specifying the network ACP suboperation. The third field is word that is unused but must be initialized to all zeros (MBZ).
`socket_characteristics`	Longword structure specifying the address family, socket type, and protocol of a new socket. This structure has three fields, as depicted in the following diagram: The first field is a word specifying the protocol to be used with the socket. The second field is a byte specifying the socket type. The third field is a byte specifying the address family.

C.2. C and C++ Implementations

Table C.2, "C and C++ Implementations" lists the OpenVMS data types and their corresponding C and C++ data type declarations.

Table C.2. C and C++ Implementations

OpenVMS Data Types	C and C++ Implementations
`buffer_list`	User defined[1]
`input_parameter_list`	User defined[1]

`ioctl_comm`	`struct ioctl_comm`
	`{`
	`int ioctl_req;  /* ioctl request code */`

OpenVMS Data Types	C and C++ Implementations
	`void *ioctl_arg;  /* ioctl argument */` `}`

`item_list_2`	`struct item_list_2`
	`{`
	`unsigned short length;  /* item length */`
	`unsigned short type;  /* item type */`
	`void *address;  /* item address */`
	`}`

`item_list_2 descriptor`	`struct item_list_2`
	`{`
	`unsigned short length;  /* argument length */`
	`unsigned short type;  /* argument type */`
	`void *address;  /* argument address */`
	`}`

`item_list_3`	`struct item_list_3`
	`{`
	`unsigned short length;  /* buffer length */`
	`unsigned short type;  /* buffer type */`
	`void *address;  /* buffer address */`
	`unsigned int *retlen;  /* buffer returned */`
	`/* length address */`
	`}`

`item_list_3 descriptor`	`struct item_list_3`
	`{`
	`unsigned short length;  /* argument length */`
	`unsigned short type;  /* argument type */`
	`void *address;  /* argument address */`
	`unsigned int *retlen;  /* argument returned */`
	`/* length address */`
	`}`

`output_parameter_list`	User defined[1]
`socket_name` (IPv4)	`include <in.h>` `struct sockaddr_in`
`socket_name` (IPv6)	`include <in6.h>` `struct sockaddr_in6`
`subfunction_code`	`struct acpfunc`

OpenVMS Data Types	C and C++ Implementations

	{
	unsigned char code; /*
	subfunction code */
	unsigned char type; /* call code
	*/
	unsigned short reserved;/* reserved
	*/
	/* (must be
	zero) */
	}

socket_characteristics	struct sockchar
	{
	unsigned short prot; /* protocol
	*/
	unsigned char type; /* type
	*/
	unsigned char af; /* address
	format */
	}

[1]The 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.

Appendix D. Error Codes

This appendix contains a table of Sockets API error codes and their equivalent OpenVMS system service status codes (*Table D.1, "Translation of Socket Error Codes to OpenVMS Status Codes"*).

Table D.1. Translation of Socket Error Codes to OpenVMS Status Codes

Sockets (VSI C) Error Code	OpenVMS System Service Status Code	Meaning
0	SS$_NORMAL	Success
1 EPERM	SS$_ABORT	Not owner
2 ENOENT	SS$_ABORT	No such file or directory
3 ESRCH	SS$_NOSUCHNODE	No such process
4 EINTR	SS$_ABORT	Interrupted system call
5 EIO	SS$_ABORT	I/O error
6 ENXIO	SS$_NOSUCHDEV	No such device or address
7 E2BIG	SS$_ABORT	Argument list too long
8 ENOEXEC	SS$_ABORT	Execution format error
9 EBADF	SS$_BADPARAM	Bad file number
10 ECHILD	SS$_ABORT	No children
11 EAGAIN	SS$_ABORT	No more processes
12 ENOMEM	SS$_INSFMEM	Not enough core
13 EACCES	SS$_ABORT	Permission denied
14 EFAULT	SS$_ACCVIO	Bad address
15 ENOTBLK	SS$_ABORT	Block device required
16 EBUSY	SS$_ABORT	Mount device busy
17 EEXIST	SS$_FILALRACC	File exists
18 EXDEV	SS$_ABORT	Cross-device link
19 ENODEV	SS$_ABORT	No such device
20 ENOTDIR	SS$_ABORT	Not a directory
21 EISDIR	SS$_ABORT	Is a directory
22 EINVAL	SS$_BADPARAM	Invalid argument
23 ENFILE	SS$_ABORT	File table overflow
24 EMFILE	SS$_ABORT	Too many open files
25 ENOTTY	SS$_ABORT	Not a terminal
26 ETXTBSY	SS$_ABORT	Text file busy
27 EFBIG	SS$_ABORT	File too large
28 ENOSPC	SS$_ABORT	No space left on device
29 ESPIPE	SS$_ABORT	Illegal seek
30 EROFS	SS$_ABORT	Read-only file system
31 EMLINK	SS$_ABORT	Too many links

Sockets (VSI C) Error Code	OpenVMS System Service Status Code	Meaning
32 EPIPE	SS$_LINKDISCON	Broken pipe
33 EDOM	SS$_BADPARAM	Argument too large
34 ERANGE	SS$_TOOMUCHDATA	Result too large
35 EWOULDBLOCK	SS$_SUSPENDED	Operation would block
36 EINPROGRESS	SS$_ABORT	Operation now in progress
37 EALREADY	SS$_ABORT	Operation already in progress
38 ENOTSOCK	SS$_NOTNETDEV	Socket operation on nonsocket
39 EDESTADDRREQ	SS$_NOSUCHNODE	Destination address required
40 EMSGSIZE	SS$_TOOMUCHDATA	Message too long
41 EPROTOTYPE	SS$_PROTOCOL	Protocol wrong type for socket
42 ENOPROTOOPT	SS$_PROTOCOL	Protocol not available
43 EPROTONOSUPPORT	SS$_PROTOCOL	Protocol not supported
44 ESOCKTNOSUPPORT	SS$_PROTOCOL	Socket type not supported
45 EOPNOTSUPP	SS$_ILLCNTRFUNC	Operation not supported on socket
46 EPFNOSUPPORT	SS$_PROTOCOL	Protocol family not supported
47 EAFNOSUPPORT	SS$_PROTOCOL	Address family not supported
48 EADDRINUSE	SS$_DUPLNAM	Address already in use
49 EADDRNOTAVAIL	SS$_IVADDR	Requested address cannot be assigned
50 ENETDOWN	SS$_UNREACHABLE	Network is down
51 ENETUNREACH	SS$_UNREACHABLE	Network is unreachable
52 ENETRESET	SS$_RESET	Network dropped connection on reset
53 ECONNABORTED	SS$_LINKABORT	Software caused connection abort
54 ECONNRESET	SS$_CONNECFAIL	Connection reset by peer
55 ENOBUFS	SS$_INSFMEM	No buffer space available
56 EISCONN	SS$_FILALRACC	Socket is already connected
57 ENOTCONN	SS$_NOLINKS	Socket is not connected
58 ESHUTDOWN	SS$_SHUT	Cannot send after socket shutdown
59 ETOOMANYREFS	SS$_ABORT	Too many references, cannot splice
60 ETIMEDOUT	SS$_TIMEOUT	Connection timed out
61 ECONNREFUSED	SS$_REJECT	Connection refused
62 ELOOP	SS$_ABORT	Too many levels of symbolic links
63 ENAMETOOLONG	SS$_ABORT	File name too long
64 EHOSTDOWN	SS$_SHUT	Host is down

Sockets (VSI C) Error Code	OpenVMS System Service Status Code	Meaning
65 EHOSTUNREACH	SS$_UNREACHABLE	No route to host

Appendix E. Porting Applications to IPv6

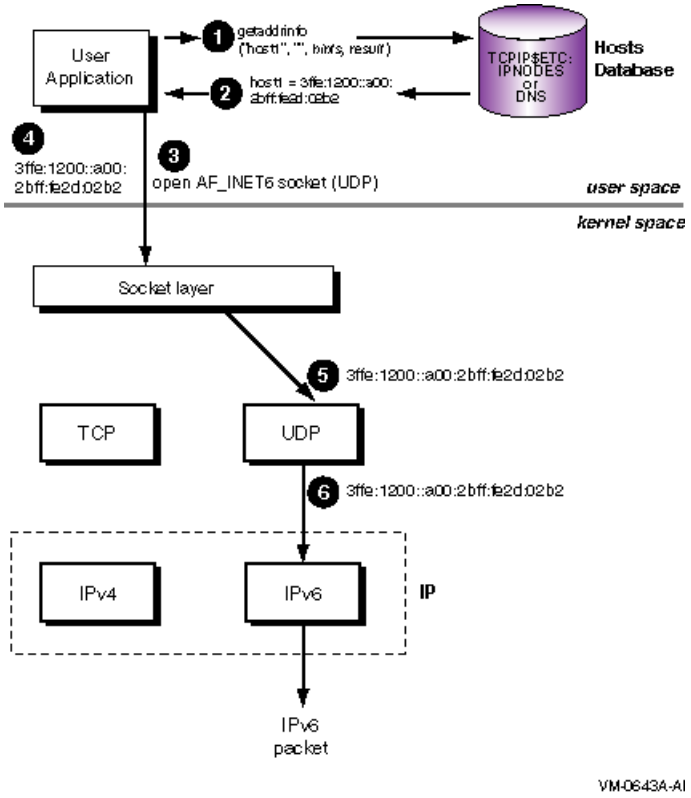
This appendix describes the changes you must make in your application code to operate in an IPv6 networking environment, including:

- Name changes
- Structure changes
- Other changes

E.1. Using AF_INET6 Sockets

Figure E.1, "Using AF_INET Socket for IPv4 Communications" shows a sample sequence of events for an application that uses an AF_INET socket to send IPv4 packets.

Figure E.1. Using AF_INET Socket for IPv4 Communications



1. Application calls `gethostbyname()` and passes the host name, `host1`.
2. The search finds `host1` in the hosts database and `gethostbyname()` returns the IPv4 address `1.2.3.4`.
3. The application opens an AF_INET socket.
4. The application sends information to the `1.2.3.4` address.

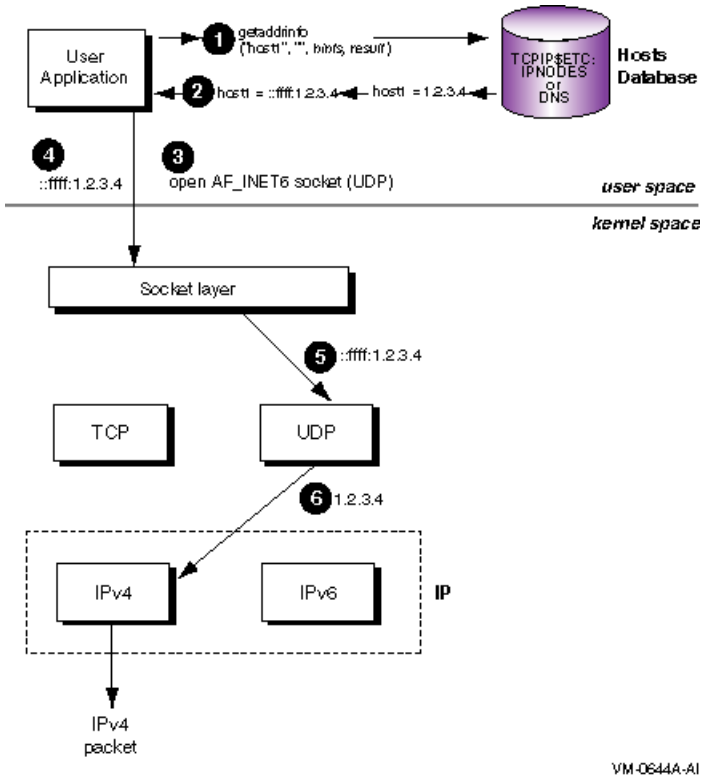
5. The socket layer passes the information and address to the UDP module.

6. The UDP module puts the `1.2.3.4` address into the packet header and passes the information to the IPv4 module for transmission.

Section E.6.1.1, "Client Program" contains sample program code that demonstrates these steps.

You can use the AF_INET6 socket for both IPv6 and IPv4 communications. For IPv4 communications, create an AF_INET6 socket and pass it a `sockaddr_in6` structure that contains an IPv4-mapped IPv6 address (for example, `::ffff:1.2.3.4`). *Figure E.2, "Using AF_INET6 Socket to Send IPv4 Communications"* shows the sequence of events for an application that uses an AF_INET6 socket to send IPv4 packets.

Figure E.2. Using AF_INET6 Socket to Send IPv4 Communications



1. Application calls `getaddrinfo()` and passes the host name (`host1`), the AF_INET6 address family hint, and the (AI_V4MAPPED | AI_ADDRCONFIG) flag hint. The flag tells the function that if an IPv4 address is found for `host1`, return the address as an IPv4-mapped IPv6 address.

2. The search finds an IPv4 address, `1.2.3.4`, for `host1` in the hosts database and `getaddrinfo()` returns the IPv4-mapped IPv6 address `::ffff:1.2.3.4`.

3. The application opens an AF_INET6 socket.

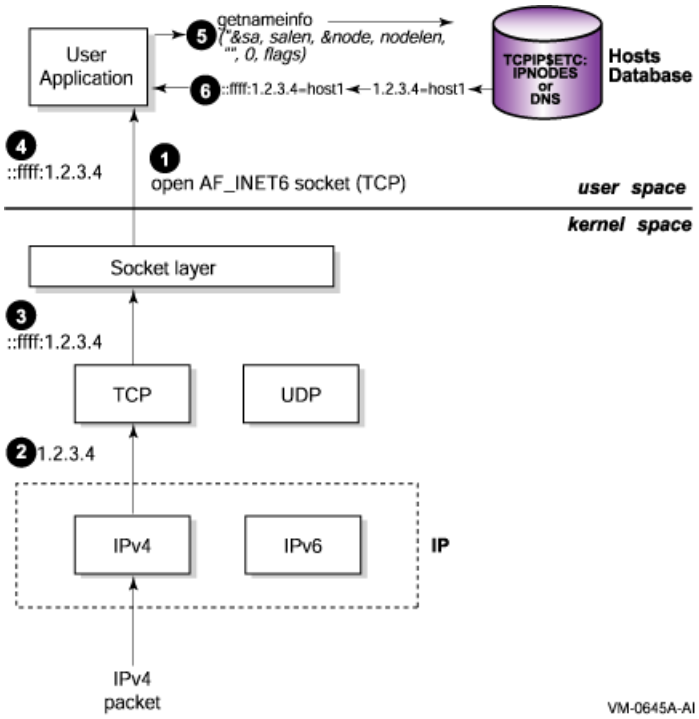
4. The application sends information to the `::ffff:1.2.3.4` address.

5. The socket layer passes the information and address to the UDP module.

6. The UDP module identifies the IPv4-mapped IPv6 address, puts the `1.2.3.4` address into the packet header, and passes the information to the IPv4 module for transmission.

AF_INET6 sockets can receive messages sent to either IPv4 or IPv6 addresses on the system. An AF_INET6 socket uses the IPv4-mapped IPv6 address format to represent IPv4 addresses. *Figure E.3, "Using AF_INET6 Socket to Receive IPv4 Communications "* shows the sequence of events for an application that uses an AF_INET6 socket to receive IPv4 packets.

Figure E.3. Using AF_INET6 Socket to Receive IPv4 Communications



1. The application opens an AF_INET6 socket, binds to it, and listens on it.

2. An IPv4 packet arrives and passes through the IPv4 module.

3. The TCP layer strips off the packet header and passes the information and the IPv4-mapped IPv6 address `::ffff:1.2.3.4` to the socket layer.

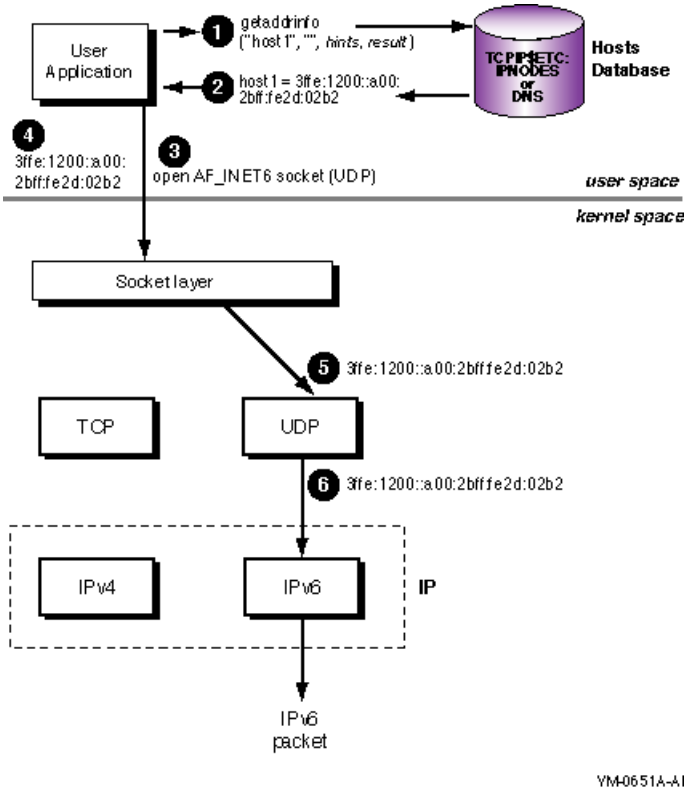
4. The application calls `accept()` and retrieves the information from the socket.

5. The application calls `getnameinfo()` and passes the `::ffff:1.2.3.4` address and the NI_NAMEREQD flag. The flag tells the function to return the host name for the address. See *Table 4.3, "`getnameinfo()` Flags"* for a description of the flag bits and their meanings.

6. The search finds the host name for the `1.2.3.4` address in the hosts database, and `getnameinfo()` returns the host name.

For IPv6 communications, create an AF_INET6 socket and pass it a `sockaddr_in6` structure that contains an IPv6 address (for example, `3ffe:1200::a00:2bff:fe2d:02b2`). *Figure E.4, "Using AF_INET6 Socket for IPv6 Communications"* shows the sequence of events for an application that uses an AF_INET6 socket to send IPv6 packets.

Figure E.4. Using AF_INET6 Socket for IPv6 Communications



1. Application calls `getaddrinfo()` and passes the host name (`host1`), the AF_INET6 address family hint, and the (AI_V4MAPPED | AI_ADDRCONFIG) flag hint. The flag tells the function that if an IPv4 address is found for `host1`, to return it.

2. The search finds an IPv6 address for `host1` in the hosts database, and `getaddrinfo()` returns the IPv6 address `3ffe:1200::a00:2bff:fe2d:02b2`.

3. The application opens an AF_INET6 socket.

4. The application sends information to the `3ffe:1200::a00:2bff:fe2d:02b2` address.

5. The socket layer passes the information and address to the UDP module.

6. The UDP module identifies the IPv6 address and puts the `3ffe:1200::a00:2bff:fe2d:02b2` address into the packet header and passes the information to the IPv6 module for transmission.

Section E.6.2.1, "Client Program" contains sample program code that demonstrates these steps.

The following sections describe how to convert an existing AF_INET application to an AF_INET6 application that is capable of communicating over both IPv4 and IPv6.

E.2. Name Changes

Most of the changes required are straightforward and mechanical, though some may require a bit of code restructuring. For example, a routine that returns an `int` data type holding an IPv4 address may need to be modified to take as an extra parameter a pointer to an `in6_addr` into which it writes the IPv6 address.

Table E.1, "Name Changes" summarizes the changes you must make to your application's code.

Table E.1. Name Changes

Search file for	Replace with	Comments
AF_INET	AF_INET6	Replace with IPv6 address family macro.
PF_INET	PF_INET6	Replace with IPv6 protocol family macro.
INADDR_ANY	`in6addr_any`	Replace with IPv6 global variable.

E.3. Structure Changes

The structure names and field names have changed for the following structures:

- `in_addr`
- `sockaddr_in`
- `sockaddr`
- `hostent`

The following sections discuss these changes.

E.3.1. in_addr Structure

Applications that use the IPv4 `in_addr` structure must be changed to use the IPv6 `in6_addr` structure, as follows:

IPv4 Structure	IPv6 Structure

`struct in_addr`
 	
`unsigned int s_addr`
	`struct in6_addr`
	
	`uint8_t s6_addr`

Make the following changes to your application, as needed:

1. Change the structure name `in_addr` to `in6_addr`.
2. Change the data type from `unsigned int` to `uint8_t` and the field name `s_addr` to `s6_addr`.

E.3.2. sockaddr Structure

Applications that use the generic socket address structure (`sockaddr`) to hold an AF_INET socket address (`sockaddr_in`) must be changed to use the AF_INET6 `sockaddr_in6` structure, as follows:

AF_INET Structure	AF_INET6 Structure
`struct sockaddr`	`struct`

AF_INET Structure	AF_INET6 Structure
	`sockaddr_in6`

Make the following change to your application, as needed:

- Change structure name `sockaddr` to `sockaddr_in6`.

Note

A `sockaddr_in6` structure is larger than a `sockaddr` structure. For more information, see *Section 3.2.14, "sockaddr_in6 Structure (IPv6)"*.

E.3.3. sockaddr_in Structure

Applications that use the BSD Version 4.4 IPv4 `sockaddr_in` structure must be changed to use the IPv6 `sockaddr_in6` structure, as follows:

IPv4 Structure	IPv6 Structure
`struct sockaddr_in`	`struct sockaddr_in6`
`unsigned char sin_len`	`uint8_t sin6_len`
`sa_family_t sin_family`	`sa_family_t sin6_family`
`in_port_t sin_port`	`int_port_t sin6_port`
`struct addr sin_addr`	`struct in6_addr sin6_addr`

Make the following changes to your application, as needed:

1. Change structure name `sockaddr_in` to `sockaddr_in6`. Initialize the entire `sockaddr_in6` structure to zero after your structure declarations.
2. Change the data type `unsigned char` to `uint8_t` and the field name `sin_len` to `sin6_len`.
3. Change the field name `sin_family` to `sin6_family`.
4. Change the field name `sin_port` to `sin6_port`.
5. Change the field name `sin_addr` to `sin6_addr`.

E.3.4. hostent Structure

Applications that use the `hostent` structure must be changed to use the `addrinfo` structure, as follows:

AF_INET Structure	AF_INET6 Structure
`struct hostent`	`struct addrinfo`

Make the following change to your application, as needed:

- Change the structure name `hostent` to `addrinfo`.

See also *Section E.4.2, "gethostbyname() Function"* for related changes.

E.4. Function Changes

The names and parameters have changed for the following functions:

- `gethostbyaddr()`
- `gethostbyname()`
- `inet_aton()`
- `inet_ntoa()`
- `inet_addr()`

The following sections discuss these changes.

E.4.1. gethostbyaddr() Function

Applications that use the IPv4 `gethostbyaddr()` function must be changed to use the IPv6 `getnameinfo()` function, as follows:

AF_INET Call	**AF_INET6 Call**
gethostbyaddr(*xxx*,4,AF_INET)	err=getnameinfo(*&sa*, *salen*, *node*, *nodelen*, *service*, *servicelen*, *flags*);

Make the following change to your application, as needed:

- Change the function name from `gethostbyaddr()` to `getnameinfo()` and provide a pointer to the socket address structure, a character string for the returned node name, an integer for the length of the returned node name, a character string to receive the returned service name, an integer for the length of the returned service name, and an integer that specifies the type of address processing to be performed.

E.4.2. gethostbyname() Function

Applications that use the `gethostbyname()` function must be changed to use the `getaddrinfo()` function, as follows:

AF_INET Call	**AF_INET6 Call**
gethostbyname(*name*)	err=getaddrinfo(*nodename*, *servname*, *&hints*, *&res*); ⋮ freeaddrinfo(*&ai*);

Make the following changes to your application, as needed:

1. Change the function name from `gethostbyname()` to `getaddrinfo()` and provide a character string that contains the node name, a character string that contains the service name to use, a pointer to a `hints` structure that contains processing options, and a pointer to an `addrinfo` structure or structures for the returned address information.

2. Add a call to the `freeaddrinfo()` function to free the `addrinfo` structure or structures when your application is finished using them.

E.4.3. inet_aton() Function

Applications that use the `inet_aton()` function must be changed to use the `inet_pton()` function, as follows:

AF_INET Call	AF_INET6 Call
inet_aton(*&string*,*&addr*)	inet_pton (AF_INET6,&src,&dst);

Make the following change to your application, as needed:

- Change the function name from `inet_aton()` to `inet_pton()` and provide an integer for the address family, a pointer to an address string to be converted, and a pointer to a buffer that is to contain the numeric address.

E.4.4. inet_ntoa() Function

Applications that use the `inet_ntoa()` function must be changed to use the `inet_ntop()` function, as follows:

AF_INET Call	AF_INET6 Call
inet_ntoa(*addr*)	inet_ntop(AF_INET6,&src,&dst,size);

Make the following change to your application, as needed:

- Change the function name from `inet_ntoa()` to `inet_ntop()` and provide an integer for the address family, a pointer to a buffer that contains the numeric internet address, a pointer to a buffer that is to contain the text string, and an integer for the size of the buffer pointed to by the **dst** parameter.

E.4.5. inet_addr() Function

Applications that use the `inet_addr()` function must be changed to use the `inet_pton()` function, as follows:

AF_INET Call	AF_INET6 Call
result=inet_addr(*&string*)	inet_pton (AF_INET6,&src,&dst);

Make the following change to your application, as needed:

- Change the function name from `inet_addr()` to `inet_pton()` and provide an integer for the address family, a pointer to an address string to be converted, and a pointer to a buffer that is to contain the numeric address.

E.5. Other Application Changes

In addition to the name changes, you should review your code for specific uses of IP address information and variables.

E.5.1. Comparing IP Addresses

If your application compares IP addresses or tests IP addresses for equality, the `in6_addr` structure changes (see in *Section E.3.1, "in_addr Structure"*) will change the comparison of `int` quantities to a comparison of structures. This will break the code and cause compiler errors.

Make one of the following changes to your application, as needed:

AF_INET Code	AF_INET6 Code
(addr1->s_addr == addr2->s_addr)	(memcmp(addr1, addr2, sizeof(struct in6_addr)) == 0)

- Change the equality expression to one that uses the `memcmp` (memory comparison) function.

AF_INET Code	AF_INET6 Code
(addr1->s_addr == addr2->s_addr)	IN6_ARE_ADDR_EQUAL(addr1, addr2)

- Change the equality expression to one that uses the `IN6_ARE_ADDR_EQUAL` macro.

E.5.2. Comparing an IP Address to the Wildcard Address

If your application compares an IP address to the wildcard address, the `in6_addr` structure changes (see *Section E.3.1, "in_addr Structure"*) will change the comparison of int quantities to a comparison of structures. This will break the code and cause compiler errors.

Make either of the following changes to your application, as needed:

AF_INET Code	AF_INET6 Code
(addr->s_addr == INADDR_ANY)	IN6_IS_ADDR_UNSPECIFIED(addr)

- Change the equality expression to one that uses the `IN6_IS_ADDR_UNSPECIFIED` macro.

AF_INET Code	AF_INET6 Code
(addr->s_addr == INADDR_ANY)	(memcmp(addr, in6addr_any, sizeof(struct in6_addr)) == 0)

- Change the equality expression to one that uses the `memcmp` (memory comparison) function.

E.5.3. Using int Data Types to Hold IP Addresses

If your application uses `int` data types to hold IP addresses, the `in6_addr` structure changes (see *Section E.3.1, "in_addr Structure"*) will change the assignment. This will break the code and cause compiler errors.

Make the following changes to your application, as needed:

AF_INET Code	AF_INET6 Code
struct in_addr foo; int bar; . .	struct in6_addr foo; struct in6_addr bar; . .

AF_INET Code	AF_INET6 Code
. bar = foo.s_addr;	. bar = foo;

1. Change the data type for `bar` from `int` to a struct `in6_addr`.
2. Change the assignment statement for `bar` to remove the `s_addr` field reference.

E.5.4. Using Functions that Return IP Addresses

If your application uses functions that return IP addresses as `int` data types, the `in6_addr` structure changes (see *Section E.3.1, "in_addr Structure"*) will change the destination of the return value from an `int` to an array of `char`. This will break the code and cause compiler errors.

Make the following changes to your application, as needed:

AF_INET Code	AF_INET6 Code
struct in_addr *addr; addr->s_addr = foo(*xxx*);	struct in6_addr **addr*; foo(*xxx, addr*);

- Restructure the function to enable you to pass the address of the structure in the call. In addition, modify the function to write the return value into the structure pointed to by `addr`.

E.5.5. Changing Socket Options

If your application uses IPv4 IP-level socket options, change them to the corresponding IPv6 options.

E.6. Sample Client/Server Programs

This section contains sample client and server programs that demonstrate the differences between IPv4 and IPv6 coding conventions:

- *Section E.6.1, "Programs Using AF_INET Sockets"* contains sample programs using IPv4 AF_INET sockets.
- *Section E.6.2, "Programs Using AF_INET6 Sockets"* contains sample programs using IPv6 AF_INET6 sockets.

To build the examples, use the following commands:

```
$ CC/DEFINE=(_SOCKADDR_LEN)/INCLUDE=TCPIP$EXAMPLES: client.c
$ LINK client, TCPIP$LIBRARY:TCPIP$LIB/LIBRARY

$ CC/DEFINE=(_SOCKADDR_LEN)/INCLUDE=TCPIP$EXAMPLES: server.c
$ LINK server, TCPIP$LIBRARY:TCPIP$LIB/LIBRARY
```

E.6.1. Programs Using AF_INET Sockets

This section contains a client and a server program that use AF_INET sockets.

E.6.1.1. Client Program

The following is a sample client program that you can build, compile and run on your system. The program sends a request to and receives a response from the system specified on the command line.

```
#include <in.h>                     /* define internet related constants,
 */
                                    /* functions, and structures
 */
#include <inet.h>                   /* define network address info
 */

#include <netdb.h>                  /* define network database library info
 */

#include <socket.h>                 /* define BSD 4.x socket api
 */
#include <stdio.h>                  /* define standard i/o functions
 */
#include <stdlib.h>                 /* define standard library functions
 */
#include <string.h>                 /* define string handling functions
 */

#include <unixio.h>                 /* define unix i/o
 */

#define BUFSZ           1024        /* user input buffer size
 */
#define SERV_PORTNUM    12345       /* server port number
 */

int  main( void );                  /* client main
 */
void get_serv_addr( void * );❶     /* get server host address
 */

int
main( void )
{
    int sockfd;                      /* connection socket descriptor
 */

    char buf[512];                   /* client data buffer
 */

    struct sockaddr_in serv_addr;❷  /* server socket address structure
 */

    memset( &serv_addr, 0, sizeof(serv_addr) );❸
    serv_addr.sin_family = AF_INET;
    serv_addr.sin_port   = htons( SERV_PORTNUM );
    get_serv_addr( &serv_addr.sin_addr );❹

    if ( (sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )❺
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }
```

```
    printf( "Initiated connection to host: %s, port: %d\n",
          inet_ntoa(serv_addr.sin_addr), ntohs(serv_addr.sin_port)❻
          );

    if ( connect(sockfd,
                 (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )❼
        {
        perror( "Failed to connect to server" );
        exit( EXIT_FAILURE );
        }

    if ( recv(sockfd, buf, sizeof(buf), 0) < 0 )
        {
        perror( "Failed to read data from server connection" );
        exit( EXIT_FAILURE );
        }

    printf( "Data received: %s\n", buf );  /* output client's data buffer
 */

    if ( shutdown(sockfd, 2) < 0 )
        {
        perror( "Failed to shutdown server connection" );
        exit( EXIT_FAILURE );
        }

    if ( close(sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}

void
get_serv_addr( void *addrptr )❽
{
    char buf[BUFSZ];        /* input data buffer              */
    struct in_addr val;     /* remote host address structure  */
    struct hostent *host;   /* remote host hostent structure  */

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read User input\n" );
            exit( EXIT_FAILURE );
            }

        buf[strlen(buf)-1] = 0;

        val.s_addr = inet_addr( buf );

        if ( val.s_addr != INADDR_NONE )
            {
```

```
            memcpy( addrptr, &val, sizeof(struct in_addr) );
            break;
            }

        if ( (host = gethostbyname(buf)) )❾
            {
            memcpy( addrptr, host->h_addr, sizeof(struct in_addr) );
            break;
            }
        }
}
```

This example of a client applications sends a request and receives a response on an AF_INET socket.

❶ Function code prototype for server host address/name translation function.

❷ Declares `sockaddr_in` structure.

❸ Clears the server `sockaddr_in` structure and sets values for fields of the structure

❹ Calls `get_serv_addr` passing a pointer to the socket address structure's `sin_addr` field.

❺ Creates an AF_INET socket

❻ Calls `inet_ntoa` to convert the server address to a text string.

❼ Calls `connect` passing a pointer to the `sockaddr_in` structure.

❽ Retrieves the server host's address from the user and then stores it in the server's socket address structure. The user can specify a server host by using either an IPv4 address in dotted decimal notation or a host domain name

❾ Calls `gethostbyname()` to retrieve the server host's address.

E.6.1.2. Server Program

The following is a sample server program that you can build, compile, and run on your system. The program receives requests from and sends responses to client programs on other systems.

```
#include <in.h>                     /* define internet related constants,
 */
                                    /* functions, and structures
 */
#include <inet.h>                   /* define network address info
 */

#include <netdb.h>                  /* define network database library info
 */

#include <socket.h>                 /* define BSD 4.x socket api
 */
#include <stdio.h>                  /* define standard i/o functions
 */
#include <stdlib.h>                 /* define standard library functions
 */
#include <string.h>                 /* define string handling functions
 */
```

```
#include <unixio.h>                 /* define unix i/o
 */

#define SERV_BACKLOG    1           /* server backlog
 */
#define SERV_PORTNUM    12345       /* server port number
 */

int  main( void );                  /* server main
 */

int
main( void )
{
    int optval = 1;                 /* SO_REUSEADDR'S option value (on)
 */

    int conn_sockfd;                /* connection socket descriptor
 */
    int listen_sockfd;              /* listen socket descriptor
 */

    unsigned int client_addrlen;    /* returned length of client socket
 */
                                    /* address structure
 */
    struct sockaddr_in client_addr;❶ /* client socket address structure
 */
    struct sockaddr_in serv_addr;   /* server socket address structure
 */

    struct hostent *host;❷         /* host name structure
 */

    char buf[] = "Hello, world!";   /* server data buffer
 */

    memset( &client_addr, 0, sizeof(client_addr) );

    memset( &serv_addr, 0, sizeof(serv_addr) );❸
    serv_addr.sin_family      = AF_INET;
    serv_addr.sin_port        = htons( SERV_PORTNUM );
    serv_addr.sin_addr.s_addr = INADDR_ANY;

    if ( (listen_sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0 )❹
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    if ( setsockopt(listen_sockfd,
      SOL_SOCKET, SO_REUSEADDR, &optval, sizeof(optval)) < 0 )
        {
        perror( "Failed to set socket option" );
        exit( EXIT_FAILURE );
        }

    if ( bind(listen_sockfd,
```

```
   (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
    {
    perror( "Failed to bind socket" );
    exit( EXIT_FAILURE );
    }

if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
    {
    perror( "Failed to set socket passive" );
    exit( EXIT_FAILURE );
    }

printf( "Waiting for a client connection on port: %d\n",
        ntohs(serv_addr.sin_port)
    );

client_addrlen = sizeof(client_addr);

conn_sockfd = accept( listen_sockfd,
                      (struct sockaddr *) &client_addr,
                      &client_addrlen
                    );
if ( conn_sockfd < 0 )
    {
    perror( "Failed to accept client connection" );
    exit( EXIT_FAILURE );
    }

host = gethostbyaddr( (char *)&client_addr.sin_addr.s_addr,
                      sizeof(client_addr.sin_addr.s_addr), AF_INET ❺
                      );

if ( host == NULL )
    {
    perror( "Failed to translate client address\n" );
    exit( EXIT_FAILURE );
    }

printf( "Accepted connection from host: %s (%s), port: %d\n",
        host->h_name, inet_ntoa(client_addr.sin_addr),
        ntohs(client_addr.sin_port)
      );

if ( send(conn_sockfd, buf, sizeof(buf), 0) < 0 )
    {
    perror( "Failed to write data to client connection" );
    exit( EXIT_FAILURE );
    }

printf( "Data sent: %s\n", buf );    /* output server's data buffer  */

if ( shutdown(conn_sockfd, 2) < 0 )
    {
    perror( "Failed to shutdown client connection" );
    exit( EXIT_FAILURE );
    }

if ( close(conn_sockfd) < 0 )
```

```
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    if ( close(listen_sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

This example of a server application sends a request and receives a response on an AF_INET socket.

❶ Declares `sockaddr_in` structures.

❷ Declares `hostent` structure.

❸ Clears the server `sockaddr_in` structure and sets values for fields of the structure.

❹ Creates an AF_INET socket.

❺ Calls `gethostbyaddr()` to retrieve client name.

E.6.2. Programs Using AF_INET6 Sockets

This section contains a client and a server program that use AF_INET6 sockets.

E.6.2.1. Client Program

The following is a sample client program that you can build, compile, and run on your system. The program sends a request to and receives a response from the system specified on the command line.

```
#include <in.h>                         /* define internet related constants,
   */
                                        /* functions, and structures
   */
#include <inet.h>                       /* define network address info
   */

#include <netdb.h>                      /* define network database library
 info */

#include <socket.h>                     /* define BSD 4.x socket api
   */
#include <stdio.h>                      /* define standard i/o functions
   */
#include <stdlib.h>                     /* define standard library functions
   */
#include <string.h>                     /* define string handling functions
   */

#include <unixio.h>                     /* define unix i/o
   */
```

```
#define BUFSZ           1024          /* user input buffer size
   */
#define SERV_PORTNUM    "12345"       /* server port number string
   */


int main( void );                     /* client main
   */
void get_serv_addr( struct addrinfo *hints, struct addrinfo **res );❶
                                      /* get server host address
   */

int
main( void )
{
    int sockfd;                       /* connection socket descriptor
  */

    char buf[512];                    /* client data buffer
  */

    struct addrinfo hints;            /* input values to direct operation
  */
    struct addrinfo *res;❷           /* linked list of addrinfo structs
 */

    memset( &hints, 0, sizeof(hints) );❸
    hints.ai_family = AF_INET6;
    hints.ai_flags = AI_ADDRCONFIG | AI_V4MAPPED | AI_CANONNAME;
    hints.ai_protocol = IPPROTO_TCP;
    hints.ai_socktype = SOCK_STREAM;
    get_serv_addr( &hints, &res );❹

    if ( (sockfd = socket(AF_INET6, SOCK_STREAM, 0)) < 0 )❺
        {
        perror( "Failed to create socket" );
        exit( EXIT_FAILURE );
        }

    printf( "Initiated connection to host: %s, port: %d\n",
            res->ai_canonname,
            htons(((struct sockaddr_in6 *)res->ai_addr)->sin6_port)❻ );

    if ( connect(sockfd, res->ai_addr, res->ai_addrlen) < 0 )❼
        {
        perror( "Failed to connect to server" );
        exit( EXIT_FAILURE );
        }

    if ( recv(sockfd, buf, sizeof(buf), 0) < 0 )
        {
        perror( "Failed to read data from server connection" );
        exit( EXIT_FAILURE );
        }

    printf( "Data received: %s\n", buf ); /* output client's data buffer
 */
```

```
    if ( shutdown(sockfd, 2) < 0 )
        {
        perror( "Failed to shutdown server connection" );
        exit( EXIT_FAILURE );
        }

    if ( close(sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}

void
get_serv_addr( struct addrinfo *hints, struct addrinfo **res )❽
{
    int gai_error;                      /* return value of getaddrinfo()
 */
    char buf[BUFSZ];                    /* input data buffer
 */
    const char *port = SERV_PORTNUM;    /* server port number
 */

    while ( TRUE )
        {
        printf( "Enter remote host: " );

        if ( fgets(buf, sizeof(buf), stdin) == NULL )
            {
            printf( "Failed to read User input\n" );
            exit( EXIT_FAILURE );
            }

        buf[strlen(buf)-1] = 0;

        gai_error = getaddrinfo( buf, port, hints, res );❾
        if ( gai_error )
          printf( "Failed to resolve name or address: %s\n",
                  gai_strerror(gai_error)❿
                  );
 else
     break;
        }
}
```

This example of a client application sends a request and receives a response on an AF_INET6 socket.

❶ Function prototype for server host address/name translation function.

❷ Declares `addrinfo` structures.

❸ Clears the `addrinfo` structure and sets values for fields of the structure.

❹ Calls `get_serv_addr()` passing pointers to the input and output `addrinfo` structures.

❺ Creates an AF_INET6 socket.

❻ Uses values from the output `addrinfo` structure for host name and port.

❼ Calls `connect()` using values from the output `addrinfo` structure.

❽ Retrieves the server host's address from the user and stores it in the `addrinfo` structure. The user can specify a server host by using any of the following:

- An IPv4 address in dotted-decimal notation
- An IPv6 address in hexadecimal
- An IPv4-mapped IPv6 address in hexadecimal
- A host domain name

❾ Calls `getaddrinfo()` to retrieve the server host's name or address.

❿ Calls `gai_strerror()` to convert one of the EAI_*xxx* return values to a string describing the error.

E.6.2.2. Server Program

The following is a sample server program that you can build, compile, and run on your system. The program receives requests from and sends responses to client programs on other systems.

```
#include <in.h>                         /* define internet related constants,
                                        /* functions, and structures
   */
#include <inet.h>                       /* define network address info
   */

#include <netdb.h>                      /* define network database library
 info */

#include <socket.h>                     /* define BSD 4.x socket api
   */
#include <stdio.h>                      /* define standard i/o functions
   */
#include <stdlib.h>                     /* define standard library functions
   */
#include <string.h>                     /* define string handling functions
   */

#include <unixio.h>                     /* define unix i/o
   */

#define SERV_BACKLOG    1               /* server backlog
   */
#define SERV_PORTNUM    12345           /* server port number
   */

int  main( void );                      /* server main
   */

int
main( void )
{
```

```
  int optval = 1;                   /* SO_REUSEADDR'S option value (on)
 */

  int conn_sockfd;                  /* connection socket descriptor
 */
  int listen_sockfd;                /* listen socket descriptor
 */
  int gni_error;❶                  /* return status for getnameinfo()
*/

  unsigned int client_addrlen;      /* returned length of client socket
 */
                                    /* address structure
 */
  struct sockaddr_in6 client_addr;  /* client socket address structure
 */
  struct sockaddr_in6 serv_addr;❷  /* server socket address structure
*/

  char buf[] = "Hello, world!";     /* server data buffer
 */
  char node[NI_MAXHOST];❸          /* buffer to receive node name
*/
  char port[NI_MAXHOST];            /* buffer to receive port number
 */
  char addrbuf[INET6_ADDRSTRLEN];   /* buffer to receive host's address
 */

  memset( &client_addr, 0, sizeof(client_addr) );

  memset( &serv_addr, 0, sizeof(serv_addr) );❹
  serv_addr.sin6_family      = AF_INET6;
  serv_addr.sin6_port        = htons( SERV_PORTNUM );
  serv_addr.sin6_addr        = in6addr_any;

  if ( (listen_sockfd = socket(AF_INET6, SOCK_STREAM, 0)) < 0 )❺
      {
      perror( "Failed to create socket" );
      exit( EXIT_FAILURE );
      }

  if ( setsockopt(listen_sockfd,
       SOL_SOCKET, SO_REUSEADDR, &optval, sizeof(optval)) < 0 )
      {
      perror( "Failed to set socket option" );
      exit( EXIT_FAILURE );
      }

  if ( bind(listen_sockfd,
       (struct sockaddr *) &serv_addr, sizeof(serv_addr)) < 0 )
      {
      perror( "Failed to bind socket" );
      exit( EXIT_FAILURE );
      }

  if ( listen(listen_sockfd, SERV_BACKLOG) < 0 )
      {
      perror( "Failed to set socket passive" );
```

```
        exit( EXIT_FAILURE );
        }

    printf( "Waiting for a client connection on port: %d\n",
            ntohs(serv_addr.sin6_port)
          );

    client_addrlen = sizeof(client_addr);

    conn_sockfd = accept( listen_sockfd,
                          (struct sockaddr *) &client_addr,
                          &client_addrlen
                          );
    if ( conn_sockfd < 0 )
        {
        perror( "Failed to accept client connection" );
        exit( EXIT_FAILURE );
        }

    gni_error = getnameinfo( (struct sockaddr
*)&client_addr,client_addrlen, ❻
                             node, sizeof(node), NULL, 0, NI_NAMEREQD
                             );
    if ( gni_error )
        {
        printf( "Failed to translate client address: %s\n",
                gai_strerror(gni_error) ❼
              );
        exit( EXIT_FAILURE );
        }

    gni_error = getnameinfo( (struct sockaddr *)&client_addr,
client_addrlen,
                             addrbuf, sizeof(addrbuf), port, sizeof(port),
                             NI_NUMERICHOST | NI_NUMERICSERV ❽
                           );
    if ( gni_error )
        {
        printf( "Failed to translate client address and/or port: %s\n",
                gai_strerror(gni_error)
              );
exit( EXIT_FAILURE );
        }

    printf( "Accepted connection from host: %s (%s), port: %s\n",
            node, addrbuf, port
          );

    if ( send(conn_sockfd, buf, sizeof(buf), 0) < 0 )
        {
        perror( "Failed to write data to client connection" );
        exit( EXIT_FAILURE );
        }

    printf( "Data sent: %s\n", buf );    /* output server's data buffer
  */

    if ( shutdown(conn_sockfd, 2) < 0 )
```

```
        {
        perror( "Failed to shutdown client connection" );
        exit( EXIT_FAILURE );
        }

    if ( close(conn_sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    if ( close(listen_sockfd) < 0 )
        {
        perror( "Failed to close socket" );
        exit( EXIT_FAILURE );
        }

    exit( EXIT_SUCCESS );
}
```

This example of a server application sends a request and receives a response on an AF_INET6 socket.

❶ Declares variable for `getnameinfo()` return value

❷ Declares `sockaddr_in6` structures

❸ Declares buffers to receive client's name, port number, and address for calls to `getnameinfo()`.

❹ Clears the server `sockaddr_in6` structure and sets values for fields of the structure.

❺ Creates an AF_INET6 socket.

❻ Calls `getnameinfo()` to retrieve client name. This is for message displaying purposes only and is not necessary for proper functioning of the server.

❼ Calls `gai_strerror()` to convert one of the EAI_*xxx* return values to a string describing the error.

❽ Calls `getnameinfo()` to retrieve client address and port number. This is for message displaying purposes only and is not necessary for proper functioning of the server.

E.6.3. Sample Program Output

This section contains sample output from the preceding server and client programs. The server program makes and receives all requests on an AF_INET6 socket using `sockaddr_in6`. For requests received over IPv4, `sockaddr_in6` contains an IPv4-mapped IPv6 address.

1. The following example shows a client program running on node `hostb6` and sending a request to node `hosta6`. The program uses an AF_INET6 socket. The node `hosta6` has the IPv6 address 3ffe:1200::a00:2bff:fe97:7be0 in the Domain Name System (BIND/DNS).

   ```
   $ run client.exe
   Enter remote host: hosta6
   Initiated connection to host: hosta6.ipv6.corp.example, port: 12345
   Data received: Hello, world!
   $
   ```

2. On the server node, the following example shows the server program invocation and the request received from the client node `hostb6`:

```
$ run server.exe
Waiting for a client connection on port: 12345
Accepted connection from host: hostb6.ipv6.corp.example
(3ffe:1200::a00:2bff:fe97:7be0), port: 49174
Data sent: Hello, world!
$
```

3. The following example shows the client program running on node `hostb` and sending a request to node `hosta`. The program uses an AF_INET6 socket. The `hosta` node has only an IPv4 address in the DNS.

```
$ run client.exe
Enter remote host: hosta
Initiated connection to host: hosta.corp.example, port 12345
Data received: Hello, world!
$
```

4. On the server node, the following example shows the server program invocation and the request received from the client node `hostb`:

```
$ run server.exe
Waiting for a client connection on port: 12345
Accepted connection from host: hostb.corp.example (::ffff:10.10.10.251),
port: 49175
Data sent: Hello, world!
$
```

5. The following example shows the client program running on node `hostb6` and sending a request to node `hosta6` using its link-local address fe80::a00:2bff:fe97:7be0. The program uses an AF_INET6 socket.

```
$ run client.exe
Enter remote host: fe80::a00:2bff:fe97:7be0
Initiated connection to host: fe80::a00:2bff:fe97:7be0, port: 12345
Data received: Hello, world!
$
```

6. On the server node, the following example shows the server program invocation and the request received from the client node `hostb6`.

```
$ run server.exe
Waiting for a client connection on port: 12345
Accepted connection from host: hosta6.ipv6.corp.example%WE0
(fe80::a00:2bff:fe97:7be0%WE0), port: 49177
Data sent: Hello, world!
$
```