TCPware 6.1 Programmer’s Guide

September 2023

This document is a guide to the programming functions of TCPware.

Operating System/Version:	OpenVMS VAX V5.5-2 or later
	OpenVMS Alpha V6.2 or later
	OpenVMS Itanium V8.2 or later

Software Version: TCPware 6.1

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Preface

Introducing This Guide

This guide describes the TCPware services and libraries from the programmer's perspective. It is for network application programmers.

What You Need to Know Beforehand

Before using TCPware, you should be familiar with:

- Computer networks in general.
- HP’s OpenVMS operating system and file system.

How This Guide Is Organized

This guide has the following contents:

- PART I, *Introduction to Programming* - Introduces network programming and the TCPware programming functions.
- PART II, *UCX Compatibility Programming* - Describes TCPware's support for the BGDRIVER and VAXCRTL socket routines.
- PART III, *QIO Programming* - Describes the TCPDRIVER, UDPDRIVER, IPDRIVER, and INETDRIVER QIO programming interfaces.
- PART IV, *Programming Libraries* - Describes the FTP Library, Socket Library, and TELNET Library routines.
- PART V, *Application Programming Interfaces* - Describes the Simple Network Management Protocol (SNMP) extendible agent application programming interface (API) routines, and the Token Authentication API functions.
- PART VI, *ONC RPC Programming* - Describes the Remote Procedure Call (RPC) routines.

Online Help

You can use help at the DCL prompt to find the following:

- Topical help - Access TCPware help topics as follows:

  ```
  $ HELP TCPWARE [topic]
  ```

  The topic entry is optional. You can also enter topics and subtopics at the following prompt and its subprompts:

  ```
  TCPWARE Subtopic?
  ```

  Online help is also available from within certain TCPware components: FTP client and server, Network Control Utility (NETCU), TELNET client, NSLOOKUP, and TRACEROUTE. Use the `HELP` command from within each component:

  ```
  NETCU>HELP [topic]
  ```

- Error messages help - Access help for TCPware error messages as follows:

  ```
  $ HELP TCPWARE MESSAGES
  ```

  If the error message is included in the `MESSAGES` help, it identifies the TCPware component and provides a meaning and user action. See the `Instructions` under `MESSAGES`.

Obtaining Customer Support

You can use the following customer support services for information and help about TCPware and other Process Software products if you subscribe to our Product Support Services. (If you bought TCPware products through an authorized TCPware reseller, contact your reseller for technical support.) Contact Technical Support directly using the following methods:

Electronic Mail

E-mail relays your question to us quickly and allows us to respond as soon as we have information for you. Send e-mail to `support@process.com`. Be sure to include your:

- Name
- Telephone number
- Company name
- Process Software product name and version number

- Operating system name and version number
- Process Software support contract number

Describe the problem in as much detail as possible. You should receive an immediate automated response telling you that your call was logged.

Telephone

If calling within the continental United States or Canada, call Process Software Technical Support toll-free at (800) 394-8700. If calling from outside the continental United States or Canada, dial +1 (508) 628-5074. Please be ready to provide your name, company name, Process Software support contract number, and telephone number.

World Wide Web

There is a variety of useful technical information available on our World Wide Web home page, http://www.process.com/

License Information

TCPware for OpenVMS includes a software license that entitles you to install and use it on one machine. Please read and understand the *Software License Agreement* before installing the product. If you want to use TCPware on more than one machine, you need to purchase additional licenses. Contact Process Software or your distributor for details.

Maintenance Services

Process Software offers a variety of software maintenance and support services. Contact us or your distributor for details about these services.

Documentation Set

The documentation set for TCPware consists of the following:

- ***Installation & Configuration Guide*** - For system managers and those installing the software. The guide provides installation and configuration instructions for the TCPware products.

- ***Management Guide*** - For system managers. This guide contains information on functions not normally available to the general network end user. It also includes implementation notes and troubleshooting information.
- ***Network Control Utility (NETCU) Command Reference*** - For users and system managers. This reference covers all the commands available with the Network Control Utility (NETCU) and contains troubleshooting information.
- ***Programmer's Guide*** - For network application programmers. This guide gives application programmers information on the callable interfaces between TCPware and application programs.
- ***Release Notes*** for the current version of TCPware - For all users, system managers, and application programmers. The *Release Notes* are available online on your TCPware media and are accessible before or after software installation.
- ***User's Guide*** - For all users. This guide includes an introduction to TCPware products as well as a reference for the user functions arranged alphabetically by product, utility, or service.

Conventions Used

Convention	Meaning
host	Any computer system on the network. The local host is your computer. A remote host is any other computer.
`monospaced type`	System output or user input. User input is in **`reversed bold`** `type`. Example: `Is this configuration correct?` **`YES`** Monospaced type also indicates user input where the case of the entry should be preserved.
italic type	Variable value in commands and examples. For example, *username* indicates that you must substitute your actual username. Italic text also identifies documentation references.

[*directory*]	Directory name in an OpenVMS file specification. Include the brackets in the specification.
[*optional-text*]	(Italicized text and square brackets) Enclosed information is optional. Do not include the brackets when entering the information. Example: `START/IP` *`line address`* `[`*`info`*`]` This command indicates that the *`info`* parameter is optional.
{value | value}	Denotes that you should use only one of the given values. Do not include the braces or vertical bars when entering the value.
Note	Information that follows is particularly noteworthy.
Caution	Information that follows is critical in preventing a system interruption or security breach.
`key`	Press the specified key on your keyboard.
`Ctrl+key`	Press the control key and the other specified key simultaneously.
`Return`	Press the Return or Enter key on your keyboard.

1. Network Programming Overview

Introduction

This chapter introduces TCP/IP network programming. It describes TCP/IP programming generally and outlines areas where TCPware provides added functions or has specific requirements. This chapter includes sample client and server programs and describes the following:

- TCP/IP programming concepts
- Data representation and exchange
- Programming services options
- Network programming with sockets
- Multicasting
- Sample application programs

For details on TCP/IP network programming, see the list of reference texts in the *User's Guide* and the following books:

- Comer, Douglas E. & David L. Stevens [1993], Internetworking with TCP/IP, Volume III: Client-Server Programming and Applications (BSD Socket Version), Prentice-Hall
- Stevens, W. Richard [1990], UNIX Network Programming, Prentice-Hall

This chapter is designed for an audience of experienced programmers who need information specific to TCPware programming.

TCP/IP Programming Concepts

TCP/IP programming requires determining the following:

- Whether to use a connection-oriented (TCP) or connectionless (UDP) networking service
- Creating sockets
- Naming the communication endpoints (internet addresses and port numbers)

Connection-Oriented Services and TCP

Connection-oriented services and protocols support applications that send multiple messages between peer applications. These services and protocols require that applications establish a logical connection (*virtual circuit*) between them before they can exchange data. They provide data transfer that is reliable, ordered, full duplex, and flow controlled. They:

- Verify receipt of data.
- Compute checksums.
- Provide sequence numbers to ensure correct segment order.
- Retransmit lost segments.
- Inform users of dropped network connections. TCP is such a connection-oriented protocol, designed for applications that need reliable data delivery between similar and dissimilar systems. Examples of applications that use TCP are:
    - FTP
    - TELNET
    - SMTP

Since these services and protocols are more complex than connectionless services, they have higher overhead. In a connection-oriented service:

- The source and destination uniquely identify each connection.
- You can multiplex connections across the network to paired host processes.
- Data streams break into portions encapsulated with control information, such as addresses. Encapsulated pieces pass through the network to the peer host.

With TCP, the number of blocks and size (in number of bytes) of a send operation need not equal that of a receive operation. The protocol may bundle several sends into one receive: a receive operation can receive more or fewer bytes than in a single send operation.

For example, if you do five send operations, you may not need five receive operations to get all the data. If a client application sends five 10-byte blocks of data (five send operations) over the network and the server program initiates a 100-byte read operation, the program can receive all 50 bytes at one time.

TCP (unlike DECnet) does not support the concept of messages. TCP is a byte-stream protocol that does not distinguish record or read/write boundaries. The individual applications have to perform messaging as needed. The client and server have to agree on a message protocol and implement it. Here are three possible strategies:

Messages of fixed length	Data acquisition applications are examples of this type of strategy. When you use this strategy, make sure the application reads a complete message-length of data from the network. After the read, the application must go back and process

	any residual data left over from the last complete message. For example, if you issue a read for 100 bytes and do not get 100 bytes, you need to update the pointers and the length, and go back until you read the full 100 bytes.
Messages preceded by byte count length	Other protocols prefix each message with a byte count. This could be a 16- or 32-bit quantity. RPC is an example of an application protocol that uses this strategy. If you use this technique, use the conversion routines for native- and network-byte order described in the *Native Byte Order and Network Byte Order*. This guarantees that the client and server agree on the byte order sequences for that number.
Messages separated by a <CR><LF> sequence	FTP is an application that uses this type of messaging strategy. A program receiving data searches for <CR><LF> characters and processes the data preceding these characters as one record. If there is more data in the buffer, the program looks for the next <CR><LF> sequence and processes the data preceding it as a separate message.

Connectionless Services and UDP

Connectionless services present data with a destination address, and the network delivers it on a best-effort basis. This is independent of other data exchanged between the same pair of hosts. Connectionless services are unreliable but have lower overhead than connection-oriented services. In a connectionless service:

- The client or server must perform data tracking and adaptive retransmission strategies.
- Applications cannot depend on the underlying transport for reliable delivery.
- Each message or portion of a message contains all delivery data.
- Operation is best in LANs since WANs can introduce more errors.

UDP is a full-duplex, connectionless datagram delivery protocol with low overhead. UDP is an excellent choice for applications that need the highest performance and can tolerate this level of service. Examples of applications that use UDP are:

- NFS
- DNS
- SNMP

UDP can lose, delay, or duplicate requests, or deliver them out of order. The application requesting the service must detect and correct transmission errors. For example, an application may retransmit a request if it does not receive a reply. Applications typically do this by enabling a short timeout period and retransmitting the request if the application does not get a response within the timeout period.

Under UDP, a server could receive multiple requests since the reply might simply be lost. This case can cause problems if some operations are not repeatable. Use UDP on LANs where transmission errors are less frequent and round-trip times more predictable. UDP is also well-suited for broadcast and multicast applications, and applications that cannot tolerate the overhead of virtual circuits.

NFS often uses UDP. Here is an example of what could happen during an NFS file deletion request:

1. The client issues a delete request.
2. The server receives and processes the request.
3. The server deletes the file and returns a reply that it deleted the file.
4. The reply gets lost.
5. Not having received a confirmation, the client reissues the original delete request.
6. The server gets the request and replies that the file no longer exists.
7. The server's reply confuses the client.

Note that you might need to add application design features if some operations are not repeatable. Remote Procedure Calls (RPCs) that NFS uses handle this situation by keeping a cache of recent requests and replies. In this case, if NFS receives a duplicate request, it sends the cached reply that it successfully deleted the file.

For DNS and SNMP, these issues are not as severe. For example, DNS resolves host name and internet addresses. It does not matter how many times you reissue a request; the response is the same and you get the information you need.

Socket Concepts

Most TCP/IP programming uses a Berkeley System Distribution (BSD) UNIX abstraction called *sockets*. Network programs use sockets to exchange data across the network. Socket programming is synchronous: each socket deals with only one connection at a time.

Socket programming requires a socket descriptor that is analogous to the file descriptor used in file programming. In socket programming (as in file programming), you create the socket descriptor, use it to read or write, then destroy the descriptor by closing the connection. The operation of creating a socket descriptor involves naming the communication endpoints.

Naming Communication Endpoints

Naming communication endpoints involves assigning:

Internet addresses	Internet addresses uniquely identify the source and destination host interfaces. Any exchange of information involves two addresses, one for the source and one for the destination.
Port numbers	Port numbers uniquely identify a source and destination port. Like DECnet object numbers, port numbers identify the particular application or service used. The TCP protocol specifies sockets that have a protocol port number and an IP address. This protocol uses the AF_INET address family type. TCP/IP programming uses well-known port numbers to contact a known service. For example, to do a file transfer you need to open a connection to port 21. Port 21 is the FTP server port number. Other services have specific port numbers as defined by the current *Assigned Numbers* RFC. If you write an application, you need to assign a port number. Any client that wants to use the service you create connects to that port number.

The *Assigned Numbers* RFC also designates a clearinghouse for assigning port numbers. Get a unique port number from this center when you develop a network service. However, if you are developing a private application, you can create your own port number so long as another service does not use it.

Sockets define endpoint addresses in data structures coded in C. Most application programs use predefined address structures, such as `sockaddr_in`, as defined in the *BSD Socket Data Structures*.

Data Representation and Exchange

This section discusses concepts about how data is formatted and exchanged between systems: data encoding schemes and native as opposed to network byte order.

Data Encoding Schemes

Different hardware and operating system platforms represent data with different encoding schemes. For example, representing floating point and integer values differ on various hardware platforms.

Your programs must decide on a compatible encoding scheme and perform any required conversion between network format and local hardware representation format. Another approach is to exchange data in ASCII instead of binary representation.

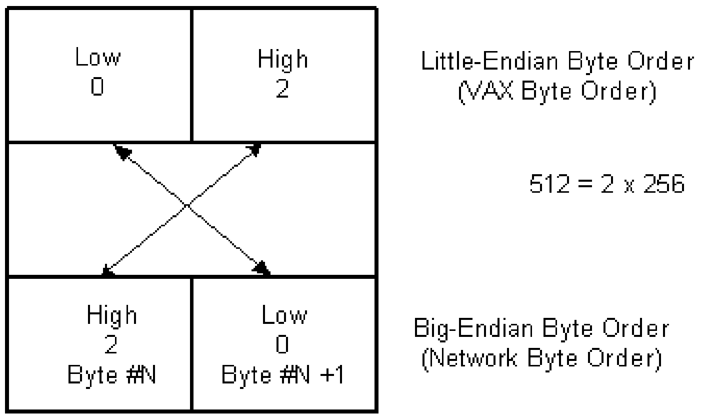
Native Byte Order and Network Byte Order

The sequence for storing binary data on a given machine is *native byte order*. The sequence for transmitting binary data over the network is *network byte order*.

Some machines are little-endian; others are big-endian. Little-endian machines (VAX systems, for example) store binary data with the least significant byte first.

Big-endian machines (Sun systems, for example) store and transmit binary data with the most significant byte first. Network byte order is always in the big-endian format. Socket libraries require network addresses in network byte order.

The below diagram shows the format for storing the decimal value 512 as a 16-bit (2 byte) quantity on little-endian and big-endian systems.



When communicating between a client and server, both need to agree to the byte sequence for transmitting data. Depending on what type of system you are on, the host's native byte order may not be the same as network byte order. For example, the byte order for VAX systems is little-endian, the opposite of network byte order.

Several routines convert between network and native byte order. Use these routines to make sure that the data is in the right format. Always use these conversion routines, even if the local host byte order is the same as network byte order. Doing so guarantees that the order of information is correct, and you can port the source code.

The function `htons` converts a short integer (16 bits) from host native to network byte order. The function `ntohs` converts a short integer from network to host native byte order. The `htonl` and `ntohl` functions convert long integers (32 bits) between the two.

For example, if you use a messaging strategy that uses a byte count length (as described in the "Messages preceded by byte count length" bulleted item), use these routines to encode the byte count length field. This way the order of information is correct, whether you are communicating between a VAX and Sun system or between two VAX systems.

Programming Services Options

This section describes the interface and services options you can use when writing TCP/IP networking applications. It includes information on the following:

- Device drivers
- VAX C and DEC C socket libraries and UCX Compatibility
- TCPware Socket Library routines
- System Queue Input/Output (QIO) interface calls
- FTP Library routines
- TELNET Library routines
- ONC RPC Services

Use the DEC C or VAX C socket libraries with C-based applications. Note that any high-level language that passes C-like arguments can call these routines.

Programming with sockets (rather than using the QIO interface discussed in the *System Queue Input/Output (QIO) Calls* subsection) makes network programs more portable across UNIX environments and more compatible with other socket-based TCP/IP applications. Sockets are easy to program since they look like standard subroutine calls and hide some of the complexity of the QIO interface system calls.

However, writing event-driven programs is much easier with the QIO interface than with sockets. This is true since sockets do not fit the standard OpenVMS event-driven IO model. The QIO interface provides access to the full range of TCPware functions; the socket library provides access to a subset of the available TCPware functions.

Device Drivers

TCPware uses the standard OpenVMS network interface device drivers that operate the hardware controller. These device drivers include DEC's Ethernet device drivers and third-party device drivers (PNDRIVER for Proteon's proNET controller; and NADRIVER, NBDRIVER, and NCDRIVER for the HYPERchannel driver).

Because TCPware uses these standard OpenVMS device drivers, other applications using these drivers (such as DECnet, but not other TCP/IP implementations) can continue to run at the same time and use the same hardware.

VAX C and DEC C Socket Library and UCX Compatibility Services

The VAX C and DEC C socket routines are the preferred methods of network programming in that they offer the greatest flexibility. These socket routines are available because of the TCPware UCX Compatibility Services.

See *VAX C Run Time Library Manual* or *DEC C Language Reference Manual* for information on these socket library routines.

The TCPware UCX Compatibility Services provides the QIO interface that the TCP/IP Services for OpenVMS BGDRIVER support. The UCX Compatibility Services provide support for:

- Any application the UCX BGDRIVER supports.
- VMS 5.5 (or later) VAX C Run-Time Library (VAXCRTL) Socket Routines.
- OpenVMS VAX, OpenVMS Alpha and OpenVMS I64 DEC C Run-Time Library (DEC/CRTL) Socket Routines.

If you developed an application for UCX, there is no need to modify it to make it work with TCPware. You can take your image (compiled and linked against UCX) and run it as is.

See the *TCP/IP Services for VMS Programming Manual* for programming information. Then see Chapter 2, *UCX Compatibility Services*, for programming information specific to TCPware's UCX compatibility.

System Queue Input/Output (QIO) Calls

Programmers can create applications that use the system Queue Input/Output calls (QIOs) for an interface. These calls use standard OpenVMS system services and support any high-level programming language. QIOs support all OpenVMS asynchronous features such as Asynchronous System Traps (ASTs) and event flags.

BGDRIVER, TCPDRIVER, UDPDRIVER, IPDRIVER, and INETDRIVER are TCPware's proprietary QIO programming interfaces, as discussed in the following subsections.

BGDRIVER

TCPware provides BGDRIVER . The BGDRIVER is the preferred programming interface.

See Chapter 2, *UCX Compatibility Services*.

TCPDRIVER, UDPDRIVER, and IPDRIVER

These drivers are proprietary to Process Software and are described as follows:

IPDRIVER implements IP and ICMP	It uses the network device drivers to send and receive datagrams. The Address Resolution Protocol (ARP) and Reverse ARP (RARP), which map internet addresses and physical addresses, are also implemented within this driver. Functions are provided to open and close a port and to transmit and receive datagrams. (See the *IPDRIVER Services* chapter for programming information.) IPDRIVER uses ports to demultiplex received datagrams. When an IP datagram is received, IPDRIVER validates the header and searches for a port opened on the protocol number in the datagram's internet header. IPDRIVER discards the datagram if no port is open for that protocol or if that port has no outstanding receive.
TCPDRIVER implements TCP	It uses the IP device driver to send and receive TCP segments. Functions are provided to open and close, receive and send data over, and perform special control functions on a connection. (See the *TCPDRIVER Services* chapter for programming information.)
UDPDRIVER implements UDP	It uses the IP device driver to send and receive UDP datagrams. Functions are provided to open and close a receive port, and to receive and send data. (See the *UDPDRIVER Services* chapter for programming information.)

INETDRIVER

TCPware provides INETDRIVER, the Stanford Research Institute (SRI) QIO interface. Some vendors of TCP/IP products (such as Process Software's MultiNet) use the SRI QIO interface as a direct socket type interface. The INET device driver maps UNIX socket calls to OpenVMS QIO requests. It supports stream (TCP) and datagram (UDP) services.

INETDRIVER Services provide an asynchronous I/O implementation of the UNIX socket calls within the OpenVMS $QIO and $QIOW system services. These system services allow Asynchronous System Trap (AST) routines and event flags to be associated with I/O requests. This allows for efficient socket operations.

The INETDRIVER interfaces directly with the TCP and UDP protocols in the transport layers. It does not replace the TCPDRIVER or UDPDRIVER services but provides another way to communicate with them.

See Chapter 6, *INETDRIVER Services*, for programming information.

FTP Library Routines

The FTP library routines provide a programming interface to the FTP protocol. Network programmers use the FTP library routines in applications to provide FTP capabilities.

See Chapter 7, *FTP Library*, for programming information.

TELNET Library Routines

The TELNET library routines provide a programming interface to the TELNET protocol. Network programmers use the TELNET library routines in applications to provide TELNET capabilities.

See Chapter 9, *TELNET Library*, for programming information.

ONC RPC Services

TCPware provides Open Network Computing (ONC) Remote Procedure Call (RPC) Services. ONC RPC Services are a set of software programming tools with which you can develop distributed applications. These tools implement the RPC and XDR (External Data Representation) protocols.

A distributed application executes different parts of its programs on different hosts in a network. Computers on the network share the processing workload, with each computer performing the tasks for which it is best equipped. For example, a distributed database application might consist of a central database running on a server and numerous client workstations. The workstations send requests to the server. The server carries out the requests and sends the results back to the workstations. The workstations use the results in other modules of the application.

Remote procedure calls (RPCs) allow programs to invoke procedures on remote hosts as if the procedures were local. ONC RPC Services hide the networking details from the application. This facilitates distributed processing because it relieves the application programmer from performing low-level network tasks such as establishing connections, addressing sockets, and converting data from one machine's format to another.

The XDR protocol provides a means for the local and remote host to agree on a way of representing data. XDR is a standard that resolves differences of data representation between different operating systems and hardware architectures.

ONC RPC Services consist of the following components:

- Shareable run-time libraries (RTLs)
- RPCGEN compiler
- Port Mapper
- RPCINFO command

The Port Mapper maps well-known RPC program numbers to UDP/TCP port numbers. The Port Mapper helps ONC RPC client programs connect to ports the ONC RPC server uses. A Port Mapper runs on each host that implements ONC RPC Services. The Port Mapper is part of TCPware's Network Control Process (NETCP).

> **Note:** You must use the TCPware Socket Library if you are using ONC RPC Services.

Network Programming with Sockets

This section provides a quick overview of socket programming. It includes information on the following:

- Using socket calls in network programming
- Socket system calls
- Messaging over stream (TCP) connections
- BSD socket data structures

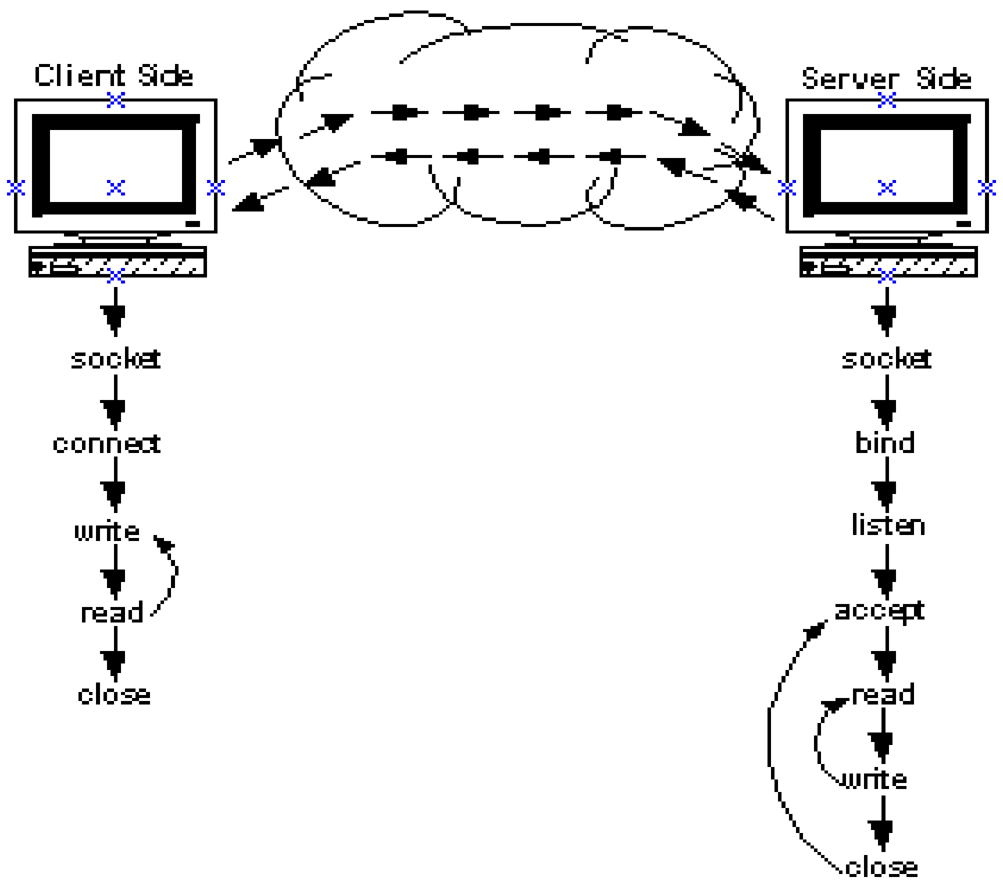
Using Socket Calls in Network Programming

The below diagram is an example of calls made by a client and server that use TCP to communicate. In this example, the server starts and waits for new connections on a well-known port. It accepts each new connection, processes the client's requests, and closes the connection.

In the example, the client creates a socket and uses `connect` to connect to the server. The client then uses `write` to send requests to the server and `read` to receive replies from the server. The client calls the `close` routine when it is finished using the connection.

The server uses a `socket` call to create a socket, then uses `bind` to specify the local well-known port for the application. Next, the server calls `listen` (which prepares the socket for incoming connections) and enters a loop. In the loop, the server calls the `accept` routine and waits for the next connection request to arrive. The server uses `read` and `write` to interact with and `close` to end communication with the client. The server then returns to `accept` and waits for the next connection request.

Servers typically use passive sockets to wait for incoming network connections. Applications (typically clients) use active sockets to initiate a connection.



Socket System Calls

When creating a socket, you create either a stream socket or a datagram socket. Stream sockets (created by specifying SOCK_STREAM) correspond to the TCP protocol. Datagram sockets (created by specifying SOCK_DGRAM) correspond to the UDP protocol.

SOCK_RAW corresponds to the IP layer directly. Note that SOCK_RAW is not described in this chapter because programming is not usually done at this level. Using TCP or UDP is far superior.

The IP layer only allows you to have 256 connections or users at the same time. TCP and UDP allow you to have about 2^{32} possible connections between any two hosts. A connection is uniquely identified by the source internet address and port number, and the destination internet address and port number.

Many operating systems provide the BSD socket call interface, including OpenVMS. Most non-socket implementations have comparable networking services. In OpenVMS, most implementations include a BSD socket library interface as well as a QIO interface. The QIO interface can be almost a one-to-one correspondence to the socket calls, and usually provides a greater range of functions than available through the socket library. While the QIO interface can be a bit different from the BSD interface, it still provides the same level of services. The below table describes typically-used socket calls.

Call	**Description**
`accept`	Accepts an incoming connection. `accept` actually blocks and waits for the connection to come in. Typically, in the case of a server, it sits in block mode until someone actually does a `connect`. Valid only for stream TCP/IP sockets.
`bind`	Used primarily by servers to name their local endpoint of the connection. Servers are contacted at well-known port numbers: they "bind" to that port number. In a bind operation, you specify the internet address as well as the port number. Most servers specify the internet address as zero (or INADDR_ANY). The servers do not want to bind to any particular internet address, just to a particular port. If a host has multiple internet addresses, it does not matter where the request comes from so long as it goes to the specified port.
`close`	Closes communication over a socket. `close` is similar to closing a file. `close` makes sure that the data has been sent over to the peer and then does the actual close operation. For the Socket Library, `close` is called `socket_close`.
`connect`	Names the remote endpoint and, in the case of TCP, establishes a connection. When you specify `connect`, you also specify an internet address and port number. This

	connects you actively to the remote peer, provided someone there is willing to accept the connection. For example, when an FTP client issues an open, it does a connect operation on the specified internet address and port 21. This establishes the connection to the remote server.
`getpeername` `getsockname`	Obtain the names of the communication endpoints. These calls return the internet address and port number of either the local end of the connection or the remote end of the connection. The local end of the connection is the port number and internet address on which you have done a bind operation. The remote endpoint is the system to which you connected or that connected to you.
`getsockopt` `setsockopt`	Obtain or set socket options. For example, you can set one option that determines if KEEPALIVE operations are done on TCP connections.
`listen`	Used by servers and prepares the socket for incoming connections. `listen` declares that the server is willing to accept connections on this socket. Any connection going to that bound port is eligible to be processed by that process.

`read`
`recv`
`recvfrom`
	`read`, `recv`, and `recvfrom` are different forms of the same request. Use these calls to read data. `recvfrom` is primarily used by UDP and returns the internet address and port number of the sender of the datagram. Typically, you use this information to send back a reply in a subsequent `sendto`.
	
	For the Socket Library, read is called `socket_read` and `recv` is called `socket_recv`.

`select`	Performs asynchronous I/Os. The `select` call allows you to service many connections from within a particular process. There is also a timeout parameter with the `select` call that limits the amount of time you can wait before it comes back to you. In this way, `select` allows you to wait indefinitely, wait until timeout, or poll on a specific socket or set of sockets.

`socket`	Comparable to opening or creating a file. Creates a socket to which you can send I/O requests.

`write`
`send`
`sendto`
	`write, send`, and `sendto` are different forms of the same request. Use these calls to send data out over the network. `sendto` is used primarily by UDP and allows you to specify the destination internet address and the port number. When using UDP, the `sendto` request allows you to send requests to any number of hosts.
	
	For the TCPware Socket Library, `write` is called `socket_write` and `send` is called `socket_send`.

BSD Socket Data Structures

The BSD sockets support a group of data structures and subroutines for the socket interface that typically are used to communicate with the socket layer. These include the `sockaddr_in` structure, `hostent` structure, and `servent` structure. The following include files are used:

Include Files	**Description**
`in.h`	defines the `sockaddr_in` structure. Almost all socket operations require use of this file.
`inet.h`	defines address conversion subroutines, such as `inet_addr()`, `inet_ntoa()`, and so on.
`netdb.h`	defines network database structures including the `hostent` and `servent` structures.
`socket.h`	defines the `sockaddr` structure, SOCK_STREAM, SOCK_DGRAM, AF_INET, and other symbols used when calling the Socket Library subroutines. All socket operations require use of this file.

See Chapter 8, *Socket Library*, for details on the files and the following sections.

`sockaddr_in` Structure

One of the more important socket data structures is the `sockaddr_in` structure. Use the `sockaddr_in` structure in calls to name a communication endpoint. The `sockaddr_in` structure communicates the internet address in the `sin_addr` field. It also communicates the port number in the `sin_port` field.

The `in.h` include file defines the `sockaddr_in` structure as shown in the below example. In this example:

1. `sin_family` is the address family (AF_INET for example)
2. `sin_port` is the port number (in network byte order)
3. `sin_addr` is the internet address (in network byte order)
4. `sin_zero` is the internet address where the remainder of the eight bytes are unused and should be set to zero

Specify both the port and address in network byte order. For example, when doing a bind operation or a connect operation, specify the `sockaddr_in` structure with the information filled in. When using `getsockname` or `getpeername`, you provide the address of the structure and the subroutine then would fill it in for you.

```
struct  in_addr  {
      unsigned long              addr;
};

struct  sockaddr_in     {
      short                      sin_family;
      unsigned short             sin_port;
      struct in_addr             sin_addr;
      char                       sin_zero[8];
};
```

`hostent` Structure

The `gethostbyname` and `gethostbyaddr` routines use the `hostent` structure for doing host by name or host by internet address lookups. For example, if you want to do an

```
FTP> open hostname
```

the underlying socket interface does not support use of a host name. In this case, use the `gethostbyname` routine to take that name and return the corresponding internet address (among other information).

The `netdb.h` include file defines the `hostent` structure as shown below.

```
struct hostent {
char       *h_name;                 /* official host name */
char       **h_aliases;             /* alias list */
int        h_addrtype;              /* host address type */
int        h_length;                /* address length */
char       **h_addr_list;           /* list of addresses */
#define  h_addr  h_addr_list[0];    /* first address */
};
```

The `hostent` structure has:

- A host name field that points to the ASCII host name.
- A pointer to a list of alias names if the host has alias names.
- A pointer to a list of internet addresses. In a more complex environment, a host might have multiple internet addresses.
- Other information, such as the address format and address family. For TCP/IP, the address is four bytes long and the address family is AF_INET (decimal value of 2).

`servent` Structure

The `servent` structure is used when looking up services by name or port. Although you can hard-code the name or port (such as port 21), you can use the following routines to obtain the service name and port:

`getservbyname`	to obtain the service port when given its name
`getservbyport`	to obtain the service name when given its port number

Use these routines to obtain port numbers and service names. Doing so makes changing port numbers easy; you simply edit the services definition file, `TCPWARE:SERVICES.`

The `netdb.h` include file defines the `servent` structure as shown below.

```
struct servent  {
char      *s_name;         /* official service */
char      **s_aliases;     /* alias list */
int       s_port;          /* port number */
char      *s_proto;        /* protocol to use */
};
```

Multicasting

Multicasting, as specified in RFC 1112, *Host Extensions for IP Multicasting*, is the transmission of an IP datagram to a multicast host group. A multicast host group is a set of zero or more hosts identified by a single class D IP destination address. Using a multicast host group allows applications running on your host to receive multicast IP datagrams destined for that host group.

TCPware implements the highest level of conformance specified in RFC 1112 – level 2 "full support for multicasting."

The following TCPware programming interfaces support IP multicasting for network interfaces that support multicasting (such as Ethernet, FDDI, and Token Ring):

- UDPDRIVER
- IPDRIVER
- BGDRIVER (SOCK_DGRAM sockets)
- INETDRIVER (SOCK_DGRAM sockets)
- Socket Library

Sending IP Multicast Datagrams

To send a multicast datagram, specify an IP multicast address in the range 224.0.0.0 to 239.255.255.255 as the destination address in a send request. This range covers the class D IP addresses that identify multicast host groups. Note that 224.0.0.0 is unassigned and 224.0.0.1 is assigned to the permanent group of all IP hosts, including gateways, used to address all multicast hosts on the directly connected network.

Each multicast transmission is sent from a single network interface, even if the host has more than one multicast-capable interface. The system manager establishes the default interface to use for multicasting by defining the appropriate routes. If no route is defined for the multicast address, TCPware uses the default gateway's interface. If you do not specify a default gateway, TCPware uses the first available interface. An application can issue a request to explicitly set the interface to use for subsequently transmitted multicast datagrams.

When you send a multicast datagram, TCPware by default delivers a local copy of it if the multicast address is joined by one or more receivers. An application can issue a request to disable the local loopback of multicast datagrams.

TCPware sends IP multicast datagrams with a time-to-live (TTL) of 1 by default, which prevents them from being forwarded beyond a single subnetwork. An application can issue a request to specify the TTL for subsequent multicast datagrams to be set to any value from 0 to 255, in order to control the scope of the multicasts.

Receiving IP Multicast Datagrams

Before an application can receive IP multicast datagrams, it must become a member of one or more IP multicast groups. The system manager can explicitly have the host join multicast groups by issuing the `NETCU ADD MULTICAST` command (and the `NETCU REMOVE MULTICAST` command to leave a group). Or, an application can ask the host to join (or leave) a multicast group by issuing a request.

See *Multicasting Commands* in the *NETCU Command Reference* for the multicasting commands.

The memberships requested by an application do not necessarily determine which datagrams that application receives. The IP layer accepts incoming multicast datagrams if anyone claimed a membership in the destination group of the datagram. However, delivery of a multicast datagram to a particular application is based on the destination port (for UDP) or protocol type, just as with unicast and broadcast datagrams. To receive multicast datagrams sent to a particular port/protocol, you must bind to that local port, leaving the local address unspecified.

Every membership is associated with a single interface, and it is possible to join the same group on more than one interface. If you do not specify a local interface's address when joining a group, TCPware uses the default multicast interface. At present, you can have a maximum of 32 memberships per socket. TCPware drops the memberships an application adds when you close the socket or port or the application exits. However, more than one socket or port can claim membership in a particular group, and the host remains a member of that group until the last claim is dropped.

Writing Application Programs

This section includes information on the following:

- Writing a stream client
- Writing a stream server
- Writing a datagram client
- Writing a datagram server
- Writing servers

Writing a Stream Client

When writing a stream client, use the following sequence, with socket library (and system QIO equivalent) routines given:

1. Create a socket by calling the `socket` routine and requesting a `SOCK_STREAM` socket (SYS$ASSGN).

2. Open the connection to the server by calling the `connect` routine (IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP).

   You need to specify a `sockaddr_in` structure with the destination internet address and destination port number filled in where the:

   Internet address is the address of the server and can be obtained by calling `gethostbyname` or `inet_addr` (`inet_addr` converts an ASCII dotted internet address to binary representation).

   Port number is the well-known port for the server and can be obtained by calling `getservbyname`.

3. Send and receive data as needed by calling the standard `send/recv` and `read/write` routines (IO$_WRITEVBLK or IO$_READVBLK). When you use `send/recv`, you can specify flag options, some of which allow you to:
   - Send urgent data, or
   - Peek at incoming data at the head of the queue to determine what to do before the data is actually read.
4. Close the connection by calling the `close` routine (IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN and then SYS$DASSGN).

The programs in the below table that demonstrate stream client applications are included in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES]` directory.

Program	**Description**
`DAYTIMED.C`	DAYTIME client that uses the TCPware Socket Library
`DISCARD.C`	DISCARD client that uses the INETDRIVER
`FINGER.C`	FINGER client that uses the TCPDRIVER
`TCPSAMPLE.FOR`	DISCARD FORTRAN client that uses the TCPDRIVER
`WHOIS.C`	WHOIS client that use the TCPware Socket Library

Writing a Stream Server

When writing a stream server, use the following sequence, with socket library (and system QIO equivalent) routines given:

1. Create a socket by calling the `socket` routine and requesting a `SOCK_STREAM` socket (SYS$ASSGN).
2. Bind the socket to the well-known port for the service by calling the `bind` routine (IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP). Specify zero for the internet address. Use the `getservbyname` routine to determine the required port.
3. Set the socket to accept incoming connections by calling the `listen` routine, which has two parameters: the socket that you want to listen on, and a backlog parameter, a value that indicates how many connections you can have at a given time (the range is 1 to 5).

   For example, if you have a single-threaded server that processes connections serially, the server listens, accepts a connection, and processes that connection. Meanwhile other connections can come in on the well-known port. In this case, the connection is established and placed in a queue waiting to be accepted. However, you can do nothing with the connection until you perform the next step.

4. Wait for a connection (call `accept`), where:
   - `accept` returns a new socket for the connection (you do the I/O on this socket).
   - The original socket is still listening for more connections.
5. Receive and send data as needed to provide the service by calling `read` or `write` and `send` or `recv` (IO$_READVBLK or IO$_WRITEVBLK).
6. Close the connection socket by calling the `close` routine (IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN).
7. Go to step 4.

The programs in the below table that demonstrate stream server applications are included in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES]` directory.

Program	**Description**
`DISCARDD.C`	DISCARD server that uses the TCPDRIVER or Socket Library
`FINGERD.C`	FINGER server that uses the TCPDRIVER
`TCPSAMPLE.FOR`	DISCARD FORTRAN server that uses the TCPDRIVER

Writing a Datagram Client

Writing a datagram client consists of the same type of operations as writing a stream client. Use the following sequence, with socket library (and system QIO equivalent) routines given:

1. Create a socket by calling the `socket` routine and requesting a `SOCK_DGRAM` socket (SYS$ASSGN).
2. (Optionally) issue a `connect` call if you are only going to exchange information with a particular remote peer (IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP).

   In this case, when you issue a `connect` call, the process reserves internal socket fields that identify the internet address and port number to which the data is to go. This means you can send data using standard `write` and `send` calls instead of having to use the `sendto` call to specify the destination. Note that:

   - `connect` names the communication endpoint. There is no need to specify it with each send.
   - No connection is opened with UDP.
3. Send a request datagram calling the `sendto` or `send` routines (use `send` only if connected). (IO$_WRITEVBLK.)

   If you did not issue a `connect` call, you need to issue a `sendto` call that specifies the buffer you want to send and where to send the buffer.

4. Start a timer. For example, the program might give the server five seconds to respond. If there is no response within that time, the program reissues the request.

   The program could also indicate to the user that there is a problem if, for example, the server does not respond after five attempts to reach the server.

5. Receive a reply datagram using the call `recvfrom` (or `recv` if connected). Cancel the timer if the proper reply was received; otherwise reissue the `recvfrom` or `recv`. (IO$_READVBLK.)
6. If the application needs to request more data, go to step 3.
7. Close the socket by calling the `close` routine (IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN and then SYS$DASSGN).

The programs in the below table that demonstrate datagram client applications are included in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES]` directory.

Program	**Description**
`UDPSAMPLE.FOR`	DISCARD FORTRAN client that uses the UDPDRIVER

Writing a Datagram Server

Writing a datagram server consists of the same type of operations as writing a stream server, with socket library (and system QIO equivalent) routines given:

1. Create a socket by calling the `socket` routine and requesting a `SOCK_DGRAM` socket (SYS$ASSGN).
2. Bind the socket to the well-known port for the service by calling the `bind` routine (IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP). This call says the socket is willing to accept datagrams sent to this particular port.
3. Wait for a request to arrive using the call `recvfrom` (IO$_READVBLK). In this call you specify the buffer, the length of the buffer, and the `sockaddr_in` structure that will be filled in with the information about who sent you that datagram.
4. Decode and service the request.
5. Send the reply using the call `sendto` (IO$_WRITEVBLK.).
6. Go to step 3.

The programs in the below table that demonstrate datagram server applications are included in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES]` directory.

Program	**Description**
`BG_UDP_SERVER.C`	DISCARD server that uses the BGDRIVER
`UDPDRIVER.C`	DISCARD server that uses the UDPDRIVER
`UDPSAMPLE.FOR`	DISCARD FORTRAN server that uses the UDPDRIVER
`UDP_SOCK_SERVER.C`	DISCARD server that uses the HP Socket Library

Writing Servers

Servers that need to service several connections at once are complex. They require use of multiplexing services because they must not block waiting for any one connection. Use:

- BSD `select` operation (if using a socket library interface)
- ASTs or EFNs for SYS$QIO (if using a QIO interface)

Such servers also typically require a context block per connection. This block includes the socket or channel number and other information about the state which that connection is in and any information processing that connection requires.

You can also use a master server (such as NETCP in TCPware or `inetd` in UNIX) if you are writing a server. Initiating the server with the master server allows you to:

- Avoid a separate listening process for each service.

  For example, you might have several different servers, for each of which you would need a unique detached process. A master server avoids doing this because there is one process that listens for any of these ports. Once a connection comes in on one of these ports, the server creates a process to service that connection. The master server process does the listen and then the accept. When the accept has completed, it creates a detached process and that detached process services that connection. In the meantime, the master server has gone back to waiting for another connection to come in.

- Simplify support for multiple connections. This means you do not need to write multithreaded servers.

  When you use the master server process, you add server information to its database as to:

  - Whether the application uses TCP or UDP.
  - The well-known port number or port name to listen on.
  - Information about the process that needs to be created (for example where the image is located, what privileges it must run with, and so on).

The server is started automatically when a connection is established or a datagram is sent to the well-known port. The server's input, output, and error files are assigned to the socket (or, in VMS, the device name). This simplifies the server because it does not need to do `socket`, `bind`, `listen`, and `accept` operations since these have been done by the master server. All the server does is service the one connection and events occurring on it.

For details on using the TCPware master server, see Appendix A, *TCPware Socket Library*, of this guide, and the `ADD SERVICE` command in the *NETCU Command Reference*.

2. UCX Compatibility Services

Introduction

This chapter describes the UCX Compatibility Services.

The UCX Compatibility Services provide the following functions:

- BGDRIVER, the front-end QIO interface to TCPware that provides support for TCP/IP Services for OpenVMS (formerly UCX) QIO functions.
- TCPware's master server supports BG devices (which are marked record-oriented). These extensions should allow UCX servers activated by the UCX master server to run under TCPware.

  See the `ADD SERVICE` command in the *NETCU Command Reference* for details on setting services in TCPware.

- Support for the VAX C Run-Time Library (VAXCRTL) Socket Routines as described in the *VAX C Run-Time Library Reference Manual*.
- Support for OpenVMS Alpha and IA64 DEC C Runtime Library (DECCRTL) Socket Routines.

For documentation on the HP TCP/IP Services for OpenVMS, see the Bookreader help in the Telecommunications and Networking library, the TCP/IP Services for OpenVMS VAX collection, and the TCP/IP for OpenVMS Services for OpenVMS System Services and C Socket Programming book. This includes sections on writing Internet applications, using the OpenVMS System Services (including QIO calls) and DEC C Socket Routines (including a reference), and on-line programming examples.

Also see the *TCP/IP Services for VMS Programming Manual* for details on the BGDRIVER $QIO interface.

Note: The UCX Compatibility Services are intended to be 100% compatible with HPE's BGDRIVER.

If you discover that our BGDRIVER is not 100% compatible with the UCX BGDRIVER $QIO interface, please send us a sample program demonstrating the incompatibility.

The following files are included as part of the UCX QIO compatibility support in the directory `TCPWARE_COMMON:[TCPWARE]`:

`BGDRIVER.EXE`	device driver that emulates the QIO functions.
`UCX$INETDEF.H`	VAX C header file containing the UCX INET functions.
`UCX$IPC.OLB`	transfer vectors used to resolve the socket routine references to the VAX C/DEC C Run-Time Library.
`UCX$IPC_SHR.EXE`	Run-Time library used by VAXCRTL/DECCTRL to support the VAX C/DEC C Socket Routines.

If you have an application that was compiled and linked against UCX, you should be able to run that image on TCPware with no modifications (you do not need to re-link against TCPware).

Note: If you make changes to that application and want to compile and link against TCPware, follow the instructions under the *Sample Programs* section. The resulting image should run on TCPware or UCX systems.

Multicasting

UCX Compatibility Services includes the following `setsockopt` and `getsockopt` options at the `UCX$C_IPOPT` level for multicasting support:

UCX$C_IP_ADD_MEMBERSHIP and UCX$C_IP_DROP_MEMBERSHIP	The setsockopt operation adds and drops a multicast membership. The following structure is specified:
	
	`struct IPMREQDEF`
	`{`
	`  /* Multicast group address */`
	`  unsigned long int IMR$L_MULTIADDR;`
	`  /* Local interface address */`
	`  unsigned long int IMR$L_INTERFACE;`
	`};`
	
	• IMR$L_MULTIADDR contains the multicast internet address to be added or dropped and
	• IMR$L_INTERFACE contains the local interface's internet address on which the multicast address is added or dropped.
	
	If IMR$L_INTERFACE is specified as INADDR_ANY (0), the default multicast interface is used.

UCX$C_IP_MULTICAST_IF	The setsockopt operation sets the interface for subsequent multicast datagrams. The longword option value specifies the local internet address of the interface to be used. A getsockopt operation of this option returns the currently set interface (or 0 if none was set).
UCX$C_IP_MULTICAST_LOOP	The setsockopt operation enables or disables the local loopback of multicast datagrams. By default, this option is enabled. Specify a byte value of 1 to enable, 0 to disable. A getsockopt operation of this option returns the current multicast loopback setting.
UCX$C_IP_MULTICAST_TTL	The setsockopt operation sets the time-to-live (TTL) value for multicast datagrams. By default, this value is 1. A getsockopt operation of this option returns the current multicast TTL.

Logicals

TCPware defines the following logicals for UCX compatibility:

`UCX$DEVICE` `TCPIP$DEVICE`	defined as `BG:`, which is the name of the UCX device drive.
`UCX$INET_HOST` `TCPIP$INET_HOST`	defined to be the host name, which is the same setting as TCPWARE_DOMAINNAME logical.
`UCX$IPC_SHR` `TCPIP$IPC_SHR`	provides the linkage to the TCPware version of the UCX$IPC_SHR Run-Time library.

Note: The VAX C/DEC C Socket Routines `getnetbyname` and `getnetbyaddr` are supported and read the `TCPWARE:NETWORKS.` file.

IOCTL commands that set interface characteristics are not supported. Sensing of interfaces (`SIOCGIFCONF`, SIOCGIFADDR, `SIOCGIFBRDADDR`, `SIOCGIFDSTADDR`, `SIOCGIFFLAGS`, and `SIOCGIFNETMASK`) is supported.

Sample Programs

The following sample programs using UNIX-like sockets are included in the `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory:

- `BGDRIVER_TCP_CLIENT.C`
- `BGDRIVER_UDP_CLIENT.C`
- `BGDRIVER_TCP_SERVER.C`
- `BGDRIVER_UDP_SERVER.C`

The `BGDRIVER_TCP_CLIENT.C` and `BGDRIVER_TCP_SERVER.C` pair of programs provides a self-declared ECHO server that sequentially accepts client connections and echoes back the client messages. The BGDRIVER_UDP_CLIENT.C and BGDRIVER_UDP_SERVER.C pair of programs provide a self-declared DISCARD server that can receive (and discard) datagrams from multiple clients. These programs are functionally equivalent to the socket programs in Chapter 8, *Socket Library*.

To build any one of these applications using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL/DEFINE=TCPWARE filename
$ LINK filename
```

To build any one of these applications using VAX C, enter:

```
$ CC/VAXC/DEFINE=TCPWARE filename
$ LINK filename, TCPWARE:UCX$IPC/LIB, SYS$INPUT/OPTIONS -
_$   SYS$SHARE:VAXCRTL/SHARE
```

You can build these programs on both TCPware and UCX systems. The /DEFINE=TCPWARE uses code to point to a TCPware include directory for building on a TCPware system.

Debugging and Tracing

TCPware provides a call tracing facility that can be used to debug and trace the use of the sockets API for many applications. This facility works for both the TCPware socket library and the API that the newer versions of the C compiler work with. This does *NOT* log QIO operations. To enable the tracing define the TCPWARE_SOCKET_TRACE logical name. The value of the logical name can be used in the following ways:

- As a bit mask for types of operations to trace. Bit 0 (zero) signifies control operations, bit 1 signifies read operations and bit 2 signifies write operations. When these values are used the information is written to SYS$OUTPUT:.
- As a partial or full file name. When used as a partial file name the default name specified to open the file is: SYS$SCRATCH:TCPWARE_SOCKET_*process_name*.LOG. Control, read and write operations are logged when logging is done to a file.

3. TCPDRIVER Services

Introduction

This chapter describes the Transmission Control Protocol (TCP) device driver (TCPDRIVER) services. It describes the user interface of this implementation of TCP only. RFC 793 contains the full TCP specifications. There are no implementation-specific restrictions for the Transmission Control Protocol (TCP). The material presented here does not explain or describe the TCP protocol.

TCP is a connection-oriented, end-to-end reliable protocol. It provides reliable communication between pairs of processes in computers attached to interconnected networks. TCP services are available through the OpenVMS Queue I/O (`SYS$QIO` and `SYS$QIOW`) system services, which:

- Open and close a connection.
- Send and receive data over the connection.
- Perform status checks on the connection.

`SYS$QIOW` is the synchronous and `SYS$QIO` the asynchronous form of VMS system services. Use each form depending on the requirements of your application.

See the appropriate OpenVMS documentation for more information on the OpenVMS I/O system services and related services, such as the asynchronous system trap (AST) and event flag services.

> **Note:** The QIO calls described in this chapter are used for direct access to the TCPDRIVER. If you are porting an application that uses the BGDRIVER or INETDRIVER QIO interface, you may not need to make modifications. Use TCPware's BGDRIVER (see Chapter 2) or INETDRIVER (see Chapter 6).

Sequence of Operations

The sequence of operations to open a connection are as follows:

1. Assign an I/O channel to `TCP0:` with the Assign I/O Channel (`SYS$ASSIGN`) system service. `SYS$ASSIGN` creates a new device unit and assigns to it the channel.
2. Open the connection with the `IO$_SETMODE` | `IO$M_CTRL` | `IO$M_STARTUP` function of one of the Queue I/O (`SYS$QIO` or `SYS$QIOW`) system services.
3. Perform read requests with the `IO$_READVBLK` function and write requests using the `IO$_WRITEVBLK` function as desired.
4. Close your end of the connection with the `IO$_SETMODE` | `IO$M_CTRL` | `IOM$_SHUTDOWN` function.
5. Perform additional read requests until the peer returns `SS$_VCCLOSED` status.
6. Deassign the I/O channel using the Deassign I/O Channel (`SYS$DASSGN`) system service.

Other Operations

In addition to the sequence of operations described in the preceding section, TCPDRIVER includes other operations that:

Place a connection into listen state and specify the maximum number of incoming connections that can be queued waiting to be accepted, then wait for and accept an incoming connection	`IO$_CREATE`
Read data immediately	`IO$_READVBLK \| IO$M_NOW`
Read the received data without removing it from the received data queue	`IO$_READVBLK \| IO$M_DATACHECK`
Read only completely filled data buffers	`IO$READVBLK \| IO$M_PACKED`
Send data stored in a list of buffers	`IO$_WRITEVBLK \| IO$M_EXTEND`
Read the active connections status	`IO$_SENSEMODE`
Read the connection characteristics for the channel	`IO$_SENSEMODE \| IO$M_CTRL`
Read the TCP counters	`IO$_SENSEMODE \| IO$M_RD_COUNT`
Set the connection characteristics	`IO$_SETMODE \| IO$M_CTRL`

Request delivery of an attention AST	`IO$_SETMODE \| IO$M_ATTNAST`
Abort a connection	`IO$_SETMODE \| IO$M_CTRL | IO$M_SHUTDOWN \| IO$M_ABORT`
Cancel any pending I/O requests	`SYS$CANCEL`

TCPDRIVER System Service Call Format

The format for the TCPDRIVER `SYS$QIO` system service call is as follows:

```
status = SYS$QIO(u_long efn, u_int chan, u_int func, unsinged quadword
*iosb, void *astadr, u_long astprm, p1, p2, p3, p4, p5, p6)
```

The `SYS$QIO` or `SYS$QIOW` system calls issue TCP functions. `SYS$QIO` is for asynchronous service completion. It specifies that the service return to the caller immediately after queuing the I/O request. `SYS$QIOW` is for synchronous service completion. It specifies that the service place the calling process in a wait state and only return to the caller `after completing the I/O operation. The OpenVMS IODEF module provides definitions for the SYS`$QIO function codes.

Note: The vertical bar (`|`) used in some of the functions described in this chapter is the C bit-wise inclusive OR operator.

TCPDRIVER System Service Call Arguments

You invoke TCPDRIVER system service calls with the standard OpenVMS QIO mechanism.

See the appropriate OpenVMS documentation (for example, the *Introduction to VMS System Services* volume) for more information on the QIO mechanism.

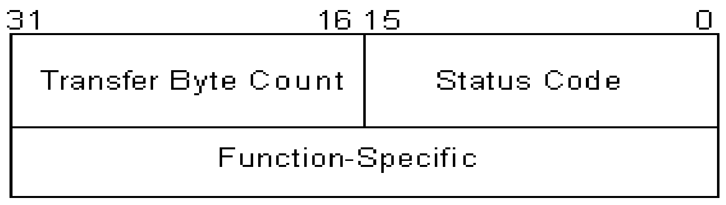
The following sections describe each system call argument.

efn
Number of the event flag set by completion of the I/O operation. The argument is optional.

chan
I/O channel assigned to the TCP device to which you are directing the request.

func
Device-specific function code and the modifier if appropriate for each operation. Each `func` is described in the *TCPDRIVER System Service Call Function Codes* section.

iosb
I/O status block that receives the final completion status of the I/O operation. Structured as in the below figure. The following table describes the status block fields in detail.



Field Name	Description
Function-Specific	Varies for each function code.
Status Code	The `SS$` status code or special error status code. If the low bit (0) of the OpenVMS error code is clear, the network has returned an error.

Transfer Byte Count	Number of bytes of data transferred in the I/O operation.

astadr
Address of the asynchronous system trap (AST) routine executed when the I/O is completed.

astprm
AST parameter to be passed to the AST routine.

p1**…**p6
Function-specific parameters, as described for each function.

TCPDRIVER System Service Call Function Codes

System service call function codes specify what action the QIO performs. This section describes the TCPDRIVER function codes.

IO$_CREATE

Provides for socket style listens and accepts.

Use the `IO$_CREATE` function to perform one of three operations:

`ACCEPT`	Accept an incoming connection
`ACCEPT-WAIT`	Wait for an incoming connection
`LISTEN`	Place a connection into listen state and specify the maximum number of incoming connections that can be queued waiting to be accepted

A typical flow for a program using this function might be as follows:

1. Assign a channel to the `TCP:` device (`SYS$ASSIGN`). This is the listening channel.
2. Issue an `IO$_SETMODE` | `IO$M_CTRL` function on the listening channel to specify the local port number for the service.
3. Issue an `IO$_CREATE` function on the listening channel to specify a large *`backlog`* (greater than 128 is recommended).
4. Issue an `IO$_CREATE` function (with all parameters set to zero) on the listening channel to await an incoming connection. (You could alternatively use an asynchronous QIO and AST routine). This function blocks until a connection is available.
5. Assign a channel to the `TCP:` device (`SYS$ASSIGN`) and issue an `IO$_CREATE` | `IO$M_NOW` function on the listening channel with *`newchan`* being the newly assigned channel.
6. The newly assigned channel (step 5) has the accepted connection and should be serviced (reads and writes).
7. Loop back to step 4 to continue accepting connections.

Ideally, steps 4 through 7 should be designed such that multiple connections can be serviced simultaneously.

Format for LISTEN

```
status = SYS$QIO(efn, chan, IO$_CREATE, iosb, astadr, astprm, 0, 0, 0,
backlog, 0, 0);
```

Description for LISTEN

This function places the connection into a listen state. If you did not previously specify a local port number for the channel (see the `IO$_SETMODE` | `IO$M_CTRL` function), a unique port number is automatically assigned. The function completes execution immediately as it does not wait for an incoming connection.

Argument for LISTEN

`p4 = u_int backlog`
Connection backlog, or maximum number of connections that can be queued. It is recommended that you specify a large backlog (greater than 128) for most applications.

Status for LISTEN

`SS$_DEVINACT`	Device not active Contact system manager and ask why TCPware (or TCPDRIVER) not started
`SS$_FILALRACC`	Port is busy Only ports that are in the closed state can be used
`SS$_ILLIOFUNC`	Invalid parameters or modifiers were specified (returned in *`status`*, not in *`iosb`*)
`SS$_NORMAL`	Success Connection put in listen state

Format for ACCEPT-WAIT

`status` `= SYS$QIO(`*`efn, chan`*`, IO$_CREATE,` *`iosb, astadr, astprm`*`, 0, 0, 0, 0, 0, 0);`

Description for ACCEPT-WAIT

This function waits for an incoming connection to be available on a listening connection. A listen function as specified in the `LISTEN` operation above must have been previously issued. You can use the

`IO$M_NOW` modifier to probe if a connection is available; `SS$_NODATA` is returned if no connection is available.

Status for ACCEPT-WAIT

`SS$_DEVINACT`	Device not in listen state or not active Contact system manager and ask why TCPware (or TCPDRIVER) not started
`SS$_NODATA`	No connection is currently available to be accepted Only returned if `IO$_CREATE` \| `IO$M_NOW` was specified as the function code
`SS$_NORMAL`	Success Connection put in listen state
`SS$_THIRDPARTY`	TCPDRIVER was shut down by a third party

Format for ACCEPT

```
status = SYS$QIO(efn, chan, IO$_CREATE | IO$M_NOW, iosb, astadr, astprm, 0,
0, newchan, 0, 0, 0);
```

Description for ACCEPT

This function accepts an incoming connection. A listen function as specified in the `LISTEN` operation above must have been previously issued on the channel (*`chan`*). As this function does not block, a wait should generally precede it for an incoming connection function, as specified in the `ACCEPT-WAIT` operation above.

Arguments for ACCEPT

`p3 = u_int newchan`

OpenVMS channel for a newly created `TCP:` device. This channel should be created by using `SYS$ASSIGN` to assign a new channel to the TCP0: device before issuing this function. The accepted connection uses this channel.

Status for ACCEPT

`SS$_DEVACTIVE`	I/O channel specified in *`newchan`* is not inactive Only inactive channels can be used
`SS$_DEVINACT`	Connection is not in listen state or the device is not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_IVDEVNAM`	I/O channel specified in *`newchan`* is not a TCP: device
`SS$_NODATA`	No connection is available to accept

IO$_READVBLK

Receives data, including urgent data, writing the received data to the specified user buffer.

The `IO$M_DATACHECK` modifier peeks at the next received data without removing it from the received data queue.

The `IO$M_NOW` modifier executes the function immediately regardless of the amount of available data. If no data is available, the function returns the `SS$_NODATA` status.

The `IO$M_PACKED` modifier requests that `IO$_READVBLK` return completely filled data buffers. `IO$_READVBLK` completes reads with this modifier only after receiving the requested number of bytes, unless the port closes or you specify `IO$M_NOW`.

Note: Use the `IO$M_PACKED` modifier with caution, as the read request only completes execution after receiving the requested number of bytes, or if the connection is closed or reset by the peer.

Format

```
status = SYS$QIO(efn, chan, IO$_READVBLK, iosb, astadr, astprm, buffer,
size, 0, 0, 0, 0);
```

Arguments

p1 = byte *buffer

Address of the user's buffer that receives the data.

p2 = u_int size

User's buffer size in bytes. Specifies the maximum amount of data written to the buffer. The value should not be greater than 64000 bytes.

Status

SS$_CANCEL	Request canceled

`SS$_DEVINACT`	Device not active Contact system manager about why TCPware (or TCPDRIVER) not started
`SS$_NODATA`	No data available and `IO$M_NOW` was specified.
`SS$_NORMAL`	Success Requested data was received.
`SS$_PATHLOST`	Route to peer lost Network or route used in communicating with peer no longer working Connection closed
`SS$_THIRDPARTY`	Connection broken by third party Usually indicates that TCPware was shut down Connection closed
`SS$_TIMEOUT`	Connection timed-out Connection closed
`SS$_VCBROKEN`	Connection broken (either locally or by source) and closed
`SS$_VCCLOSED`	Peer closed end of the connection and no more data is available, or the connection was never opened

The number of bytes received is returned in the high-order word of the first longword of the I/O status block. This may be less than the number of bytes requested.

The second longword of the I/O status block contains flag bits as follows:

- If bit 1 (mask value of 2) is set, there is still more data to be read before the end of the urgent data marker. This indicates that `IO$_READVBLK` has not read all of the urgent data.
- If bit 2 (mask value of 4) is set, the data was delivered with the urgent data marker in advance of the data. There may still be more data to be read before the end of the urgent data depending on the state of bit 1. This bit is always set if bit 1 is set.

All other bits in the second longword of the I/O status block are clear (0).

IO$_SENSEMODE

Reads the active connections status and returns status information for all of the active and listening TCPDRIVER connections.

Format

```
Status = SYS$QIO(efn, chan, IO$_SENSEMODE, iosb, astadr, astprm, buffer,
address, 0, 0, 0, 0);
```

Arguments

p1 = byte **buffer*

Optional address of the 8-byte device characteristics buffer. Data returned is: the device class (`DC$_SCOM`) in the first byte, the device type (0) in the second byte, and the default buffer size, which is the maximum datagram size, in the high-order word of the first longword. `IO$_SENSEMODE` returns the second longword as 0.

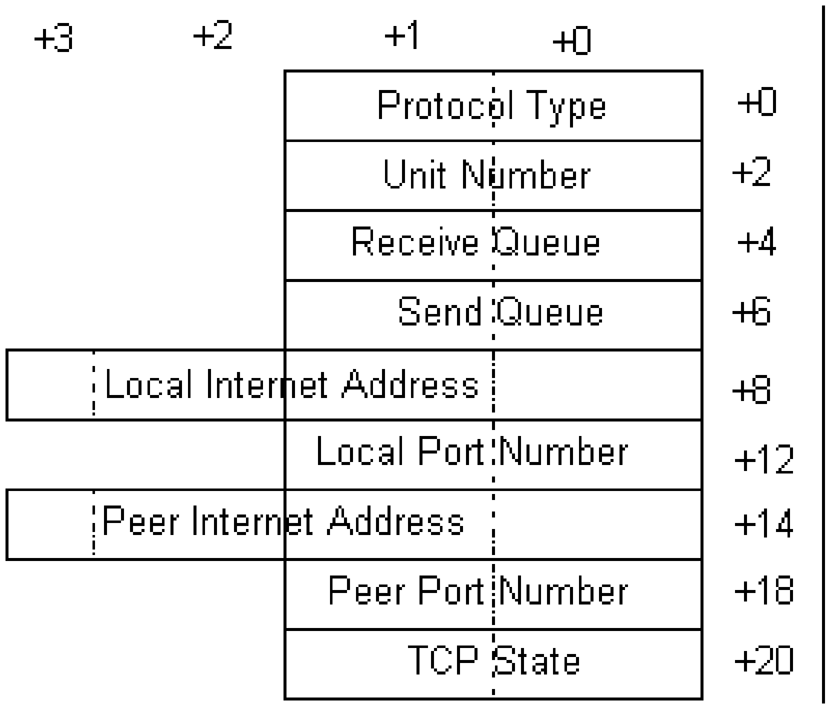
p2 = u_int *address*

Address of the descriptor for the buffer to receive the status information on the active connections.

The below diagram shows the 22 bytes of information returned for each connection.

Protocol type	Word value is 2 for TCPDRIVER connections, 4 for INETDRIVER stream sockets, and 5 for BGDRIVER stream sockets.
Unit number	Word value is the TCPDRIVER, INETDRIVER, or BGDRIVER device unit number for the connection.
Receive queue	Word value is the number of bytes received from the peer waiting to be delivered to the user through the `IO$_READVBLK` function.
Send queue	Word value is the number of bytes waiting to be transmitted to or to be acknowledged by the peer.
Local internet address	Longword value is the local internet address (or 0 if the connection is not open and no local internet address was specified for the connection).

Local port number	Word value is the local port number.
Peer internet address	Longword value is the peer's internet address (or 0 if the connection is not open and no peer internet address was specified for the connection).
Peer port number	Word value is the peer's port number, or 0 if the connection is not open and you did not specify a peer port number for the connection.
TCP state	Word value is the Transmission Control Protocol connection state mask. See the `IO$_SETMODE	IO$M_CTRL` description for the mask value definitions.



Status

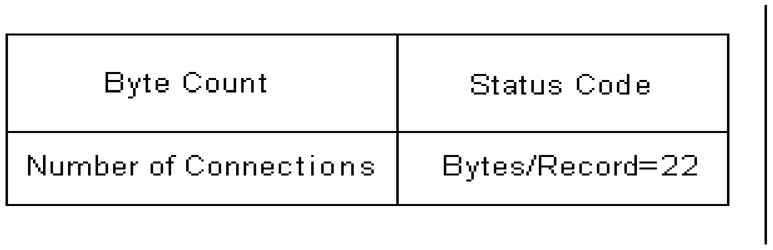
`SS$_BUFFEROVF`	Buffer too small for all connections Truncated buffer returned

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_NORMAL`	Success Status information returned

The byte count for the status information buffer is returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested. See the below figure for more information.

The size in bytes of each connection's record (22 bytes) is returned in the low order word of the second longword of the I/O status block.

The total number of active connections is returned in the high-order word of the second longword of the I/O status block. This can be greater than the number of reported connections if the buffer is full.



IO$_SENSEMODE | IO$M_CTRL

Reads the connection characteristics for the channel.

Format

```
status = SYS$QIO(efn, chan, IO$_SENSEMODE | IO$M_CTRL, iosb, astadr, astprm,
buffer, address, 0, 0, 0, 0);
```

Arguments

p1 = byte **buffer*

Optional address of the 8-byte device characteristics buffer. Data returned is: device class (`DC$_SCOM`) in the first byte, device type (0) in the second byte, and default buffer size (the maximum window size) in the high-order word of the first longword. `IO$_SENSEMODE | IO$M_CTRL` returns the second longword as 0.

p2 = u_int *address*

Address of the descriptor for the extended characteristics buffer to receive the characteristics. Information returned in the buffer is formatted the same as the extended characteristics buffer used to set the connection characteristics. See the `IO$_SENSEMODE` function for details.

If bit 12 (mask 4096) is set in the parameter identifier (PID), the PID is followed by a counted string. If bit 12 is clear, the PID is followed by a longword value. While TCPware currently never returns a counted string for a parameter, this may change in the future.

The below table shows the read connection characteristics.

PID	Meaning
0	Local internet address. Internet address is returned as the longword value. Only returned if the connection is open or a local internet address has been specified.
1	Local port number. Port number is returned in the low order word of the longword value. Local port number is either the default port number or the last specified local port number.
2	Peer internet address. Internet address is returned as the longword value. Only returned if the peer's internet address has been specified or the connection is open.

3	Peer port number. Port number is returned in the low order word of the longword value. Only returned if the peer's port number has been specified or the connection is open.
4	Connection time-out value. Time-out value (in seconds) is returned as the longword value.
5	Connection window size. Window size (in bytes) is returned as the longword value.
6	TCP state. State is returned as a longword bit mask value. Mask values and states are shown in the following table. Only one bit can be set at any time.
7	Passive open access control. Value indicating shared (non-zero) or exclusive (zero) access to the same port number is returned as the longword value.
10	Socket options. For the values of this option, see the socket options entry in **Error! Reference source not found.**.

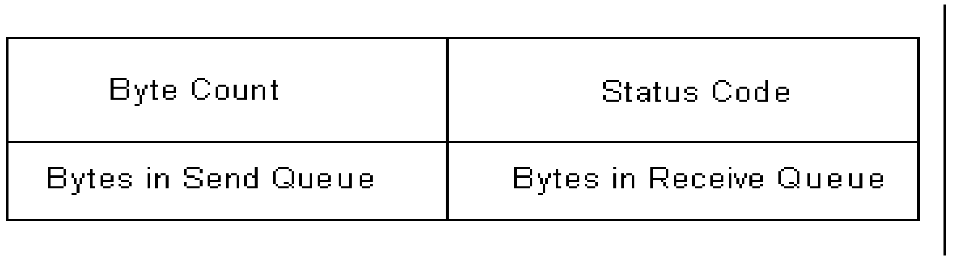
Note: The order in which `IO$_SENSEMODE` | `IO$M_CTRL` returns the parameters can change. It is recommended that you search the buffer for the desired parameter.

Mask Value	State	Mask Value	State	Mask Value	State
1	`LISTEN`	16	`FIN-WAIT-1`	256	`LAST-ACK`
2	`SYN-SENT`	32	`FIN-WAIT-2`	512	`TIME-WAIT`
4	`SYN-RECEIVED`	64	`CLOSE-WAIT`	1024	`CLOSED`
8	`ESTABLISHED`	128	`CLOSING`		

Status

`SS$_BUFFEROVF`	Buffer too small for all characteristics Truncated characteristics buffer is returned
`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_NORMAL`	Success Characteristics returned

The byte count for the characteristics buffer is returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested. The number of bytes in the receive queue is returned in the low order word of the second longword in the I/O status block. The number of bytes in the read queue is returned in the high-order word of the second longword in the I/O status block. The below figure shows the I/O Status Block.



Note: You can use the `SYS$GETDVI` system service to obtain the local port number, peer port number, and peer internet address. The `DEVDEPEND` field stores the local port number (low order word) and peer port number (high-order word). The `DEVDEPEND2` field stores the peer internet address.

IO$_SENSEMODE | IO$M_RD_COUNT

Reads the TCP counters. You can add the `IO$M_CLR_COUNT` modifier to this function to zero the counters after they are read. However, you must have the OPER privilege to use this modifier.

Format

```
status = SYS$QIO(efn, chan, IO$_SENSEMODE | IO$M_RD_COUNT, iosb, astadr,
astprm, 0, address, 0, 0, 0, 0);
```

Argument

p2 = u_long *address*

Address of the descriptor for the buffer to receive the counters. These counters relate only to the TCP level and are for all connections opened since the counters were last zeroed.

The counters (longword values) in the order in which they are returned:

1. Number of seconds since last zeroed
2. Number of segments transmitted (excludes retransmissions)
3. Number of segments retransmitted (includes keep-alive check transmissions)
4. Number of segments transmitted with transmission errors
5. Number of segments received
6. Number of segments received in error (invalid TCP header or checksum)
7. Number of receive data buffers concatenated (data segments are concatenated whenever possible)
8. Number of delayed acknowledgments transmitted (included in segments transmitted count)
9. Number of window updates transmitted due to receive request completions (included in segments transmitted count)
10. Number of out-of-sequence segments received
11. Number of transmit data buffers concatenated
12. Number of keep-alives transmitted (included in number of segments re-transmitted)

Status

`SS$_BUFFEROVF`	Buffer too small for all counters Truncated buffer is returned

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_NORMAL`	Success Counters returned

The byte count for the counters buffer is returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested.

IO$_SETMODE | IO$M_ATTNAST

Requests the delivery of an attention AST whenever urgent data is available, or the connection is broken.

This function enables an attention AST to be delivered only once. The function is subject to AST quotas. After the function delivers the AST, you must issue another `IO$_SETMODE | IO$M_ATTNAST` to re-enable AST delivery.

When a connection fully closes, all attention ASTs for the connection are disabled.

Note: If the existence of urgent data triggers the attention AST, and that data is not read before you re-enable the AST, the AST triggers again immediately.

Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_ATTNAST, iosb, astadr,
astprm, address, param, mode, 0, 0, 0);
```

Arguments

p1* `= void *`*address

Address of an AST service routine or 0 to disable attention ASTs.

p2* `= u_long` *param

AST parameter to be passed to the AST service routine.

p3* `= u_long` *mode

Access mode at which to deliver the AST. The access mode is maximized with the requestor's access mode.

Status

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_EXQUOTA`	AST quota exceeded
`SS$_NORMAL`	Success Attention AST enabled or previous ASTs disabled

IO$_SETMODE | IO$M_CTRL

Sets the connection characteristics.

You specify the connection characteristics in the extended characteristics buffer. The buffer consists of a series of six-byte entries. The first word of each entry stores the parameter identifier (PID) followed by a longword that stores one of the values associated with that parameter.

Format

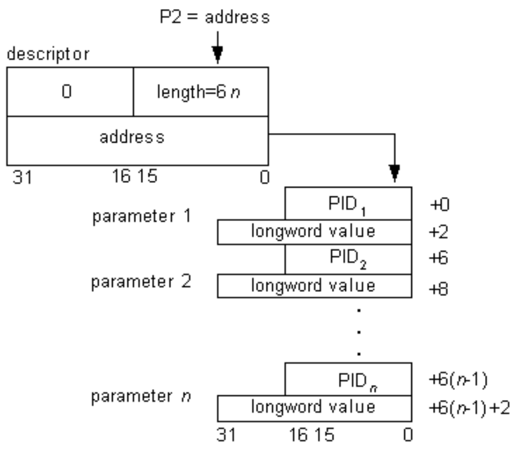
```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL, iosb, astadr, astprm,
0, address, 0, 0, 0, 0);
```

Argument

p2* = u_int *address

Address of the descriptor for the extended characteristics buffer. Counted strings consist of a word with the size of the character string followed by the character string.

The below figure shows the format of the descriptor for the extended characteristics buffer.



The below table lists the connection characteristics you can set. These characteristics remain set, even after you close the connection, until you change them with another `IO$_SETMODE` operation.

PID	Meaning

0	**Local internet address.** Longword with the local host's internet or multicast address. If used, must be a valid local internet or multicast address. Set this parameter only if the port is not open. Specify in internet byte order, reversed from the normal VMS byte order. For example, internet address 2.3.4.5 is stored as ^X05040302. To determine if an internet address is local, issue an `IO$_SETMODE \| IO$M_CTRL` function specifying the address in this characteristic. If the address is not local, the function returns an `SS$_BADPARAM` status.
1	**Local port number.** Low order word of the longword containing the port number. If omitted, the function uses the unique port number generated when you assign the UDP device unit. Set this parameter only if the port is not open. If you use `0`, the function generates a new, unique number. Specify in normal VMS byte order.
2	**Peer internet address.** Longword with the peer host's internet address. If you specify both the peer's internet address and port number after opening the port (or when the port is opened) the port is considered fully specified (or opened as fully specified) and all further receive requests receive datagrams from that address and port only. Transmitted requests that do not provide a source/destination buffer are sent to that address and port. Specify in internet byte order, as the local internet address characteristic above. Using `0` functionally omits the address.
3	**Peer port number.** Low order word of the longword containing the port number. (See PID 2 above.) Specify in normal VMS byte order. Using `0` functionally omits the port number.
4	**Connection time-out value.** Longword specifying the connection time-out value in seconds. You can also specify the connection time-out value as P6 in the `IO$_SETMODE \| IO$M_CTRL | IO$M_STARTUP` and `IO$_WRITEVBLK` functions. The value specified by P6 has precedence over the value specified by the extended characteristics buffer. The default value is 5 minutes (300 seconds). The minimum is 20 seconds.
5	**Connection window size.** Longword specifying the connection's window size (in bytes). Typical values for connection window sizes range from 4096 to 32768 and specify how much data the TCP layer will buffer for the application. If omitted, the default window size configured during network start up is used for the connection.

7	**Passive open access control.** Specifies whether others may (shared access) or may not (exclusive access) use the same local port number in passive opens. To specify exclusive access (the default), the longword value must be 0. To specify shared access (used primarily by servers), the longword value must be non-zero. This parameter only applies to passive opens.
9	**Change ownership.** Longword that allows the current owner of the device unit to prepare to pass ownership to another process. Removes the owner's process ID from the connection. If the value field is non-zero, specifies the new owner UIC for the connection and changes the connection protection so that only system and owner have access (`S:RWLP,O:RWLP`). Changes the following fields for the connection: owner process ID, owner UIC, and device protection. Primarily the NETCP master server but also other programs use it.
10	**Set socket options.** Low order word of the longword value field containing the mask value of the socket options to set. Specify the following options, as defined in the `TCPWARE_INCLUDE:SOCKET.H` header file (with values in hexadecimal): `SO_DEBUG`, with a value of 0001, enables debugging (ignored) `SO_REUSEADDR`, with a value of 0004, allows reuse of local address (controllable through the passive open access control parameter) `SO_KEEPALIVE`, with a value of 0008, keeps connections alive `SO_DONTROUTE`, with a value of 0010, prevents routing (ignored) `SO_BROADCAST`, with a value of 0020, enables use of broadcasts (ignored) `SO_USELOOPBACK`, with a value of 0040, bypasses hardware when possible (ignored) `SO_LINGER`, with a value of 0080, lingers on a close
11	**Clear socket options.** Low order word of the longword value field containing the mask of the socket options to clear. (See the options under PID 10 above.)
12	**No delay.** Determines whether TCPDRIVER delays sending data to coalesce data from several small sends into a large packet for transmission over the network. The default is for TCPDRIVER to delay. Most applications should not change this option since the delay is very short and makes for better overall network performance. TCPDRIVER uses the parameter value passed to disable the delay (if the value is non-zero) or enable the delay (if the value is `0`).

13	**IP options.** Counted string containing the IP options to be included in datagrams.

Note: The multicasting-related parameters (14 through 20) are supported but cannot be used with TCP (a connection-oriented protocol). Therefore, the settings are meaningless.

Status

`SS$_BADPARAM`	Bad parameter or value specified PID returned in low order word of second longword
`SS$_DEVACTIVE`	Connection open on unit; local port number, peer's internet address, and peer's port number cannot be changed
`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_INSFMEM`	Insufficient memory to complete request
`SS$_IVBUFLEN`	Extended characteristics buffer length invalid
`SS$_NOPRIV`	Setting IP layer options (PIDs 13 through 20) requires privileges Application must either be running under SYSTEM UIC or have SYSPRV, BYPASS, or OPER privilege
`SS$_NORMAL`	Successful operation Characteristics set
`SS$_UNREACHABLE`	Default interface for multicast group address could not be found Specify local interface's IP address when joining multicast group

IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN

Closes your end of the connection. Lets the other end of the connection know that you completed sending data. You cannot perform any `IO$_WRITEVBLK` functions after issuing `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN`. However, you can perform `IO$_READVBLK` functions on the connection until the other end of the connection closes and you have read all the data.

Note: A connection does not close until it closes on both ends. In other words, your end of the connection does not close until the peer has acknowledged the `IO$_SETMODE` | `IO$M_CTRL` | `IO$M_SHUTDOWN`.

The recommended procedure for closing a connection is to issue `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN` and then read until `SS$_VCCLOSED` status is returned. Use the `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN | IO$M_ABORT` function to abort a connection. This function returns all requests for the connection with the `SS$_VCBROKEN` status. If the connection is open, it is reset.

Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN, iosb,
astadr, astprm, 0, 0, 0, 0, 0);
```

Arguments

None.

Status

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_NORMAL`	Successful operation Connection closed

`SS$_PATHLOST`	Route to peer lost Network or route used in communicating with peer no longer working Connection closed
`SS$_THIRDPARTY`	Connection broken by third party Usually indicates that TCPware was shut down Connection closed
`SS$_TIMEOUT`	Connection timed-out Connection closed
`SS$_VCBROKEN`	Connection broken (either locally or by source) and closed
`SS$_VCCLOSED`	Connection already closed or in process of being closed

IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP

Opens an active connection. For an active open connection, specify the peer's internet address and port number. If you omit the local port number, the function uses a unique port number assigned when the unit was created.

Use the `IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP` function to open a passive connection. You can omit the peer's internet address or port number. The function completes execution only after the connection is fully established.

Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP, iosb,
astadr, astprm, 0, address, 0, 0, 0, time);
```

Arguments

p2* = u_int *address
Address of the descriptor for the extended characteristics buffer. See the `IO$_SENSEMODE | IO$M_CTRL` description for details on this buffer.

p6* = u_long *time
Optional connection time-out value in seconds. The default is the value specified in the extended characteristics buffer (or 5 minutes, if none was specified). The minimum value is 20 seconds.

Status

`SS$_BADPARAM`	Bad parameter or value specified
`SS$_CANCEL`	Request canceled
`SS$_DEVACTIVE`	Connection open on unit
`SS$_DUPUNIT`	Connection not unique Check local port number, peer's internet address, and peer's port number

`SS$_IVBUFLEN`	Buffer length invalid
`SS$_NORMAL`	Successful operation Connection open Use write and read requests to send or receive data
`SS$_NOPRIV`	Insufficient privilege Tried to open passive connection on port number below 1024 without BYPASS or SYSPRIV privilege
`SS$_PATHLOST`	Route to peer lost Network or route used in communicating with peer no longer working Connection closed
`SS$_THIRDPARTY`	Connection broken by third party Connection closed
`SS$_TIMEOUT`	Connection timed-out and closed Active open not completed within connection timeout
`SS$_VCBROKEN`	Connection broken (either locally or by peer) and closed Active open returns if peer refused connection

IO$_WRITEVBLK

Sends data stored in the specified user buffer. Completes execution after queuing the data for transmission.

You can use the `IO$M_OUTBAND` modifier with `IO$_WRITEVBLK` to transmit urgent data.

Format

status = SYS$QIO(*efn*, *chan*, IO$_WRITEVBLK, *iosb*, *astadr*, *astprm*, *buffer*, *size*, 0, 0, 0, *time*);

Arguments

p1 = byte **buffer*

Address of the user's buffer. The user's buffer stores the data to be sent.

p2 = u_int *size*

User's buffer size in bytes. Amount of data that the user is sending. If 0, the `IO$_WRITEVBLK` completes execution after transmitting all previously written data to the peer. However, the peer has not necessarily received this data yet. The value should not be greater than 64000 bytes.

p6 = u_long *time*

Optional new-connection timeout value (in seconds).

Status

SS$_BADPARAM	Bad parameter or value specified If P6 is not zero, value specified is not acceptable; if `IO$M_EXTEND` modifier specified, P2 is not 24 (size of `msghdr` structure)
SS$_DEVINACT	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
SS$_IVBUFLEN	Extended characteristics buffer length invalid

`SS$_NORMAL`	Successful operation Data queued for sending to destination
`SS$_PATHLOST`	Route to peer lost Network or route used in communicating with peer no longer working Connection closed
`SS$_THIRDPARTY`	Connection broken by third party Usually indicates that TCPware was shut down Connection closed
`SS$_TIMEOUT`	Connection timed-out and fully closed Data could not be delivered to destination within connection time-out
`SS$_VCBROKEN`	Connection broken (either locally or by source) and fully closed
`SS$_VCCLOSED`	You issued close function to close end of connection, or connection never opened

The number of bytes sent is returned in the high-order word of the first longword of the I/O status block.

IO$_WRITEVBLK | IO$M_EXTEND

Sends data stored in a list of buffers.

Format

status = SYS$QIO(*efn*, *chan*, IO$_WRITEVBLK | IO$M_EXTEND, *iosb*, *astadr*, *astprm*, *msghdr*, *size*, 0, 0, 0, 0);

Arguments

p1* = u_long **msghdr

Address of the msghdr structure. Points to the address of the structure storing the array of additional structures. Each of these array structures contains the address and size of one of the user buffers. The msghdr structure is as follows:

```
struct msghdr {
   char     *msg_name;              /*optional address*/
   int      msg_namelen;            /*size of address*/
   struct   iovec *msg_iov;         /*scatter/gather array*/
   int      msg_iovlen;             /*elements in msg_iov*/
   char     *msg_accrights;         /*access rights*/
   int      msg_accrightslen;
};

struct iovec {
   char     *iov_base;              /*address of buffer*/
   int      iov_len;                /*length of buffer*/
};
```

In the msghdr structure, this function uses only msg_iov and msg_iovlen. It ignores the values of the other elements.

msg_iov stores the address of the array of iovec structures and msg_iovlen is the number of iovec elements in the array. The iovec array stores the address and length of each buffer (in bytes) that holds the data to be sent.

p2* = u_long *size

Size of the msghdr structure, which must be 24 bytes. The following is an example using the scatter-gather write function. The below figure shows a diagram for the example.

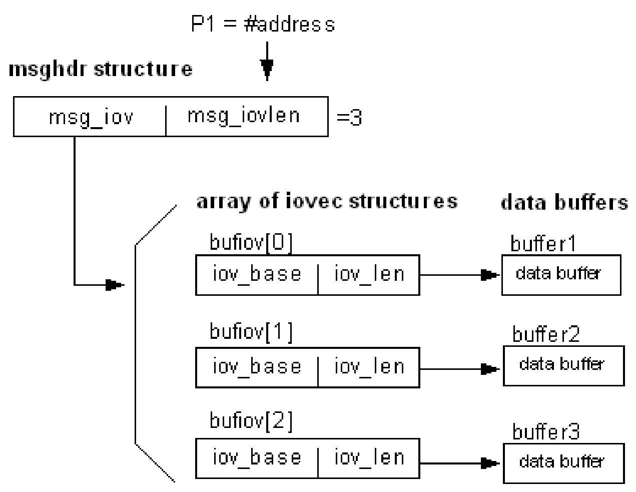
```
struct  msghdr  buflst;
struct  iovec   bufiov[3];
```

```
char    buffer1[100];
char    buffer2[20];
char    buffer3[200];

buflst.msg_iov = bufiov;
buflst.msg_iovlen = 3;

bufiov[0].iov_base = buffer1;
bufiov[0].iov_len = sizeof(buffer1)
bufiov[1].iov_base = buffer2;
bufiov[1].iov_len = sizeof(buffer2)
bufiov[2].iov_base = buffer3;
bufiov[2].iov_len = sizeof(buffer13)

istat = SYS$QIOW(0,chan,
   IO$_WRITEVBLK | IO$M_EXTEND,&iosb,0,0,buflst,sizeof(buflst),
   0,0,0);
```



Status

See `IO$_WRITEVBLK`

SYS$ASSIGN

Assigns a channel to a device.

Format

```
status = SYS$ASSIGN(char *devnam, u_int *chan, [u_long acmode], [char
*mbxnam]);
```

Arguments

devnam

Address of a character string descriptor pointing to the device name string (`TCP0:`).

chan

Address of a word into which SYS$ASSIGN writes the channel number.

acmode

Optional access mode associated with the channel. The most privileged access mode used is that of the caller.

mbxnam

Optional logical mailbox associated with the device. (Not supported by TCPDRIVER.)

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$CANCEL

Cancels any I/O that is pending on a socket. The I/O will be completed with an *`iosb`* status of `SS$_CANCEL`.

Outstanding I/O operations are automatically cancelled at image exit.

Format

```
status = SYS$CANCEL(u_int chan);
```

Argument

`chan`
Number of the channel to be canceled.

Status

See HP’s *VMS System Services Reference Manual* for a complete list of status messages.

SYS$DASSGN

Releases a channel.

When you deassign a channel, any outstanding I/O is completed with an `iosb` status of `SS$_CANCEL`. If a connection is open on the channel, it is aborted.

I/O channels are automatically deassigned at image exit.

Format

```
status = SYS$DASSGN(u_int chan);
```

Argument

chan
Number of the channel to be deassigned.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

Sample Programs

C Programs

The following sample programs are included in the `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory:

- `TCPDRIVER_CLIENT.C`
- `TCPDRIVER_SERVER.C`
- `FINGER.C`

The first two pairs of programs show the use of stream sockets with `SYS$QIO` system service calls to the TCPDRIVER. They are functionally the same as the `TCP_SOCKET_CLIENT.C` and `TCP_SOCKET_SERVER.C` socket library programs.

The client sequence of operations is as follows:

1. Assigns an I/O channel to TCP0, using `SYS$ASSIGN`.
2. Opens a connection, using (`IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP`).
3. Exchanges data, using `IO$_WRITEVBLK` and `IO$_READVBLK`.
4. Closes the connection, using (`IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN`).
5. Performs additional reads until the peer returns an `SS$_VCCLOSED` status.
6. Deassigns the channel, using `SYS$DASSGN`.

The server sequence of operations is as follows:

1. Assigns an I/O channel to `TCP0`, using `SYS$ASSIGN`.
2. Causes a passive open of the connection, using (`IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP | 0x0800`). You can alternately use TCPDRIVER's `IO$_CREATE` function that listens and accepts connections with UNIX-like functionality (use the `/DEFINE=USE_CREATE` command in the `cc` line of the build process).
3. Exchanges data, using `IO$_WRITEVBLK` and `IO$_READVBLK`.
4. Closes the connection, using (`IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN`).
5. Deassigns the channel, using `SYS$DASSGN`.

FINGER

The `FINGER.C` file for the FINGER protocol also contains sample source code using TCPDRIVER services.

Link the files to the TCPware Socket Library as follows for Alpha, VAX, and Itanium systems for DEC C:

```
$ LINK FINGER SYS$INPUT/OPTIONS SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
$ Ctrl+Z
```

To build on a VAX with VAX C:

```
$ CC FINGER.C
$ LINK FINGER,SYS$INPUT/OPTIONS TCPWARE:UCX$IPC.OLB/LIBRARY -
_$ SYS$SHARE:VAXCRTL/SHARE
$ Ctrl+Z
$ FINGER :== $device:[directory]FINGER
```

To build on an Alpha, VAX, or Itanium systems with DEC C:

```
$ CC/PREFIX=ALL FINGER.C
$ LINK FINGER
$ FINGER :== $device:[directory]FINGER
```

Then type:

```
$ FINGER username@host
```

or

```
$ FINGER @host
```

FINGERD

To build on a VAX with VAX C:

```
$ CC FINGERD.C
$ LINK FINGERD,SYS$INPUT/OPTIONS TCPWARE:UCX$IPC.OLB/LIBRARY -
_$ SYS$SHARE:VAXCRTL.EXE/SHARE
```

To build on an Alpha,VAX, or Itanium system with DEC C:

```
$ CC/PREFIX=ALL FINGERD.C
$ LINK FINGERD,SYS$INPUT/OPTIONS SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
```

Use the `NETCU ADD SERVICE` and (optionally) the `ADD ACCESS` commands to "start" the server. The `ADD ACCESS` commands can be used to restrict access to the FINGER server to specific hosts or networks. For example:

```
$ NETCU ADD SERVICE FINGER TCP path:FINGERD -
_$ /PRIV=(NOSAME,NETMBX,TMPMBX,WORLD,SYSPRV) /ACCESS=n
```

Add these commands to the TCPWARE:SERVERS.COM file so that the server starts whenever TCPware starts.

FORTRAN Program

The TCPWARE_COMMON:[TCPWARE.EXAMPLES] directory also includes a TCPSAMPLE.FOR FORTRAN language file that transmits or receives data. This program links to the TCPware Socket Library as follows:

ALPHA and IA64

```
$ FORTRAN/NOALIGN TCPWARE_COMMON:[TCPWARE.EXAMPLES]TCPSAMPLE
$ LINK TCPSAMPLE, SYS$INPUT/OPTIONS
SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
Ctrl+Z
```

VAX

```
$ FORTRAN TCPWARE_COMMON:[TCPWARE.EXAMPLES]TCPSAMPLE
$ LINK TCPSAMPLE, SYS$INPUT/OPTIONS
SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
Ctrl+Z
```

4. UDPDRIVER Services

Introduction

This chapter describes the User Datagram Protocol (UDP) device driver (UDPDRIVER) services. It describes the user interface of TCPware for the OpenVMS UDP implementation only. RFC 768 contains the protocol specification for UDP.

UDP allows an application on one machine to send a datagram to an application on another machine. The datagram includes a protocol port number that identifies the receiving application from among other applications executing on the remote machine.

The UDP protocol is transaction-oriented so it does not guarantee reliable delivery of data. If your applications require ordered and reliable delivery of data, you should use TCP.

UDP services are available through the OpenVMS Queue I/O (`SYS$QIO` and `SYS$QIOW`) system services. These system services:

- Open and close a port.
- Send and receive data over the port.
- Perform status checks on the port.

`SYS$QIOW` is the synchronous and `SYS$QIO` the asynchronous form of VMS system services. Use each form depending on your application's requirements.

See the appropriate OpenVMS documentation for details on the OpenVMS I/O system services and related services such as asynchronous system traps (ASTs) and event flags.

Note: The QIO calls described in this chapter are used for direct access to the UDPDRIVER. If you are porting an application that uses the BGDRIVER or INETDRIVER QIO interface, there may be no need to make modifications. Use TCPware's BGDRIVER (see Chapter 2) or INETDRIVER (see Chapter 7).

Sequence of Operations

Perform the following sequence of operations to open a port:

1. Assign an I/O channel to the `UDP0:` device using the `SYS$ASSIGN` system service. `SYS$ASSIGN` creates a new device unit and assigns to it the channel for the port.
2. Open the port with the `IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP` function of the `SYS$QIO` or `SYS$QIOW` system services.
3. Perform read requests with the `IO$_READVBLK` function and write requests with the `IO$_WRITEVBLK` function as desired.
4. Close the port with the `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN` function.
5. Deassign the I/O channel with the `SYS$DASSGN` system service.

Other Operations

In addition to the sequence of operations described in the preceding section, UDPDRIVER includes other operations that:

Read a datagram immediately with	`IO$_READVBLK \| IO$M_NOW`
Read the next received message without removing it from the received message queue with	`IO$_READVBLK \| IO$M_DATACHECK`
Suppress checksum generation at the UDP level with	`IO$_WRITEVBLK \| IO$M_NOFORMAT`
Request a list of buffers to be sent as a single datagram with each request with	`IO$_WRITEVBLK \| IO$M_EXTEND`
Read the open ports status with	`IO$_SENSEMODE`
Read the port characteristics with	`IO$_SENSEMODE \| IO$M_CTRL`
Read the UDP counters with	`IO$_SENSEMODE \| IO$M_RD_COUNT`

Clear these UDP counters after they have been read with	`IO$_SENSEMODE \| IO$M_RD_COUNT | IO$M_CLR_COUNT` You must have OPER privilege to clear the counters.
Cancel any pending I/O requests with	`SYS$CANCEL`

User Datagram Protocol Implementation Notes

There are no implementation specific restrictions for the User Datagram Protocol (UDP). The material presented here does not explain or describe the UDP protocol.

UDPDRIVER System Service Call Format

The format for the UDPDRIVER SYS$QIO system service call is as follows:

```
status = SYS$QIO[W](u_long efn, u_int chan, u_long func, unsigned quadword
*iosb, void *astadr, u_long astprm, p1, p2, p3, p4, p5, p6);
```

`SYS$QIO` and `SYS$QIOW` are used to issue UDP functions.

`SYS$QIO` is for asynchronous service completion, specifying that the service return to the caller immediately after queuing the I/O request.

`SYS$QIOW` is for synchronous service completion, specifying that the service place the calling process in a wait state and only return to the caller after completing the I/O operation.

The OpenVMS IODEF module provides definitions for the `SYS$QIO` function codes.

Note: The vertical bar (|) used in some of the functions described in this chapter is the C bit-wise inclusive OR operator.

UDPDRIVER System Service Call Arguments

You invoke UDPDRIVER system service calls with the standard OpenVMS QIO mechanism.

See the appropriate OpenVMS documentation (for example, the *Introduction to VMS System Services* volume) for details on the QIO mechanism.

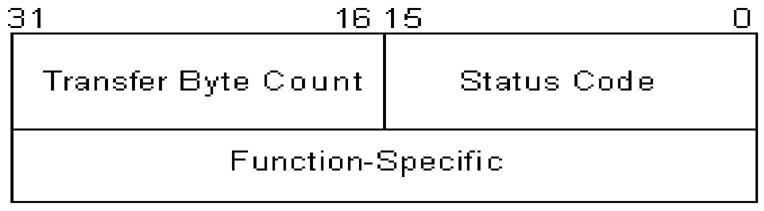
The following sections describe each system call argument.

`efn`
Number of the event flag set by completion of the I/O operation. The argument is optional.

`chan`
Channel assigned to the UDP device to which you are directing the request.

`func`
Device-specific function code and the modifier, if appropriate, for each operation.

`iosb`
I/O status block that receives the final completion status of the I/O operation, structured as in the below figure.



The below table describes the status block fields in more detail.

Field Name	Description
Transfer Byte Count	Number of bytes of data transferred in the I/O operation.
Status Code	SS$ status code or special error status code. If the low bit (0) of the OpenVMS error code is clear, the network has returned an error.
Function-Specific	Varies for each function code.

`astadr`
Address of the asynchronous system trap (AST) routine executed when the I/O is completed.

`astprm`
AST parameter to be passed to the AST routine.

`p1`…`p6`
Function-specific parameters, as described for each function.

UDPDRIVER System Service Call Function Codes

System service call function codes specify what action the QIO performs. This section describes the following function codes:

`IO$_READVBLK`	`IO$_WRITEVBLK \| IO$M_EXTEND`
`IO$_WRITEVBLK`	`IO$_SENSEMODE \| IO$M_RD_COUNT`
`IO$_SENSEMODE`	`IO$_SETMODE \| IO$M_CTRL | IO$M_STARTUP`

`IO$_SETMODE \| IO$M_CTRL`	`IO$_SETMODE \| IO$M_CTRL | IO$M_SHUTDOWN`
`IO$_SENSEMODE \| IO$M_CTRL`	

IO$_READVBLK

Receives a datagram. The received datagram is written to the specified user buffer.

Use the `IO$M_NOW` modifier to execute the function immediately regardless of the amount of available data. If no data is available, the function returns `SS$_NODATA` status.

Use the `IO$M_DATACHECK` modifier with a read request to peek at the next received message without removing it from the received message queue.

Unless you set a local internet address, datagrams sent to any local interface address, any local broadcast address (TCPware supports both the standard -1 and nonstandard 0 broadcast address forms), or any joined multicast host group address are eligible to be received.

> **Note:** UDPDRIVER holds a maximum of five unsolicited datagrams. It is good programming practice to have a read request pending for incoming datagrams.

Format

```
status = SYS$QIO(efn, chan, IO$_READVBLK, iosb, astadr, astprm, buffer,
size, udp_address, 0, 0, receive_timeout);
```

Arguments

p1 **= byte** ****buffer***

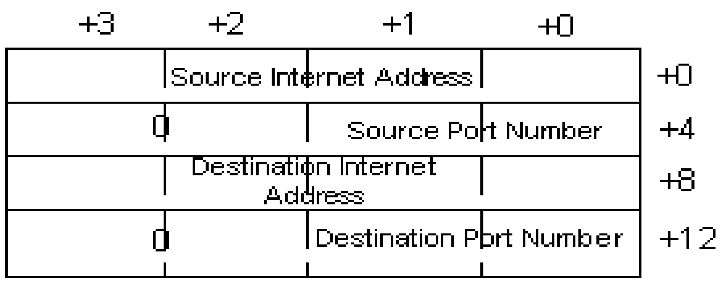
Address of the user's buffer that receives the data.

p2 **= u_int** ***size***

Length (in bytes) of the buffer to which the *`address`* argument points. This is the amount of data the user is willing to receive. The value must be at least 20 bytes.

p3 **= u_long** ****udp_address***

Address of an optional 4-longword buffer. Receives the source and destination IP addresses and UDP port numbers from the received datagrams. The below figure shows the buffer format.



> **Note:** `IO$_READVBLK` returns the source and destination internet addresses in internet byte order, which is reversed from the normal VMS byte order. For example, internet address 2.3.4.5 is stored as ^X05040302.

p6* = u_long *receive_timeout
Contains the receive time-out time (in seconds). If this value is non-zero, the `SS$_TIMEOUT` status is returned if a datagram isn't received within this time.

Status

`SS$_ABORT`	Request aborted due to closed connection
`SS$_BUFFEROVF`	User's buffer too small for entire datagram Truncated datagram is returned Remainder of datagram is lost
`SS$_CANCEL`	Request cancelled
`SS$_DEVINACT`	Device is not active or port not opened
`SS$_NODATA`	No datagram available and `IO$M_NOW` was specified

`SS$_NORMAL`	Success Datagram received
`SS$_THIRDPARTY`	Port closed by third party Usually indicates that TCPware was shut down.
`SS$_TIMEOUT`	Receive time out time specified and no datagram received within allowed time

The number of bytes received are returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested.

IO$_SENSEMODE

Reads the active ports status and returns status information for all of the open UDPDRIVER ports.

Format

```
status = SYS$QIO(efn, chan, IO$_SENSEMODE, iosb, astadr, astprm, buffer,
address, 0, 0, 0, 0);
```

Arguments

***p1* = byte *buffer**

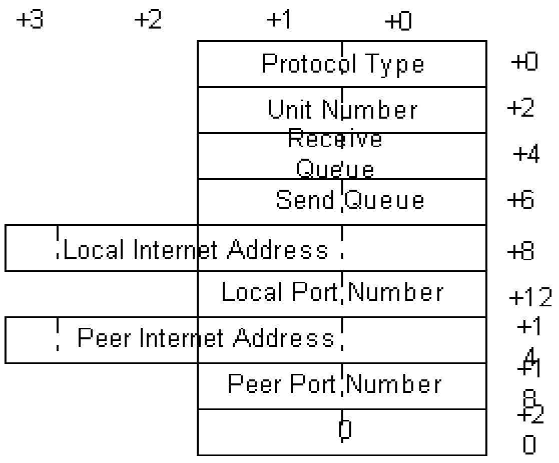
Optional address of the 8-byte device characteristics buffer. The data returned is: the device class (`DS$_SCOM`) in the first byte, the device type (0) in the second byte, and the default buffer size, which is the maximum datagram size, in the high-order word of the first longword. `IO$_SENSEMODE` returns the second longword as 0.

***p2* = u_int *address**

Address of the descriptor for the buffer to receive the status information on the open ports. The buffer receives 22 bytes of information for each open UDP port. The below figure shows the 22 bytes of status information returned.

Protocol type	Word value is 3 for UDPDRIVER ports, 4 for INETDRIVER datagram sockets, and 5 for BGDRIVER datagram sockets.
Unit number	Word value is the UDPDRIVER, INETDRIVER or BGDRIVER device unit number for the port.
Receive queue	Word value is the number of bytes received on the port waiting to be delivered to the user (via the read function).
Send queue	Word value is the number of bytes waiting to be transmitted for the port.
Local internet address	Longword value is the local internet address specified for the opened port. 0 means that none was specified.

Local port number	Word value is the local port number for the opened port.
Peer internet address	Longword value is the peer's internet address for a fully specified opened port. 0 means the port is not fully specified.
Peer port number	Word value is the peer's port number for a fully specified opened port. 0 means the port is not fully specified.



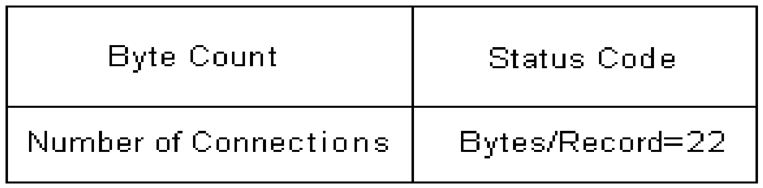
Status

`SS$_BUFFEROVF`	Buffer too small for all connections Truncated buffer returned
`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware (or UPDRIVER) was not started
`SS$_NORMAL`	Success Status information returned

The byte count for the status information buffer is returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested. See the below figure for more information.

The size in bytes of each connection's record (22 bytes) is returned in the low order word of the second longword of the I/O status block.

The total number of active connections is returned in the high-order word of the second longword of the I/O status block. This can be greater than the number of reported connections if the buffer is full.



Byte Count	Status Code
Number of Connections	Bytes/Record=22

IO$_SENSEMODE | IO$M_CTRL

Reads the port characteristics for the channel.

Format

```
status = SYS$QIO(efn, chan, IO$_SENSEMODE | IO$M_CTRL,iosb, astadr,
astprm,buffer, address, 0, 0, 0, 0);
```

Arguments

p1 = byte **buffer*

Optional address of the 8-byte device characteristics buffer. The data returned is: the device class (`DC$_SCOM`) in the first byte, the device type (0) in the second byte, and the default buffer size, which is the maximum datagram size, in the high-order word of the first longword. `IO$_SENSEMODE` returns the second longword as 0.

p2 = u_int *address*

Address of the descriptor for the extended characteristics buffer to receive the characteristics. The information returned in the buffer is formatted the same as the extended characteristics buffer used to set the connection characteristics. See the `IO$_SETMODE` function description for more information.

If bit 12 (mask 4096) is set in the parameter identifier (PID), the PID is followed by a counted string. If bit 12 is clear, the PID is followed by a longword value. While TCPware currently never returns a counted string for a parameter, this may change in the future.

The below table lists the port characteristics that the function returns.

PID	Meaning
0	**Local internet or multicast address.** Internet or multicast address is returned as the longword value. Last specified value or 0 is returned.
1	**Local port number.** Port number is returned in the low order word of the longword value. Local port number is either the default port number or the last specified local port number.
2	**Peer internet address.** Internet address is returned as the longword value. Last specified value or 0 is returned.

3	**Peer port number.** Port number is returned in the low order word of the longword value. Last specified value or 0 is returned.
5	**Port datagram size.** Maximum datagram size (in bytes) is returned as the longword value.
6	**Port state.** Longword value is 0 if the port is not open and 1 if the port is open.
7	**Shared access control.** Longword value is 0 if the port is set for exclusive access and 1 if the port is set for shared access.
10	**Socket options.**
14	**IP TTL.** Longword. Low byte contains the time-to-live (TTL).
15	**IP TOS.** Longword. Low byte of the longword contains the type of service (TOS).
18	**Multicast interface.** Longword. IP address of the local interface to use in sending multicast datagrams. If 0, the default interface is used.
19	**Multicast TTL.** Longword. Low byte contains the time-to-live (TTL) to be used in multicast datagrams to be transmitted.
20	**Multicast loopback.** Longword. Low byte is 0 to disable and 1 to enable local loopback of multicast datagrams.

Note: The order in which `IO$_SENSEMODE` | `IO$M_CTRL` returns the parameters can change. It is recommended that you search the buffer for the desired parameter.

Status

`SS$_BUFFEROVF`	Buffer too small for all connections Truncated characteristics buffer returned

`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware (or UPDRIVER) was not started
`SS$_NORMAL`	Success Characteristics returned

The byte count for the characteristics buffer is returned in the high-order word of the first longword of the I/O status block. This may be less than the bytes requested.

The number of bytes in the receive queue is returned in the low order word of the second longword in the I/O status block.

> **Note:** You can use the `SYS$GETDVI` system service to obtain the local port number, peer port number, and peer internet address. The `DEVDEPEND` field stores the local port number (low order word) and peer port number (high-order word). The `DEVDEPEND2` field stores the peer internet address.

IO$_SENSEMODE | IO$M_RD_COUNT

Reads the UDP counters. You can add the `IO$M_CLR_COUNT` modifier to this function to zero the counters after they are read. However, you must have the OPER privilege to use this modifier.

Format

```
status = SYS$QIO(efn, chan,IO$_SENSEMODE | IO$M_RD_COUNT, iosb, astadr,
astprm, 0, address, 0, 0, 0, 0);
```

Argument

p2 = u_long address

Address of the descriptor for the buffer that receives the counters. These counters relate only to the UDP level and are for all ports since the counters were last zeroed. The counters in the order they are returned:

1. Number of seconds since last zeroed
2. Number of datagrams transmitted
3. Number of datagrams transmitted with transmission errors
4. Number of datagrams received
5. Number of datagrams received in error (invalid UDP header or checksum)
6. Number of datagrams that were discarded because they could not be delivered to a receiver

All counters are longword values. All counters stop at their maximum value instead of overflowing.

Status

`SS$_BUFFEROVF`	Buffer too small for all connection Truncated buffer returned
`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware (or UPDRIVER) was not started
`SS$_NORMAL`	Success, Counters returned

IO$_SETMODE | IO$M_CTRL

Sets the port characteristics in the extended characteristics buffer.

The buffer consists of a series of six-byte or counted string entries. The first word of each entry contains the parameter identifier (PID) of a characteristic, followed by either a longword that contains the value of that characteristic, or a counted string. Counted strings consist of a word with the size of the character string, followed by the character string.

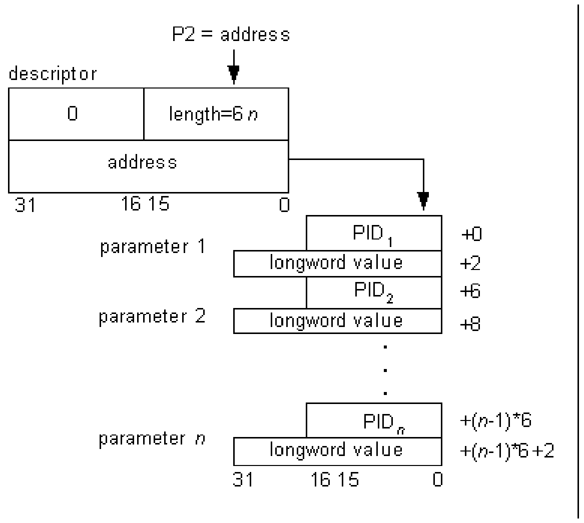
Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL,iosb, astadr, astprm, 0,
address, 0, 0, 0, 0);
```

Argument

p2* = u_int *address

The *address* argument is the address of the extended characteristics buffer's descriptor. The below figure shows the format of the extended characteristics buffer and its descriptor.



The below table lists the port characteristics you can set. The characteristics remain set, even after you close the port, until you change them with another `IO$_SETMODE` operation.

PID	Meaning

0	**Local internet address.** Longword with the local host's internet or multicast address. If used, must be a valid local internet or multicast address. Set this parameter only if the port is not open. Specify in internet byte order, reversed from the normal VMS byte order. For example, internet address 2.3.4.5 is stored as ^X05040302. To determine if an internet address is local, issue an `IO$_SETMODE \| IO$M_CTRL` function specifying the address in this characteristic. If the address is not local, the function returns an `SS$_BADPARAM` status.
1	**Local port number.** Low order word of the longword containing the port number. If omitted, the function uses the unique port number generated when you assign the UDP device unit. Set this parameter only if the port is not open. If you use `0`, the function generates a new, unique number. Specify in normal VMS byte order.
2	**Peer internet address.** Longword with the peer host's internet address. If you specify both the peer's internet address and port number after opening the port (or when the port is opened) the port is considered fully specified (or opened as fully specified) and all further receive requests receive datagrams from that address and port only. Transmitted requests that do not provide a source/destination buffer are sent to that address and port. Specify in internet byte order, as the local internet address characteristic above. Using `0` functionally omits the address.
3	**Peer port number.** Low order word of the longword containing the port number. (See PID 2 above.) Specify in normal VMS byte order. Using `0` functionally omits the port number.
7	**Shared access control.** Longword that specifies whether others can (shared access) or cannot (exclusive access) use the same local port number. For shared access (used primarily by servers), the value must be non-zero. You can open any number of ports on the local port number. Received datagrams are placed in a common queue so that the first receive on any of these opened ports returns the next datagram. For exclusive access (the default), the longword value must be `0`.
9	**Change ownership.** Longword that allows the current owner of the device unit to prepare to pass ownership to another process. Removes the owner's process ID from the connection. If the value field is non-zero, specifies the new owner UIC for the connection and changes the

	connection protection so that only system and owner have access (`S:RWLP,O:RWLP`). Changes the following fields for the connection: owner process ID, owner UIC, and device protection. Primarily the NETCP master server but also other programs use it.
10	**Set socket options.** Low order word of the longword value field containing the mask value of the socket options to set. Specify the following options, as defined in the `TCPWARE_INCLUDE:SOCKET.H` header file (the values are in hexadecimal): `SO_DEBUG`, with a value of 0001, enables debugging (ignored) `SO_REUSEADDR`, with a value of 0004, allows reuse of local address (controllable through the passive open access control parameter `SO_KEEPALIVE`, with a value of 0008, keeps connections alive `SO_DONTROUTE`, with a value of 0010, prevents routing (ignored) `SO_BROADCAST`, with a value of 0020, enables use of broadcasts (ignored) `SO_USELOOPBACK`, with a value of 0040, bypasses hardware when possible (ignored)
11	**Clear socket options.** Low order word of the longword value field containing the mask of the socket options to clear. (See the options under PID 10 above.)
13	**IP options.** Counted string containing the IP options to be included in datagrams.
14	**IP TTL.** Low byte of the longword containing the time-to-live (TTL) for datagrams.
15	**IP TOS.** Low byte of the longword containing the type of service (TOS) for datagrams.
16	**Join multicast group.** Counted string of eight bytes of which the first longword contains the multicast group IP address to join, and the last longword contains the IP address of the local interface on which to join the group. If `0`, the default interface is used.
17	**Leave multicast group.** Counted string of eight bytes of which the first longword contains the multicast group IP address to leave, and the last longword contains the IP address of the local interface from which to leave the group. If `0`, the default interface is used.

18	**Multicast interface.** Longword with the IP address of the local interface to use in sending multicast datagrams. If `0`, the default interface is used.
19	**Multicast TTL.** Longword of which the low byte contains the time-to-live (TTL) for multicast datagrams transmitted.
20	**Multicast loopback.** Longword of which the low byte is `0` to disable, or `1` to enable local loopback of multicast datagrams.

Status

`SS$_BADPARAM`	Bad parameter or value specified PID returned in low order word of second longword
`SS$_DEVACTIVE`	Port is open, and you made a request to change a parameter that cannot be changed when the port is open
`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_DUPUNIT`	Multicast group address already joined
`SS$_INSFMEM`	Insufficient memory to complete request
`SS$_IVBUFLEN`	Extended characteristics buffer length invalid
`SS$_NOPRIV`	Setting IP layer options (PIDs 13 through 20) requires privileges Application must either be running under SYSTEM UIC or have SYSPRV, BYPASS, or OPER privilege
`SS$_NORMAL`	Success Characteristics set
`SS$_TOOMUCHDATA`	Too many multicast group addresses specified

`SS$_UNREACHABLE`	Default interface for multicast group address could not be found Specify local interface's IP address when joining multicast group

IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN

Closes a previously opened port.

After you issue this modifier, any received datagrams are discarded.

Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN, iosb,
astadr, astprm, 0, 0, 0, 0, 0, 0);
```

Arguments

None.

Status

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_NORMAL`	Success Port is now (or was) closed Port can no longer receive datagrams; however, datagrams can still be sent

IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP

Opens a new receive port. When opening a new receive port, you have a choice of either fully or partially specifying the port characteristics.

To open a fully specified port, you must specify both the peer's internet address and port number. UDPDRIVER then delivers only datagrams received from that address and port and destined for the local port number.

To open a partially specified port, do not specify the peer's internet address and port number. UDPDRIVER then delivers all datagrams destined for the local port number, except those to be delivered to fully specified ports for the same local port number. You can convert a partially specified port into a fully specified port by issuing a `IO$_SETMODE | IO$M_CTRL` function and specifying both the peer's internet address and port number.

Format

```
status = SYS$QIO(efn, chan, IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP, iosb,
astadr, astprm, 0, address, 0, 0, 0, 0);
```

Argument

p2* = u_int *address

Address of the descriptor for the extended characteristics buffer. See the previous `IO$_SENSEMODE | IO$M_CTRL` function description for details on the extended characteristics buffer.

Note: You only need to open ports if you are to receive datagrams. You can send datagrams whether or not you open the port.

Status

`SS$_BADPARAM`	Bad parameter or value specified PID returned in low order word of second longword

`SS$_DEVACTIVE`	Port is already open
`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_DUPUNIT`	Specified port number is already in use by another user, and that user or you did not request shared access
`SS$_NOPRIV`	Insufficient privilege Program tried to open local port below 1024, but program does not have BYPASS or SYSPRV privilege
`SS$_NORMAL`	Success Port is open and ready for receives
`SS$_THIRDPARTY`	Port closed by third party Usually indicates that TCPware was shut down.

IO$_WRITEVBLK

Sends a datagram stored in a single user buffer.

The `IO$M_NOFORMAT` modifier suppresses checksum generation at the UDP level.

Format

```
status = SYS$QIO(efn, chan,IO$_WRITEVBLK, iosb, astadr, astprm,buffer, size,
address, 0, 0, 0);
```

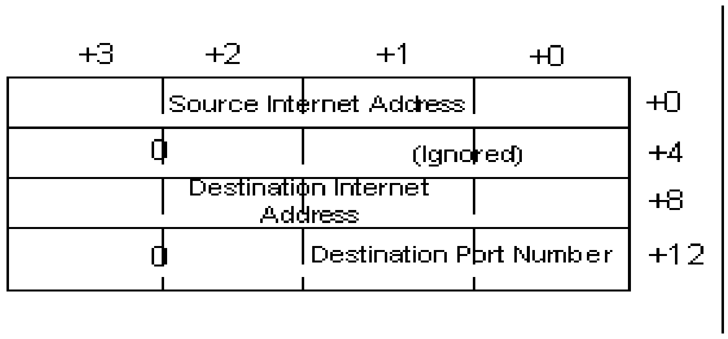
Arguments

p1 = byte *buffer
Address of the buffer that contains the data to be sent.

p2 = u_int size
User's buffer size in bytes (the byte count), which is the amount of data that the user is sending. The value should not be greater than 64000 bytes.

p3 = u_long address
Address of the optional 4-longword source/destination buffer. The source and destination internet address and port number specified in this buffer are used to transmit the datagram.

The below figure shows the buffer format.



You can use any destination port. You can specify the source internet address, which must be a valid local address, or specify it as `0`. When you specify the address as `0`, UDPDRIVER supplies the appropriate local internet address. You must specify internet addresses in internet byte order, which is reversed from the normal VMS byte order. For example, internet address 2.3.4.5 is stored as ^X05040302.

If you do not specify the address buffer or if fields in this buffer are `0`, UDPDRIVER uses the port's characteristic values set using the `IO$_SETMODE | IO$M_CTRL` or `IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP` functions for the unspecified fields.

To broadcast a datagram, you must either specify the source address and a destination address of 255.255.255.255, or specify a local network's broadcast address. The local network's broadcast address is an address with all bits set (or cleared) for the host number portion of the internet address.

Status

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_IVBUFLEN`	User's buffer too large
`SS$_NORMAL`	Success Datagram was transmitted
`SS$_OPINCOMPL`	Datagram not transmitted because no destination internet address or port number was specified by source/destination buffer or port's characteristics
`SS$_THIRDPARTY`	TCPware shut down
`SS$_UNREACHABLE`	No route to specified destination internet address

The number of bytes sent are returned in the high-order word of the first longword of the I/O status block.

IO$_WRITEVBLK | IO$M_EXTEND

Sends a datagram stored in an array of buffers.

The `IO$M_NOFORMAT` modifier suppresses checksum generation at the UDP level.

Format

```
status = SYS$QIO(efn, chan, IO$_WRITEVBLK | IO$M_EXTEND,iosb, astadr,
astprm,msghdr, size, 0, 0, 0, 0);
```

Arguments

p1 = u_long *msghdr

Address of the `msghdr` structure. Points to the address of the structure storing the array of additional structures. Each of these array structures contains the address and size of one of the user buffers.

p2 = u_long size

Size of the `msghdr` structure. The size must be 24 bytes.

For details on the `msghdr` structure and an example of using the scatter-gather write function, see Chapter 3, *TCPDRIVER Services*.

Status

`SS$_DEVINACT`	Device not active Contact system manager why TCPware (or TCPDRIVER) not started
`SS$_IVBUFLEN`	User's buffer too large
`SS$_NORMAL`	Success Datagram was transmitted
`SS$_OPINCOMPL`	Datagram not transmitted because no destination internet address or port number was specified by source/destination buffer or port's characteristics

`SS$_THIRDPARTY`	TCPware shut down
`SS$_UNREACHABLE`	No route to specified destination internet address

The number of bytes sent are returned in the high-order word of the first longword of the I/O status block.

SYS$ASSIGN

Assigns a channel to a device.

Format

status = `SYS$ASSIGN(char *`*devnam*`, u_int *`*chan*`, [unsigned long `*acmode*`], [char *`*mbxnam*`]);`

Arguments

devnam

Address of a character string descriptor pointing to the device name string (`UDP0:`).

chan

Address of a word into which `SYS$ASSIGN` writes the channel number.

acmode

Optional access mode associated with the channel. The most privileged access mode used is that of the caller.

mbxnam

Optional logical mailbox associated with the device.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$CANCEL

Cancels any I/O that is pending on a channel. The I/O will be completed with an `iosb` status of `SS$_CANCEL`.

Outstanding I/O operations are automatically cancelled at image exit.

Format

```
status = SYS$CANCEL(u_int chan);
```

Argument

chan
Number of the channel to be canceled.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$DASSGN

Releases a channel.

When you deassign a channel, any outstanding I/O is completed with an *iosb* status of `SS$_CANCEL`.

I/O channels are automatically deassigned at image exit.

Format

```
status = SYS$DASSGN(u_int chan);
```

Argument

chan
Number of the channel to be deassigned.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

Sample Programs

C Programs

The following sample programs, which show the use of `SYS$QIO` system service calls to the UDPDRIVER to set up a DISCARD client and server, are included in the `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory:

- `UDPDRIVER_CLIENT.C`
- `UDPDRIVER_SERVER.C`

The client sequence of operations is as follows:

1. Assigns an I/O channel to `UDP0`, using `SYS$ASSIGN`.
2. Sends data using `$QIO` with `IO$_WRITEVBLK`.
3. Deassigns the channel, using `SYS$DASSGN`.

The server sequence of operations is as follows:

1. Assigns an I/O channel to `UDP0`, using `SYS$ASSIGN`.
2. Opens a receive port, using `$QIO(IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP).`
3. Exchanges data, using `$QIO(IO$_WRITEVBLK) and $QIO(IO$_READVBLK).`
4. Closes the port, using `$QIO(IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN).`
5. Deassigns the channel, using `SYS$DASSGN`.

To build any one of these applications using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL filename
$ LINK filename
Ctrl+Z
```

To build any one of these applications using VAX C, enter:

```
$ CC/VAXC filename
$ LINK filename, TCPWARE:UCX$IPC/LIB, SYS$INPUT/OPTIONS -
_$  SYS$SHARE:VAXCRTL/SHARE
Ctrl+Z
```

FORTRAN Program

The `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory also includes a `UDPSAMPLES.FOR` FORTRAN language file that transmits or receives data. This program links to the TCPware Socket Library as follows:

VAX

```
$ FORTRAN TCPWARE_ROOT:[TCPWARE.EXAMPLES]UDPSAMPLE
$ LINK UDPSAMPLE, SYS$INPUT/OPTIONS
    SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
Ctrl+Z
```

Alpha and I64

```
$ FORTRAN/NOALIGN TCPWARE_ROOT:[TCPWARE.EXAMPLES]UDPSAMPLE
$ LINK UDPSAMPLE, SYS$INPUT/OPTIONS
    SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
Ctrl+Z
```

5. IPDRIVER Services

Introduction

This chapter describes the IP device driver (IPDRIVER) services. It describes both the user and external interfaces of this IP implementation:

- The user interface exists above the IP layer, de-multiplexing received datagrams, as described below.
- The external interface provides a method by which you can support four types of network interfaces. The program you create is responsible for sending and receiving raw IP datagrams over the network interface.

IP does not include end-to-end data reliability, flow control, sequencing, or other services usually found in host-to-host protocols. Since TCP does include these services, you should use TCP unless the applications programs intend to implement or do not require these services.

IP services are available through the OpenVMS Queue I/O (`SYS$QIO` and `SYS$QIOW`) system services. Functions are provided to open and close a port, and to transmit and receive datagrams.

`SYS$QIOW` is the synchronous and `SYS$QIO` the asynchronous form of VMS system services. Use each form depending on your application's requirements.

The IPDRIVER uses ports to demultiplex received datagrams. When an IP datagram is received, IPDRIVER validates the header and searches for a port opened on the protocol number indicated within the datagram's internet header. If no port is opened for that protocol or that port has no outstanding receive, IPDRIVER discards the datagram.

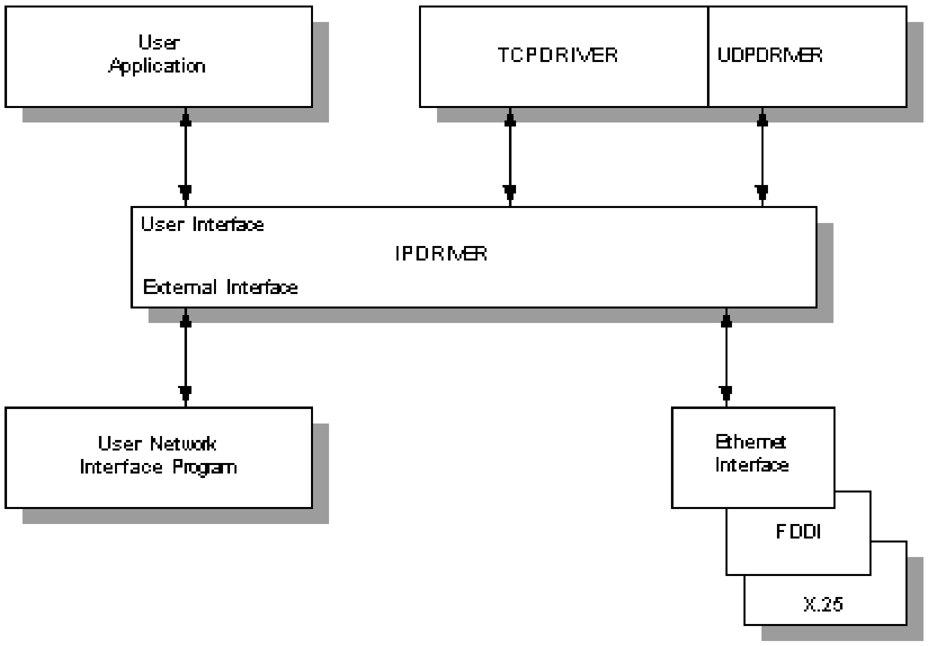
See the below figure for an illustration of the user interface and external interface working with IPDRIVER. The IP specifications are in RFC 791.

The external interface is intended primarily for sites that use proprietary network hardware. This interface lets you write programs that support the use of IPDRIVER with various network controllers. This chapter refers to these programs as Network Interface Programs.

Basically, the Network Interface Programs perform two functions:

- Delivery of received datagrams to IPDRIVER for processing.
- Receiving of datagrams from IPDRIVER for transmission.

These programs do not handle IP activities such as routing, fragmentation and reassembly, or datagram validation. IPDRIVER performs these activities.



Sequence of Operations

Perform the following sequence of operations to open a port:

1. Assign an I/O channel to `IPA0:` with the `SYS$ASSIGN` system service. `SYS$ASSIGN` creates a new device unit and assigns to it the channel for the port.
2. Open the port with the `IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP` function of the `SYS$QIO` or `SYS$QIOW` system service.
3. Perform read requests with the `IO$_READVBLK` function and write requests with the `IO$_WRITEVBLK` function to receive and transmit datagrams as desired.
4. Close the port with the `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN` function.
5. Deassign the I/O channel with the `SYS$DASSGN` system service.

See the appropriate OpenVMS documentation for information on the OpenVMS I/O system services (`SYS$ASSIGN`, `SYS$CANCEL`, `SYS$DASSGN`, `SYS$QIO`, and `SYS$QIOW`) and on related system services, such as asynchronous system trap (AST) and event flag services.

Other Operations

In addition to the sequence of operations described above, IPDRIVER includes other operations that:

Read the network device information, read the ARP table, or read the routing table with	`IO$_SENSEMODE \| IO$M_CTRL`
Read the IP counters with	`IO$_SENSEMODE \| IO$M_RD_COUNT`

Internet Protocol Implementation Notes

The material presented here does not explain or describe the Internet Protocol (IP).

TCPware for OpenVMS implements IP Version 4, and the following restrictions apply:

- The type of service field is ignored.
- All options are ignored (options may be present in incoming datagrams). Options are copied to fragmented datagrams as required by the Internet Protocol specification.
- The TCPware host may send the following Internet Control Message Protocol (ICMP) messages:

`Destination unreachable`	When the datagram cannot be forwarded or the destination port is not active
`Echo`	In response to a echo request
`Parameter problem`	When you enable forwarding and the datagram contains a parameter error
`Redirect`	When you enable forwarding and the forwarded datagram exits by the same interface on which it was received (see the NETCU ENABLE FORWARDING command)

`Timestamp reply`	In response to a timestamp request

IPDRIVER System Service Call Format

The format for the IPDRIVER `SYS$QIO` system service call is as follows:

```
status = SYS$QIO[W]( u_long efn, u_int chan, u_long func, unsigned quadword
*iosb, void *astadr, u_long astprm, p1, p2, p3, p4, p5, p6);
```

`SYS$QIO` or `SYS$QIOW` issues IP functions.

`SYS$QIO` is for asynchronous service completion, specifying that the service return to the caller immediately after queuing the I/O request.

`SYS$QIOW` is for synchronous service completion, specifying that the service place the calling process in a wait state and only return to the caller after completing the I/O operation.

The OpenVMS IODEF module provides definitions for the `SYS$QIO` function codes.

Note: The vertical bar (`|`) used in some of the functions described in this chapter is the C bitwise inclusive OR operator.

IPDRIVER System Service Call Arguments

You invoke IPDRIVER system service calls with the standard OpenVMS QIO mechanism.

See the appropriate OpenVMS documentation (for example, the Introduction to VMS System Services volume) for details on the QIO mechanism.

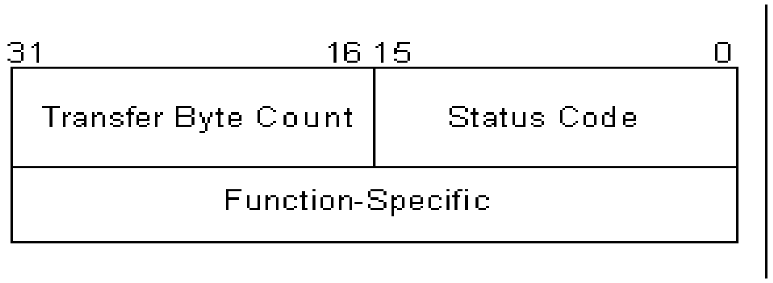
The following sections describe each system call argument.

efn
Number of the event flag set by completion of the I/O operation. The argument is optional.

chan
I/O channel assigned to the IP device to which you are directing the request.

func
Device-specific function code and the modifier, if appropriate, for each operation.

iosb
I/O status block that receives the final completion status of the I/O operation, structured as in the below figure.



The below table describes the status block fields in more detail.

Field Name	**Description**
Function-Specific	Varies for each function code.
Status Code	`SS$` status code or special error status code. If the low bit (0) of the OpenVMS error code is clear, the network returned an error.
Transfer Byte Count	Number of bytes of data transferred in the I/O operation.

astadr
Address of the asynchronous system trap (AST) routine executed when the I/O is completed.

astprm

AST parameter to be passed to the AST routine.

`p1`…`p6`
Function-specific parameters, as described for each function.

IPDRIVER User Interface System Service Call Function Codes

System service call function codes specify what action the QIO performs. This section describes the following function codes for the User Interface:

`IO$_READVBLK`	`IO$_SETMODE \| IO$M_CTRL`
`IO$_SENSEMODE \| IO$M_RD_COUNT`	`IO$_SETMODE \| IO$M_CTRL | IO$M_STARTUP`
`IO$_SENSEMODE`	`IO$_SETMODE \| IO$M_CTRL | IO$M_SHUTDOWN`
`IO$_SENSEMODE \| IO$M_CTRL`	`IO$_WRITEVBLK`

IO$_READVBLK

Receives a datagram. The data received is written to the specified user buffer.

Note: IPDRIVER delivers ICMP messages received for the active protocol. It is up to the application to check the "protocol" field in the received datagram to determine if the received datagram is an ICMP message. IPDRIVER can deliver the following ICMP messages: destination unreachable, time exceeded, parameter problem, source quench, and redirect.

Note: A copy of a broadcast or multicast datagram is looped back by default. This means that your application receives its own broadcast and multicast datagrams.

Format

```
status = SYS$QIO(efn, chan,IO$_READVBLK,iosb, astadr, astprm, buffer,
size,0, 0, 0, 0);
```

Arguments

`p1 = byte *buffer`

Address of the user’s buffer that receives the datagram. This buffer must be large enough to store the internet header as well as the expected data. The maximum size of an internet header is 60 bytes.

`p2 = u_int size`

User’s buffer size in bytes (the byte count). This is the amount of data the user is willing to receive (including the internet header). The value should not be greater than 65000 bytes.

The internet header contains the following fields:

Destination internet address (i.e., the local internet address)	Longword at an offset of 16 bytes into the header. Stored in internet byte order.

Identification	Word at an offset of 4 bytes into the header. Stored in internet byte order.
Options	Variable length buffer (internet header size - 20) at an offset of 20 bytes into the header.
Source internet address	Longword at an offset of 12 bytes into the header. Stored in internet byte order.
Time to Live	Byte at an offset of 8 bytes into the header.
Type of Service	Byte at an offset of 1 byte into the header.

See RFC 791 for details on the internet header.

Status

`SS$ABORT`	Request aborted due to closed connection
`SS$_BUFFEROVF`	User's buffer was too small for entire datagram Truncated datagram is returned Remainder of datagram is lost
`SS$_CANCEL`	Request cancelled
`SS$_DEVINACT`	Device not active or port was not opened
`SS$_NODATA`	No datagram is available and IO$M_NOW was specified
`SS$_NORMAL`	Success Datagram received

The number of bytes of the entire datagram (including the internet header) is returned in the high-order word of the first longword of the I/O status block. The size (in bytes) of the internet header is returned in the low-order word of the second longword. The size (in bytes) of the data within the datagram is returned in the high-order word of the second longword.

IO$_SENSEMODE | IO$M_CTRL

Performs the following functions:

- Reads extended characteristics
- Reads network device information
- Reads the ARP table
- Reads the routing table

Format

```
status = SYS$QIO(efn, chan, IO$_SENSEMODE | IO$M_CTRL,iosb, astadr, astprm,
buffer, address, function, line-id, 0, 0);
```

Arguments

p1 = byte *buffer

Optional address of the 8-byte device characteristics buffer. The data returned is the device class (`DC$_SCOM`) in the first byte, the device type (`0`) in the second byte, and the default buffer size (`0`) in the high-order word of the first longword. The second longword is returned as `0`.

p2 = u_int *address

Address of the descriptor for the buffer to receive the information. The format of the buffer depends on the information requested. Each buffer format is described separately in the section that follows.

If bit 12 (mask 4096) is set in the parameter identifier (PID), the PID is followed by a counted string. If bit 12 is clear, the PID is followed by a longword value. While TCPware currently never returns a counted string for a parameter, this may change in the future.

p3 = u_long function

Code that designates the function. The function codes are shown in the below table.

Code	Function
`0`	Read extended characteristics
`1`	Read network device information

`2`	Read routing table
`3`	Read ARP table
`8`	Read routing table (includes CIDR-related mask information)
`9`	Returns a record for each interface in the following format: Line Id Bytes Transmitted Bytes Received All values are longwords.

`p3` function code 8 is a superset of function code 2. Both read the routing table, although the output is different. For details, see the *Reading the Routing Table* section.

p4* = u_long *line-id
Specify this argument only if you are reading a network device's ARP table function.

Reading Extended Characteristics

Use `IO$_SENSEMODE | IO$M_CTRL` with *`function`*`=0` to read the extended characteristics. The information returned consists of one or more records, each record containing a word parameter identifier (PID) value followed by either a longword or a counted string. A counted string consists of a word length followed by the specified number of bytes. The parameters that can be returned are listed in the below table.

PID	**Meaning**
14	**IP TTL.** Longword. Low byte of the longword contains the time-to-live (TTL).
15	**IP TOS.** Longword. Low byte of the longword contains the type of service (TOS).

18	**Multicast interface.** Longword. IP address of the local interface to use in sending multicast datagrams. If `0`, the default interface is used.
19	**Multicast TTL.** Longword. Low byte contains the time-to-live (TTL) to be used in sending multicast datagrams.
20	**Multicast loopback.** Longword. Low byte is 0 to disable and 1 to enable local loopback of multicast datagrams.

Reading Network Device Information

Use `IO$_SENSEMODE | IO$M_CTRL` with *p3*=`1` to read network device information. The information returned in the buffer (specified by *p2*=*address*) can consist of multiple records. Each record consists of nine longwords, and one record is returned for each device.

The `SHOW NETWORKS` command in NETCU uses this function.

When you read network device information, the data in each record is returned in the order presented below. All are longword values.

1. Line id (see the description of the line-id argument)
2. Line’s local internet address
3. Line’s internet address network mask
4. Line’s maximum transmission unit (MTU) in the low-order word, and the line flags in the high-order word
5. Number of packets transmitted (includes ARP packets for Ethernet lines)
6. Number of transmit errors
7. Number of packets received (includes ARP and trailer packets for Ethernet lines)
8. Number of receive errors
9. Number of received packets discarded due to insufficient buffer space

Reading the Routing Table

Use `IO$_SENSEMODE | IO$M_CTRL` with *p3*=`2` or *p3*=`8` to read the routing table. The information returned in the buffer (specified by *p2*=*address*) can consist of multiple records. Each record consists of five longwords, and one record is returned for each table entry.

The `SHOW ROUTES` command in NETCU uses this function.

The `p3=8` function returns full routing information and is a superset of `p3=2`, which was retained for backwards compatibility with existing programs. `p3=2` and `p3=8` return the same table of routing entries, in the following order, except that `p3=2` does not return items 7 and 8 (address mask and Path MTU):

1	**Destination internet address.**	Destination host or network to which the datagram is bound. Returned as a longword value.
2	**Gateway internet address.**	Internet address to which the datagram for this route is transmitted. Returned as a longword value.
3	**Flags.**	Routing table entry's flag bits. Returned as a word value: Mask 1, name `GATEWAY`, if set, the route is to a gateway (the datagram is sent to the gateway internet address). If clear, the route is a direct route. Mask 2, name `HOST`, if set, the route is for a host. If clear, the route is for a network. Mask 4, name `DYNAMIC`, if set, the route was created by a received ICMP redirect message. Mask 8, name `AUTOMATIC`, if set, this route was added by TCPWARE_RAPD process and will be modified or remoted by that process as appropriate. Mask 16, name `LOCKED`, if set, the route cannot be changed by an ICMP redirect message. Mask 32, name `INTERFACE`, if set, the route is for a network interface.

		Mask 64, name `DELETED`, if set, the route is marked for deletion (it is deleted when the reference count reaches 0). Mask 128, name `POSSDOWN`, if set, the route is marked as possibly down.
4	**Reference count.**	Number of connections currently using the route. Returned as a word value.
5	**Use count.**	Number of times the route has been used for outgoing traffic. Returned as a longword value.
6	**Line ID.**	Line identification for the network device used to transmit the datagram to the destination. See the description of the line-id argument later in this section for the line ID codes. The following table shows the line identification values
7	**Address mask.**	Address mask for the destination address. Returned as a longword value.
8	**Path MTU.**	Path maximum transmission unit. Returned as a longword value.

Line ID Values:

Line ID	**Line ID Value**
`LPB-0`	`^X00000001`
`PRO-`*`n`*	`^X00`*`nn`*`0003`
`HYP-`*`n`*	`^X00`*`nn`*`0004`
`X25-`*`n`*	`^X00`*`nn`*`0006`
`UNA-`*`n`*	`^X00`*`nn`*`0102`
`DSV-`*`n`*	`^X00`*`nn`*`0105`

SLIP-*n*	^X00*nn*0141
QNA-*n*	^X00*nn*0202
DSB-*n*	^X00*nn*0205
DECNET-*n*	^X00*nn*0241
BNA-*n*	^X00*nn*0302
DST-*n*	^X00*nn*0305
PPP-*n*	^X00*nn*0341
SVA-*n*	^X00*nn*0402
MNA-*n*	^X00*nn*0502
ISA-*n*	^X00*nn*0602
KFE-*n*	^X00*nn*0702
MXE-*n*	^X00*nn*0802
ERA-*n*	^X00*nn*0902
EWA-*n*	^X00*nn*0A02
CLIP-*n*	^X00*nn*2002
ELA-*n*	^X00*nn*2102
MFA-*n*	^X00*nn*4102
FZA-*n*	^X00*nn*4202
FAA-*n*	^X00*nn*4302
FEA-*n*	^X00*nn*4402
FQA-*n*	^X00*nn*4502

`TRA-`*`n`*	`^X00`*`nn`*`6102`
`TRE-`*`n`*	`^X00`*`nn`*`6202`

Note: The I/O status block (*`iosb`*) returns routing table entry size information for the *`p3`*=8 function to assist in diagnosing buffer overflow situations. See the *Status* section for details.

Reading the ARP Table Function

Use `IO$_SENSEMODE | IO$M_CTRL` with *`function`*`=3` to read a network device's ARP table function. The information returned in the buffer (specified by *`p2=address`*) depends on the line ID specified in *`line-id`*. The `SHOW ARP` command in NETCU uses this function.

The *`line-id`* argument is the line ID and is a longword value. The least significant byte of the line ID is the major device type code. The next byte is the device type subcode. The next byte is the controller unit number. The most significant byte is ignored.

The information returned in the buffer can consist of multiple records. Each record consists of 12 bytes, and one record is returned for each ARP table entry.

When reading a table function, the data in each record is returned in the following order:

1	**Internet address.**	Returned as a longword value.
2	**Physical address.**	Returned as a 6 byte value.
3	**Flags.**	Returned as a word value. The ARP table entry's flag bits are shown in the following table.

ARP Table Entry Flag Bits:

Mask	Name	Description
1	PERMANENT	If set, the entry can only be removed by a `NETCU REMOVE ARP` command and if RARP is enabled, the local host responds if a RARP request is received for this address. If clear, the entry can be removed if not used within a short period.
2	PUBLISH	If set, the local host responds to ARP requests for the internet address (this bit is usually only set for the local host's entry). If clear, the local host does not respond to received ARP requests for this address.
4	LOCKED	If set, the physical address cannot be changed by received ARP requests/replies.
4096	LASTUSED	If set, last reference to entry was a use rather than an update.
8192	CONFNEED	If set, confirmation needed on next use.
16384	CONFPEND	If set, confirmation pending.
32768	RESOLVED	If set, the physical address is valid.

Status

SS$_BADPARAM	Code specified in *function* argument invalid
SS$_BUFFEROVF	Buffer too small for all information Truncated buffer returned.
SS$_DEVINACT	Device not active Contact your system manager to determine why TCPware was not started
SS$_NORMAL	Success Requested information returned
SS$NOSUCHDEV	Line identification specified in *arp* argument does not exist

The byte count for the information or counters buffer is returned in the high-order word of the first longword of the I/O status block. This can be less than the bytes requested.

- For the `p3=2` routing table function, in the second longword of the I/O status block, bit 0 is always set, bit 1 is set if the forwarding capability is enabled, and bit 2 is set if ARP replies for non-local internet addresses are enabled.
- For the `p3=8` routing table function, the IOSB contains the following:

Status Code	`SS$_NORMAL` or `SS$_BUFFEROVF`
Transfer Byte Count	Number of bytes of returned information
Entry Size	Number of bytes in each entry
Number of Entries	Number of entries in the routing table

If the status is `SS$_BUFFEROVF`, you can determine the number of routing entries actually returned by calculating (Transfer Byte Count) DIV (Entry Size) and comparing that with the Number of Entries value. Be sure to check the Entry Size in the IO status block. Later versions of TCPware may return more information for each entry, which will return a larger Entry Size. Any additional information to be returned in the future will be added to the end of the returned entry.

IO$_SENSEMODE | IO$M_RD_COUNT

Reads the IP counters.

The `IO$M_CLR_COUNT` modifier with this function zeros the counters after they are read. Using `IO$M_CLR_COUNT` requires the OPER privilege.

Format

```
status = SYS$QIO(efn, chan,IO$_SENSEMODE | IO$M_RD_COUNT, iosb, astadr,
astprm, buffer, address, 0, 0, 0, 0);
```

Arguments

***p1* = byte *buffer**

Optional address of the 8-byte device characteristics buffer. The data returned is the device class (`DC$_SCOM`) in the first byte, the device type (0) in the second byte, and the default buffer size (0) in the high-order word of the first longword. The second longword is returned as 0.

***p2* = u_long *address**

Address of the descriptor for the buffer to receive the information. The information returned in the buffer is a record that consists of eleven longwords. The data in the record is returned in the order below. Each value is a longword.

1. Number of seconds since last zeroed
2. Number of IP datagrams transmitted
3. Number of IP datagrams fragmented
4. Number of IP datagrams forwarded (if gateway capability is enabled)
5. Number of ICMP messages transmitted
6. Number of IP datagrams and fragments received
7. Number of IP fragments received
8. Number of ICMP messages received
9. Number of datagrams delivered to receivers
10. Number of IGMP messages transmitted
11. Number of IGMP messages received

Status

`SS$_BUFFEROVF`	Buffer too small for all characteristics Truncated characteristics buffer returned
`SS$_NOPRIV`	Insufficient privilege OPER privilege required to zero counters

The byte count for the counters buffer is returned in the high-order word of the first longword of the I/O status block. This is the actual number of bytes received, which may be less than what was requested.

IO$_SETMODE | IO$M_CTRL

Sets the port characteristics.

Format

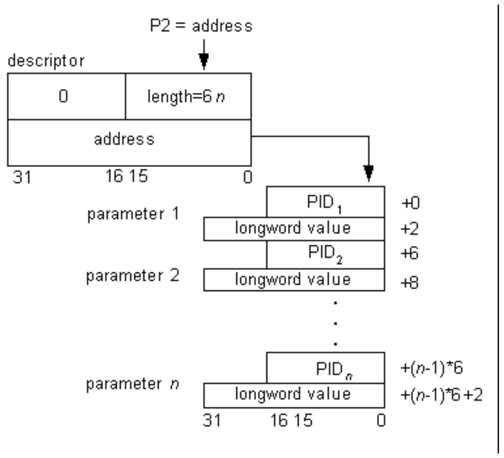
`status = SYS$QIO(efn, chan,IO$_SETMODE | IO$M_CTRL, iosb, astadr, astprm, 0, address, 0, 0, 0, 0);`

Argument

p2 = u_int *address

`IO$_SETMODE` | `IO$M_CTRL` sets the port characteristics in the extended characteristics buffer. The buffer consists of a series of six-byte or counted string entries. The first word of each entry contains the parameter identifier (PID) of a characteristic, followed by either a longword that contains the value for that characteristic or a counted string. Counted strings consist of a word with the size of the character string followed by the character string.

The address argument is the address of the descriptor for the extended characteristics buffer. The below diagram shows the format of the descriptor for the extended characteristics buffer and the extended characteristics buffer.



The below table lists the port characteristics you can set.

PID	Meaning
13	**IP options.** Counted string. Internet Protocol options to be included in datagrams to be transmitted.

`14`	**IP TTL.** Longword. Low byte of the longword contains the time-to-live (TTL) to be used in datagrams to be transmitted.
`15`	**IP TOS.** Longword. Low byte of the longword contains the type of service (TOS) to be used in datagrams to be transmitted.
`16`	**Join multicast group.** Counted string of eight bytes. First longword contains the multicast group IP address to join. Last longword contains the IP address of the local interface on which to join the group (if 0, the default interface is used).
`17`	**Leave multicast group.** (See the previous PID.)
`18`	**Multicast Interface.** Longword. IP address of the local interface to use in sending multicast datagrams. If 0, the default interface is used.
`19`	**Multicast TTL.** Longword. Low byte contains the time-to-live (TTL) to be used in multicast datagrams to be transmitted.
`20`	**Multicast loopback.** Longword. Low byte is 0 to disable and 1 to enable local loopback of multicast datagrams.

Note: The above parameters remain set even after you close the port until you change them with another `IO$_SETMODE` operation

Status

`SS$_BADPARAM`	Specified bad parameter or parameter value Returns PID in low order word of second longword
`SS$_DEVACTIVE`	Port is open, and you made request to change parameter that cannot be changed when port is open

`SS$_DEVINACT`	Device is not active Contact your system manager to determine why TCPware (or IPDRIVER) was not started
`SS$_DUPINIT`	Multicast group address already joined
`SS$_INSFMEM`	Insufficient memory to complete request
`SS$_IVBUFLEN`	Extended characteristics buffer length invalid
`SS$_NOPRIV`	Setting IP layer options (PIDs 13 through 20) requires privileges Application must either be running under SYSTEM UIC or have SYSPRV, BYPASS, or OPER privilege
`SS$_NORMAL`	Success Characteristics set
`SS$_TOOMUCHDATA`	Too many multicast group addresses specified
`SS$_UNREACHABLE`	No default interface for multicast group address could not be found Specify local interface’s IP address when joining multicast group

IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN

Closes a port.

Closing a port aborts all pending receives for the port, prevents further receives and transmissions on the port, and lets another user use the protocol number.

Format

```
status = SYS$QIO(efn, chan,IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN,iosb,
astadr, astprm, 0, 0, 0, 0, 0, 0);
```

Arguments

None.

Status

`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware (or IPDRIVER) was not started
`SS$_NORMAL`	Success Port now (or was) closed Port can no longer receive any datagrams; however, datagrams can still be sent
`SS$_NOPRIV`	Insufficient privileges BYPASS or SYSPRV privilege required to open port

IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP

Opens a port. Opening a port lets you receive internet datagrams.

Requires BYPASS or SYSPRV privileges.

Format

```
status = SYS$QIO(efn, chan,IO$_SETMODE | IO$M_CTRL | IO$M_STARTUP, iosb,
astadr, astprm, 0, 0, protocol, num, 0, 0);
```

Arguments

p3 = u_int *protocol*

Internet protocol number in the low byte. Datagrams are transmitted using this protocol number, and you can only receive datagrams with it.

See the latest Assigned Numbers RFC for a list of the currently assigned protocol numbers.

p4 = u_long *num*

Number of unsolicited receives to be queued for delivery. A value of 0 to 5 is valid. 0 results in all unsolicited receives being discarded.

Status

`SS$_DEVACTIVE`	Port already open
`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware was not started
`SS$_DUPUNIT`	Specified port number already in use by another port
`SS$_NOPRIV`	Insufficient privileges You need BYPASS or SYSPRV privilege to open port
`SS$NORMAL`	Success Port open and write and read functions can be used to transmit or receive datagrams

IO$_WRITEVBLK

Sends data. This builds and transmits the datagram using the protocol number for the port.

The `IO$M_NOFORMAT` modifier prevents fragmentation. This sets the “don’t fragment” bit in the IP datagram.

The `IO$M_FORCEPATH` modifier prevents routing on the datagram. This limits the datagram to be sent to a locally connected address.

The `IO$M_LPBEXT` modifier inhibits a copy of a broadcast or multicast datagram from being looped back.

Format

```
status = SYS$QIO(efn, chan,IO$_WRITEVBLK,iosb, astadr, astprm, buffer, size,
address, dest, source, 0);
```

Arguments

p1 = byte **buffer*

User’s buffer address. This is the buffer that contains the data to be sent. The buffer does not include the internet header.

p2 = u_int *size*

User’s buffer size in bytes (the byte count). This is the amount of data that the user has to send. The value should not be greater than 65000 bytes.

If the resulting datagram is larger than the maximum transmission unit (MTU) for the network, the datagram is fragmented, unless you specified `IO$M_NOFORMAT`. In that case, `IO$_WRITEVBLK` returns an error.

p3 = u_int *address*

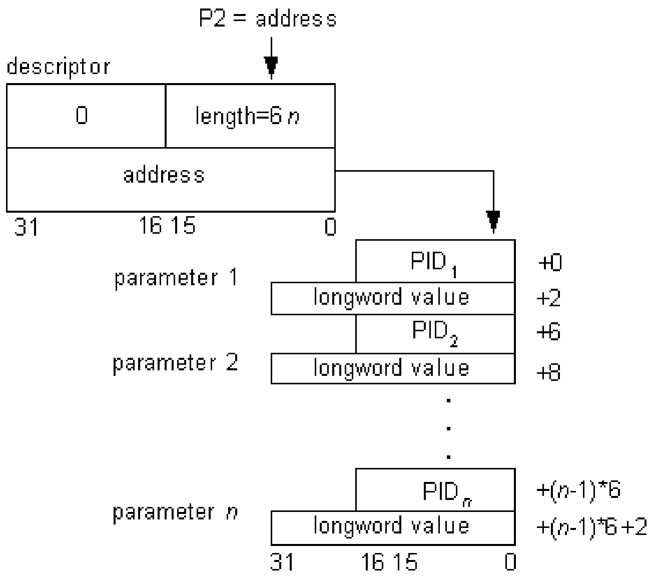
Address of the descriptor for the optional transmit characteristics buffer.

The transmit characteristics buffer consists of a series of 6-byte and counted string entries. The first word of each entry contains the parameter identifier (PID) followed either by a longword or by a counted string.

The PID determines whether a longword value or counted string follows. The longword contains one of the values that can be associated with that parameter. The counted string consists of a word byte count field followed by the specified number of bytes of data.

The below diagram shows the format of the descriptor for the extended characteristics buffer and the extended characteristics buffer.

The following table lists the characteristics you can specify.



PID	Meaning
1	**Type of service.** Low-order byte of the longword value. Contains the type of service. If omitted, the previously specified value or the default of 0 is used.
2	**Time to live.** Low-order byte of the longword value field. Contains the time to live. If not specified, the previously specified value of the default is used. The default time to live is specified by the `IPDEFAULTTTL` parameter for non-multicast datagrams and is 1 for multicast datagrams.
3	**Identification.** Low-order word of the longword value field. Contains the identification number. IPDRIVER automatically increments this value for each transmission (the initial value starts at 0).
4	**Options.** Counted string. Contains the internet options buffer. This buffer is used as is and is not validated. The maximum size of this counted string is 40 bytes. Note that if the options are

	not a multiple of 4 bytes, IPDRIVER adds the required padding (using the End of Option List option).
5	**Protocol.** Lowest-order byte of the longword value field. Contains the IP protocol number to be used in sending the datagram. Can be used to override the protocol under which this unit was opened.

See the specifications for the Internet Protocol (RFC 791) for details on each of the internet header items described above.

p4* = u_long *dest
Destination internet address. Internet addresses are specified in internet byte order (which is reversed from the normal VAX byte order). For example, internet address 2.3.4.5 is stored as ^X05040302. If the destination internet address is the loopback internet address, IPDRIVER loops-back the datagram.

p5* = u_long *source
Optional source internet address. Must be a valid local internet address (if specified). Internet addresses are specified in internet byte order (which is reversed from the normal VAX byte order). For example, internet address 2.3.4.5 is stored as ^X05040302.

Status

`SS$_BADPARAM`	Bad parameter or parameter value specified PID returned in low order word of second longword If parameter ID is `0`, source internet address is not valid (it is not local address)
`SS$_DEVINACT`	Device not active Contact your system manager to determine why TCPware (or IPDRIVER) was not started
`SS$_INSFMEM`	Insufficient memory available to fragment datagram
`SS$_INVSECLASS`	Basic Security Option label incompatible with outgoing IPSO settings
`SS$_IVBUFLEN`	User’s buffer too large

`SS$_NORMAL`	Success Datagram transmitted Failure of translation is not considered an error because datagram would most likely be retransmitted by higher level software at a later time Also allows some time for ARP reply to be received
`SS$_OPINCOMPL`	Datagram not transmitted because no destination internet address or port number was specified by source/destination bugger or port's characteristics
`SS$_THIRDPARTY`	TCPware shut down
`SS$_UNREACHABLE`	No route to the destination internet address exists Add route for destination or check internet address

The number of data bytes transmitted are returned in the high-order word of the first longword of the I/O status block.

SYS$ASSIGN

Assigns a channel to a device.

Format

```
status = SYS$ASSIGN (char *devnam, word *chan, [u_long acmode], [char
*mbxnam]);
```

Arguments

devnam
Address of a character string descriptor pointing to the device name string (`IPA0:`).

chan
Address of a word into which `SYS$ASSIGN` writes the channel number.

acmode
Optional access mode associated with the channel. The most privileged access mode used is that of the caller.

mbxnam
Optional logical mailbox associated with the device. (Not supported by IPDRIVER)

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$CANCEL

Cancels any I/O that is pending on a channel.

The I/O will be completed with an *iosb* status of `SS$_CANCEL`.

Outstanding I/O operations are automatically canceled at image exit.

Format

```
status = SYS$CANCEL(u_int chan);
```

Argument

chan
Number of the channel to be canceled.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$DASSGN

Releases a channel.

When you deassign a channel, any outstanding I/O is completed with an `iosb` status of `SS$_CANCEL`.

I/O channels are automatically deassigned at image exit.

Format

```
status = SYS$DASSGN(u_int chan);
```

Argument

chan
Number of the channel to be deassigned.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

IPDRIVER External Interface

This section describes the IPDRIVER External Interface.

This interface allows you to write Network Interface Programs that support the use of IPDRIVER with various network controllers.

I/O Functions for the External Interface

The Network Interface Program uses four functions to communicate with IPDRIVER. The below table lists these functions.

Function	Purpose
`IO$_INITIALIZE`	Initializes the IPDRIVER External Interface for the network device. (Informs IPDRIVER that the External Interface is on-line.)
`IO$_READVBLK`	Receives datagrams from IPDRIVER for transmission over the network.
`IO$_SETMODE \| IO$M_CTRL | IO$M_SHUTDOWN`	Shuts down the IPDRIVER External interface.
`IO$_WRITEVBLK`	Delivers datagrams that are received from the network to IPDRIVER. IPDRIVER processes and delivers them to higher-level applications (such as TCP and UDP).

Sequence of Operations for the Network Interface Program

This section provides the typical sequence of operations for the Network Interface Program. These operations apply only to the IPDRIVER External Interface. Any operations needed to set up and use the network device depend on the specific requirements of that device.

The Network Interface Program:

1. Uses the Assign I/O Channel (`SYS$ASSIGN`) system service to assign an I/O channel to `IPA0:`. `SYS$ASSIGN` creates a new unit for the channel.
2. Issues the `IO$_INITIALIZE` function on the assigned channel to initialize the network line.
3. Issues the `IO$_READVBLK` function to read IP datagrams from IPDRIVER, then sends the datagrams over the network device.
4. Issues the `IO$_WRITEVBLK` function for each datagram received from the network device.
5. Issues the `IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN` function to shut down the network device.
6. Uses the Deassign I/O Channel (`SYS$DASSGN`) system service to deassign the channel.

Your Network Interface programs must provide their own means of starting up and shutting down. You cannot use the `NETCU START/IP` and `STOP/IP` commands to start up or shut down these network lines.

IPDRIVER External Interface System Service Call Codes

The following pages describe each `SYS$QIO[W]` function code for the external interface. System service call function codes specify what action the QIO performs. See the format specified in the *IPDRIVER System Service Call Format* section before referencing each function.

You can use OpenVMS system services `SYS$ASSIGN`, `SYS$DASSGN`, and `SYS$CANCEL` for the External Interface in the same way as described for the User Interface in the *IPDRIVER User Interface System Service Call Functions* section.

This section describes the following function codes for the External Interface:

`IO$_INITIALIZE`	`IO$_SETMODE`	`IO$_READVBLK`	`IO$_WRITEVBLK`

IO$_INITIALIZE (External)

Informs IPDRIVER that the External Interface is on-line. IPDRIVER adds the External Interface to a list of existing network interfaces and creates a route for it.

Once a Network Interface program issues an `IO$_INITIALIZE` on a channel, that channel becomes the External Interface. After that, the functions documented in the IPDRIVER User Interface System Service Call Function section for the User Interface (such as those used to open and close ports) are no longer valid: you must use only those functions documented in this part of the chapter, the IPDRIVER External Interface section.

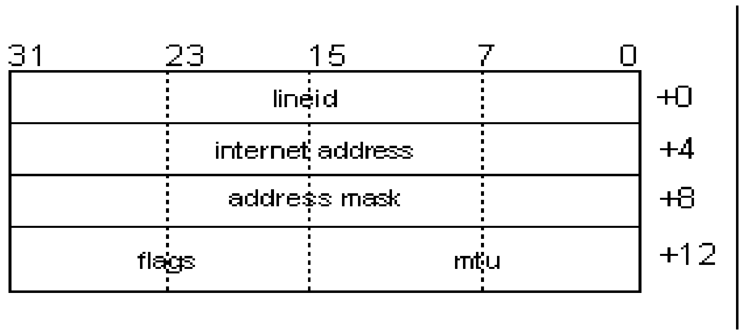
Format

```
status = SYS$QIO(efn, chan,IO$_INITIALIZE,iosb, astadr, astprm, buffer,
size, 0, 0, 0, 0);
```

Arguments

p1 **= byte** ***buffer***

Address of the line information buffer. The below diagram illustrates this buffer.



In the figure:

address mask	is the address mask for the network. The bits set in the mask are the bits that specify the host number (the one’s complement of the network mask).
flags	is the line’s flag bits. Typically, this value is 0, but the following bits can be set as needed:

internet address	is the internet address of the host on the network or, for unnumbered interfaces, the internet address used as the source address when sending datagrams over the interface if a source address was not explicitly specified.
lineid	is the line identification. Its value should be 00*nnxx*41 (hex), where: *nn* is the unit number of the line. *xx* is a unique value for the specific network line. SLIP lines are 01. IP-over-DECnet lines are 02. PPP lines are 03. For Network Interface Programs, *nn* should start at 80 (hex).
mtu	is the maximum transmission unit for the network. It is the size of the largest IP datagram that can be transmitted over the network.

Bit	**Mask**	**Meaning**
`0`	`1`	Unnumbered interface. If this bit is set, the interface does not have a local address and the internet address specified is only used when originating datagrams over the interface when no source address was explicitly specified.

p2* = u_int *size
Size of the line information buffer, in bytes.

Status

`SS$_NORMAL`	Initialization successful
`SS$_BADPARAM`	*`lineid`* parameter does not contain valid value, or already in use Lowest order byte must be 41 (hex) for External Interface
`SS$_DEVACTIVE`	Device already active
`SS$_DEVREQERR`	You are trying to start up new interface while IPDRIVER is in process of shutting down

`SS$INSFMEM`	Insufficient system memory Necessary control block cannot be allocated
`SS$_IVADDR`	Address already in use
`SS$_NOPRIV`	Insufficient privileges You need OPER privilege to start network interface

IO$_READVBLK (External)

Requests IPDRIVER to return the next IP datagram to the Network Interface program. The Network Interface program should then send the datagram over the network.

The Network Interface program is responsible for adding the network header to the datagram.

IPDRIVER provides "unsolicited" read support. This means that datagrams are held in a queue until the Network Interface Program issues an `IO$_READVBLK` function. IPDRIVER queues up to 100 datagrams.

Format

```
status = SYS$QIO(efn, chan, IO$_READVBLK,iosb, astadr, astprm, buffer, size,
0, 0, 0, 0);
```

Arguments

p1* = byte ****buffer

Address of the buffer that receives the next IP datagram.

p2* = u_int *size

Size, in bytes, of the buffer. This buffer must be at least as large as the MTU of the interface and not greater than 65000 bytes. Otherwise, IPDRIVER might return a `SS$_DATAOVERUN` status code.

Status

`SS$_NORMAL`	Read successful In I/O status block, high order word of first longword contains size of IP datagram in bytes
`SS$_ABORT`	Requests aborted External Interface is down
`SS$_DATAOVERUN`	Receive buffer in Network Interface Program too small for IP datagram Truncated datagram returned to user-specified buffer

	In I/O status block high order word of first longword contains truncated size of IP datagram in bytes
`SS$DEVINACT`	Device not active Use IO$_INITIALIZE function first

The high-order word of the first longword contains the size of the IP datagram read.

The second longword of the I/O status block contains the internet address of the next destination. The next destination can be the final destination or a gateway. This longword is valid only for the `SS$_NORMAL` and `SS$_DATAOVERUN` status codes.

IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN (External)

Shuts down the External Interface for the channel.

Causes IPDRIVER to remove the network interface from the list of available interfaces. It also removes any routes for the network interface.

Format

```
status = SYS$QIO(efn, chan,IO$_SETMODE | IO$M_CTRL | IO$M_SHUTDOWN,iosb,
astadr, astprm, 0, 0, 0, 0, 0, 0);
```

Arguments

None.

Status

`SS$_Normal`	Success

IO$_WRITEVBLK (External)

Used after the Network Interface program receives a datagram from the network. Delivers the datagram to IPDRIVER for processing.

Format

```
status = SYS$QIO(efn, chan,IO$_WRITEVBLK,iosb, astadr, astprm, buffer, size,
0, flags, 0, 0);
```

Arguments

p1* = byte *buffer
Address of the buffer containing the full IP datagram.

p2* = u_int *size
Size of the IP datagram in bytes. The value should not be greater than 65000 bytes.

Note: The buffer specified by these parameters must not include the network header.

p4* = u_long *flags
Flag bits providing information about the received datagram as follows:

Bit	Mask	Meaning
0	1	Datagram was sent to a broadcast/multicast address. This information is used to prevent sending ICMP datagrams to broadcast/multicast addresses. All other bits must be 0.

Status

SS$_NORMAL	Write successful

`SS$_ABORT`	Request aborted External Interface shut down
`SS$_DEVINACT`	Device not active Use `IO$_INITIALIZE` function first

6. INETDRIVER Services

Introduction

This chapter describes the internet device driver (INETDRIVER) services.

The INETDRIVER services provide an asynchronous I/O implementation of the UNIX socket calls within the OpenVMS Queue I/O Request (`SYS$QIO` and `SYS$QIOW`) system services. These system services allow for efficient socket operations in that Asynchronous System Trap (AST) routines can be associated with I/O requests.

The INETDRIVER services provide the Stanford Research Institute (SRI) QIO interface. The interface is an international de facto standard that provides a one-to-one mapping between the UNIX socket functions and the OpenVMS `SYS$QIO` system services.

INETDRIVER interfaces directly with the TCP, UDP, and IP (for raw functions) protocols in the transport layers. It does not replace the TCPDRIVER or UDPDRIVER services but provides another way to communicate with them.

For details, see the *TCPDRIVER Services* and *UDPDRIVER Services* chapters.

INETDRIVER supports QIOs to:

- Create a stream, datagram, or raw socket
- Bind a socket to a local port or address
- Set a socket to listen mode
- Accept a connection
- Create a connection
- Send and receive data
- Perform other socket and control functions

Note: The TCPware INETDRIVER supports stream, datagram, and raw sockets, but only for the `AF_INET` address family.

Sequence of Operations

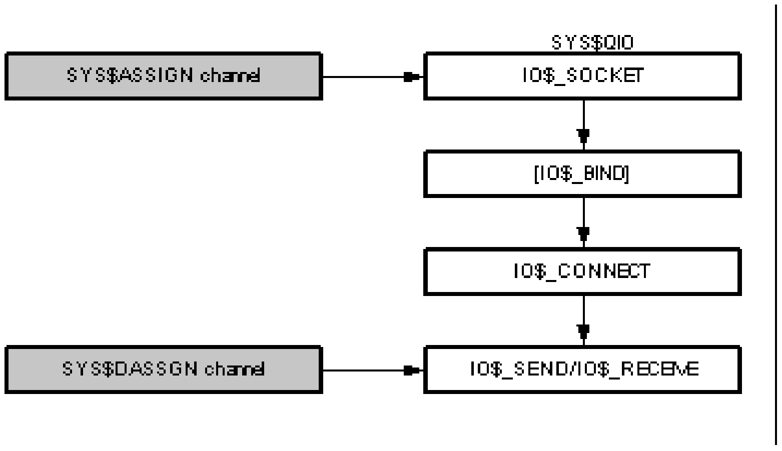
The INETDRIVER sequences of operations are divided into client operations and server operations. Each have distinct steps, as outlined in the following sections.

Client Operations

The INETDRIVER client operations for a stream socket connection are as follows:

1. Assign an INET channel to the `INET0:` device using the `SYS$ASSIGN` system service. This creates a new INET device unit and assigns a channel to it.
2. Create a stream socket using the `SYS$QIO[W]` system service with the `IO$_SOCKET` function.
3. If you want to assign a particular address to an unnamed socket, use the `SYS$QIO[W]` `IO$_BIND` function. This is optional and not necessary under most circumstances.
4. Connect to a peer on the server using the `SYS$QIO[W]` `IO$_CONNECT` function. Specify the server's internet address as a "well-known" port number.
5. Exchange data with the peer using the `SYS$QIO[W]` `IO$_SEND` and `SYS$QIO[W]` `IO$_RECEIVE` functions.
6. After the data exchange is complete, deassign the channel using the `SYS$DASSGN` system service.

The below figure shows the client operation steps.

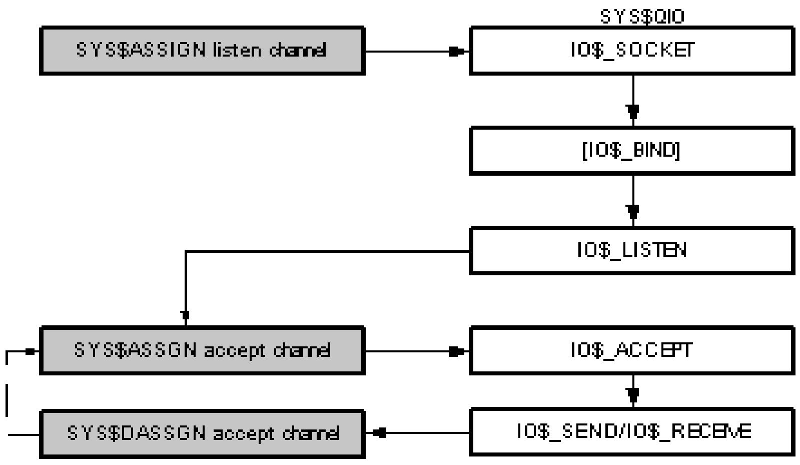


Server Operations

The INETDRIVER server operations for a simple, single-thread stream socket connection are as follows:

1. Assign an INET listen channel to the `INET0:` device using the `SYS$ASSIGN` system service. This creates a new INET device unit and assigns a channel to it.
2. Create a stream socket using the `SYS$QIO[W] IO$_SOCKET` function.
3. Bind the socket to the server's "well-known" port number using the `SYS$QIO`[`W`] `IO$_BIND` function.
4. Enable listens and set up the listen queue length using the `SYS$QIO`[`W`] `IO$_LISTEN` function.
5. Assign an INET accept channel to the `INET0:` device using the `SYS$ASSIGN` system service again.
6. Accept incoming connect requests using the `SYS$QIO`[`W`] `IO$_ACCEPT` function on the accept channel, specifying the listen channel as a parameter. Then wait for the client to connect.
7. Exchange data with the client on the accept channel using the `SYS$QIO`[`W`] `IO$_SEND` and `SYS$QIO`[`W`] `IO$_RECEIVE` functions.
8. After the data exchange is complete, deassign the accept channel using the `SYS$DASSGN` system service. This closes the connection.

Repeat steps 5 through 8 to process additional server connections. The below figure shows the server operations steps.



Multicasting

INETDRIVER Services includes the following `setsockopt()` and `getsockopt()` definitions at the `IPPROTO_IP` level for multicasting support:

```
#define   IP_MULTICAST_IF     2
#define   IP_MULTICAST_TTL    3
#define   IP_MULTICAST_LOOP   4
#define   IP_ADD_MEMBERSHIP   5
#define   IP_DROP_MEMBERSHIP  6
```

The `IP_ADD_MEMBERSHIP` and `IP_DROP_MEMBERSHIP` requests use the following structure:

```
struct ip_mreq {
  struct in_addr  imr_multiaddr; /* Multicast address of group */
  struct in_addr  imr_intrface;  /* local IP address of interface */
};
```

Other Operations

In addition to the routines associated with the sequence of operations above, INETDRIVER also includes other operations that:

- Set socket options (`IO$_SETSOCKOPT`)
- Get socket options (`IO$_GETSOCKOPT`)
- Shut down sockets (`IO$_SHUTDOWN`)
- Get socket names (`IO$_GETSOCKNAME`)
- Change the INET device characteristics (`IO$_SETCHAR`)
- Get the address of the remote end for a socket (`IO$_GETPEERNAME`)
- Change socket characteristics (`IO$_IOCTL`)
- Deliver an AST to the process if out-of-band data arrives (`IO$_SETMODE | IO$_ATTNAST`)

INETDRIVER Socket Library

The Socket Library routines described in the *Socket Library* chapter make use of the TCPDRIVER and UDPDRIVER programming interface. An alternate set of socket routines is available that makes use of the INETDRIVER programming interface and allows a mix of socket routines and INETDRIVER QIO calls. This alternate set of socket routines is presently only available in the `TCPWARE:SOCKLIB.OLB` socket library (the routines are not part of the `TCPWARE_SOCKLIB_SHR.EXE` shareable run-time library). The following routines are available:

`inet_socket`	`inet_socket_recv`	`inet_sendto`	`inet_socket_ioctl`
`inet_bind`	`inet_recv`	`inet_shutdown`	`inet_getsockname`
`inet_connect`	`inet_recvfrom`	`inet_socket_close`	`inet_getpeername`
`inet_listen`	`inet_socket_write`	`inet_setsockopt`	`inet_socket_perror`
`inet_accept`	`inet_socket_send`	`inet_getsockopt`	`inet_tcpware_server`
`inet_socket_read`	`inet_send`		

The socket number (descriptor) used by these routines is the VMS I/O channel of the INETDRIVER device being used. This allows for the mixing of these routines and direct QIOs to the driver.

INETDRIVER System Service Call Format

The format for the INETDRIVER `SYS$QIO` system service call is as follows:

```
status = SYS$QIO[W](u_long efn, u_int chan, u_long func, unsigned quadword
*iosb, void *astadr, u_long astprm, p1, p2, p3, p4, p5, p6)
```

The `TCPWARE_INCLUDE:INETIODEF.H` file provides definitions for the QIO function codes.

Note: The E-prefix status codes (such as `ECONNRESET`) listed under the STATUS headings are returned in the I/O status block (`iosb`) and are not the UNIX errno values. As described in the *I/O*

Status Block Fields section under the `iosb` argument, the values returned for these codes are the UNIX errno values multiplied by 8 and logically ORed with 0x8000.

Note: The vertical bar (`|`) used in some of the functions described in this chapter is the C bitwise inclusive OR operator.

INETDRIVER System Service Call Arguments

You invoke UDPDRIVER system service calls with the standard OpenVMS QIO mechanism.

See the appropriate OpenVMS documentation (for example, the *Introduction to VMS System Services* volume) for details on the QIO mechanism.

The following sections describe each system call argument.

efn

(Optional) Number of the event flag to be set when the I/O operation completes.

chan

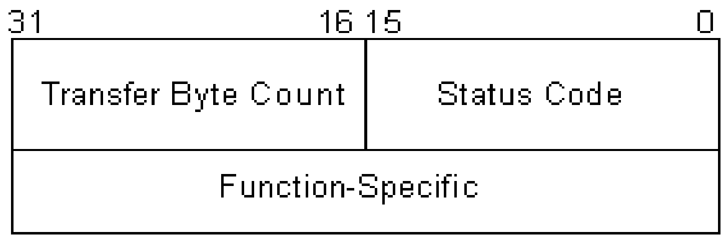
I/O channel assigned to the INET device to which the request is directed.

func

Device-specific function codes and modifiers for each operation.

iosb

I/O status block that receives the final completion status of the I/O operation, structured as in the below figure.



The below table describes the status block fields in more detail.

Field Name	**Description**
Transfer Byte Count	Number of bytes of data transferred in the I/O operation.
Status Code	`SS$` status code or special error status code. If the low bit (0) of the OpenVMS error code is clear, the network has returned an error. If the most significant bit of this word is set (mask of 0x8000), the status code is the UNIX errno code multiplied by 8 and logically ORed with 0x8000.
Function-Specific	Varies for each device and function code.

astadr
Asynchronous system trap (AST) routine to be executed when the I/O is completed.

astprm
AST parameter to be passed to the AST routine.

p1…p6
Function-specific parameters, as described for each function.

INETDRIVER System Service Call Function Codes

System service call function codes specify what action the QIO performs.

IO$_ACCEPT

Waits for a connection to a listening socket and associates a OpenVMS channel to the socket for that new connection. The connection's socket has the same properties as the listening socket.

If no pending connections exist on the queue and the socket is not marked as nonblocking, `IO$_ACCEPT` blocks the caller until a connection is made to the listening socket. If the socket is marked as nonblocking and no pending connections exist on the queue, `IO$_ACCEPT` returns an `EWOULDBLOCK` error.

Multiple `IO$_ACCEPT` requests are supported on a single channel.

See `IO$_ACCEPT_WAIT` for an alternative to `IO$_ACCEPT`.

Format

```
status = SYS$QIO(efn, new-inet-chan,  IO$_ACCEPT,  iosb,  astadr,  astprm,
address,  addrlen,  inet-chan, 0, 0, 0);
```

Arguments

chan* = u_int *new-inet-chan

OpenVMS channel to a newly created INET: device. This channel should be created by using `SYS$ASSIGN` to assign a new channel to INET0: prior to issuing the `IO$_ACCEPT` function. The accepted connection uses this channel.

***p1* = struct *address**

Optional pointer to a structure that receives the peer's address for the connection following completion of the `IO$_ACCEPT` function. The structure is defined as follows:

```
Struct
{
  unsigned long Length;
  struct sockaddr_in Address;
}
```

p2* = u_int *addrlen

Length (in bytes) of the buffer to which the *`address`* argument points. The value must be at least 20 bytes.

p3* = u_int *inet-chan
OpenVMS channel for the INET: device on which the `IO$_LISTEN` was performed. After accepting the connection, this device remains available to accept additional connections.

Status

`EALREADY`	Operation is already in progress or the socket is in use (e.g. an `IO$_ACCEPT` is active on the channel).
`ECONNABORTED`	Listening channel was shut down or aborted.
`EINVAL`	Operation is not valid (for a nonstream socket), or an invalid *`inet-chan`* or *`addrlen`* argument was specified.
`ENETDOWN`	Network was shut down.
`ENOTSOCK`	No socket exists on the listening channel.
`EOPNOTSUPP`	Socket is not of type `SOCK_STREAM`.
`EWOULDBLOCK`	Connection is marked as nonblocking and no connection is waiting to be accepted.
`SS$_IVCHAN`	Invalid listening channel number was specified.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_ACCEPT_WAIT

Waits for an incoming connection on a listening socket without accepting the connection. When the `IO$_ACCEPT_WAIT` is complete, a connection is available for accepting; `IO$_ACCEPT` is then used to accept it.

Multiple `IO$_ACCEPT_WAIT` requests are supported on a single channel.

`IO$_ACCEPT_WAIT` is useful to avoid holding an additional INET channel while waiting to service a connection.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_ACCEPT_WAIT, iosb, astadr, astprm, 0, 0,
0, 0, 0, 0);
```

Argument

`chan = u_int inet-chan`

OpenVMS channel to the INET: device on which the `IO$_LISTEN` was performed.

Status

`ECONNABORTED`	Listening channel was shut down or aborted.
`EINVAL`	Operation is not valid (for a nonstream socket), or an invalid *`inet-chan`* or *`addrlen`* argument was specified.
`ENETDOWN`	Network was shut down.
`ENOTSOCK`	No socket exists on the listening channel.
`EOPNOTSUPP`	Socket is not of type `SOCK_STREAM`.
`EWOULDBLOCK`	Connection is marked as nonblocking and no connection can be accepted.

`SS$_THIRDPARTY`	Network is being shut down.

IO$_BIND

Assigns an address to an unbound socket. When a socket is created with `IO$_SOCKET`, it has no assigned address. `IO$_BIND` requests that the address be assigned to the socket.

Normally used by servers to bind to their "well-known" port number before issuing the `IO$_LISTEN` function. Clients typically do not use this function, since `IO$_CONNECT` normally will assign an unused port number.

> **Note:** To bind to port numbers 1 through 1023, a process must be running under a privileged UIC, or with the SYSPRV or BYPASS privilege.

Format

```
status = SYS$QIO(efn, inet-chan, IO$_BIND, iosb, astadr, astprm, name,
namelen,0, 0, 0, 0);
```

Arguments

chan* = u_int *inet-chan
OpenVMS channel to the INET: device on which the `IO$_SOCKET` was performed.

p1* = struct sockaddr_in **name
Address to which the socket should be bound.

p2* = u_long *namelen
Length of the *name* argument (in bytes).

Status

EACCES	Specified address is not available from the local machine.
EADDRNOTAVAIL	Requested address is protected; the user has no permission to have access to it.

EADDRINUSE	Specified address is already in use.
EINVAL	Operation is not valid (for a nonstream socket).
ENETDOWN	Network was shut down.
SS$_THIRDPARTY	Network is being shut down.

IO$_CONNECT

For stream sockets, attempts a connection to a peer socket. For datagram sockets, permanently specifies the peer to which the datagrams are to be sent or from which they are to be received.

Format

```
status = SYS$QIO(efn, inet-chan, IO$_CONNECT,iosb, astadr, astprm,name,
namelen,0, 0, 0, 0);
```

Arguments

chan* = u_int *inet-chan

Channel to the socket.

p1* = struct sockaddr_in *name

Address of the peer to which the socket should be bound.

p2* = u_long *namelen

Length of the *name* argument (in bytes).

Status

EADDRNOTAVAIL	Requested address is protected; the user has no permission to have access to it.
EADDRINUSE	Specified address is already in use.
EALREADY	Operation is already in progress.
ECONNABORTED	Operation was aborted.
ECONNREFUSED	Connection was refused by the peer.
EHOSTUNREACH	Host was unreachable.

`EINVAL`	Socket has already been used for a connection, or the *namelen* argument is invalid.
`EISCONN`	Socket is already connected.
`ENETDOWN`	Network has been shut down.
`ENETUNREACH`	Destination network is unreachable.
`EOPNOTSUPP`	Operation is not supported (e.g., a connect on a listening socket).
`ETIMEDOUT`	Connection timed out.
`EWOULDBLOCK`	Socket is marked as nonblocking; connection attempt is in progress.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_GETPEERNAME

Returns the address of the peer connected to the specified socket.

Format

`status = SYS$QIO(efn,inet-chan, IO$_GETPEERNAME, iosb, astadr, astprm, address, addrlen,0, 0, 0, 0);`

Arguments

chan* = u_int *inet-chan

Channel to the socket.

***p1* = struct sockaddr_in *address**

Receives the peer's address.

***p2* = u_long *addrlen**

On entry, contains the byte length of the space pointed to by *address*. On return, it contains the byte length of the data returned.

Status

`EINVAL`	Invalid *addrlen* was specified.
`ENETDOWN`	Network has been shut down.
`ENOTCONN`	Socket is not connected.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_GETSOCKNAME

Returns the local address of a socket.

Format

`status = SYS$QIO(efn,inet-chan, IO$_GETSOCKNAME,iosb, astadr, astprm, address, addrlen,0, 0, 0, 0);`

Arguments

chan* = u_int *inet-chan

Channel to the socket.

***p1* = struct sockaddr_in *address**

Receives the local or multicast address.

***p2* = u_long *addrlen**

On entry, contains the byte length of the space pointed to by *address*. On return, it contains the byte length of the data returned.

Status

`EINVAL`	*addrlen* argument is invalid.
`ENETDOWN`	Network was shut down.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_GETSOCKOPT

Retrieves the value of options associated with a socket.

The `TCPWARE_INCLUDE:SOCKET.H` file contains definitions for the socket-level options. The `IPPROTO_IP` level options defined in the `TCPWARE_INCLUDE:IN.H` file are not compatible with INETDRIVER.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_GETSOCKOPT,iosb, astadr, astprm, level,
optname, optval, optlen, 0, 0);
```

Arguments

chan* = u_int *inet-chan

Channel to the socket.

p1* = u_long *level

`SOL_SOCKET` to change socket options, or `IPPROTO_IP` to change IP options (which requires system UIC, SYSPRV, or BYPASS privilege).

p2* = u_long *optname

TCPware ignores this option where indicated. However, you should include it if you created other routines that set this option to that you do not get an error message.

***p3* = byte *_optval_**

Pointer to a buffer that is to receive the current value of the option. The format of this buffer is dependent on the option requested. Options other than `SO_LINGER` return a longword value. For those options that are enabled or disabled, 0 is returned if disabled, 1 is returned if enabled.

`SO_LINGER` uses the following structure for the linger value:

```
structlinger
{
  intl_onoff   ;/* option on/off */
  intl_linger  ;/* linger time */
};
```

p4* = u_long ****optlen

On entry, contains the byte length of the space pointed to by *optval*. On return, contains the byte length of the option returned.

Status

EINVAL	*level* specified is invalid.
ENOPROTOOPT	Option is unknown.
ENETDOWN	Network was shut down.
SS$_THIRDPARTY	Network is being shut down.

IO$_IOCTL

Manipulates socket characteristics. The `TCPWARE_INCLUDE:IOCTL.H` file contains definitions for the `IO$_IOCTL` request codes.

> **Note:** This function does not support operations to set network interface information.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_IOCTL, iosb, astadr, astprm, request,
argp, 0, 0, 0, 0);
```

Arguments

chan = u_int inet-chan
Channel to the socket.

p1 = u_long request
`IO$_IOCTL` function to perform. The `IO$_IOCTL` functions are listed in the below table:

Value	**Description**
`FIONBIO`	Sets/clears nonblocking mode
`FIONREAD`	Returns bytes available for reading
`SIOCADDRT`	Adds a routing entry
`SIOCATMARK`	Returns whether the read point is at the out-of-band (TCP urgent) mark
`SIOCDARP`	Deletes an address resolution (ARP) entry
`SIOCDELRT`	Deletes a routing entry

`SIOCGARP`	Gets an address resolution (ARP) entry
`SIOCGIFCONF`	Returns list of network interfaces
`SIOCGIFADDR`	Returns the internet address for an interface
`SIOCGIFBRDADDR`	Returns the broadcast address for an interface
`SIOCGIFDSTADDR`	Returns the destination address for a point-to-point interface
`SIOCGIFFLAGS`	Returns the flags for an interface
`SIOCGIFMETRIC`	Returns the metric for an interface
`SIOCGIFMTU`	Returns the minimum transmission unit for an interface
`SIOCGIFNETMASK`	Returns the network mask for an interface
`SIOCSARP`	Adds an address resolution (ARP) entry

p2* = byte ****argp

Pointer to a buffer whose format and function depends on the *request* specified.

Status

`ENOPROTOOPT`	*`request`* specified is invalid.
`ENETDOWN`	Network was shut down.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_LISTEN

Places the stream in a listen state and specifies the maximum number of incoming connections that can be queued waiting to be accepted. This backlog must be specified before accepting a connection on a socket.

Applies to sockets of type SOCK_STREAM only.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_LISTEN, iosb, astadr, astprm,backlog, 0,
0, 0, 0, 0);
```

Arguments

chan* = u_int *inet-chan
Channel to the socket.

p1* = u_long *backlog
Maximum length of the queue of pending connections. If a connection request arrives when the queue is full, the request is ignored. The backlog queue is limited by the TCPware `BACKLOG_LIMIT` parameter. If the specified value is greater than `BACKLOG_LIMIT`, `BACKLOG_LIMIT` is used.

See the `ADD SERVICE` command description in Chapter 2, *NETCU Commands*, in the *NETCU Command Reference* for details on setting the `BACKLOG_LIMIT` parameter.

Status

EISCONN	Socket is already connected.
EOPNOTSUPP	Operation is not supported (such as when the connection on a listening socket).
ENETDOWN	Network was shut down.
SS$_THIRDPARTY	Network is being shut down.

IO$_RECEIVE

Receives data from a socket.

The length of the data received is returned in the second word of the I/O Status Block (*iosb*). A count of 0 indicates an end-of-file condition, or the connection was closed.

For SOCK_DGRAM and SOCK_RAW messages, if the message is too long to fit in the supplied buffer, excess bytes are discarded. For SOCK_STREAM data, no bytes are discarded, even though the amount of data processed on a request may be different than the amount sent.

If no data is available for the socket, the IO$_RECEIVE function waits for data to arrive, unless the socket is in nonblocking mode.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_RECEIVE,iosb, astadr, astprm, buffer,
size, flags, from, fromlen, 0);
```

Arguments

chan* = u_int *inet-chan
Channel to the socket.

p1* = byte **buffer
Address of the user's buffer.

p2* = u_long **size
Byte size of the user's buffer. The value should not be greater than 64000 bytes. The actual number of bytes read is returned in the *iosb*.

p3* = u_long *flags
Control information that affects the IO$_RECEIVE function and is formed by logically OR-ing one or more of the following values:

```
#define  MSG_OOB            0x1/*send out-of-band data*/
#define  MSG_PEEK           0x2*peek at incoming message*/
#define  MSG_NONBLOCKING    0x10/*override blocking state*/
#define  MSG_TIME           0x100/*limit receive wait time*/
```

The `MSG_OOB` flag causes `IO$_RECEIVE` to read any out-of-band data arriving on the socket.

The `MSG_PEEK` flag causes `IO$_RECEIVE` to read the data present in the socket without removing the data. This allows the caller to view the data, but leave it in the socket for future `IO$_RECEIVE` functions.

The `MSG_NONBLOCKING` flag causes `IO$_RECEIVE` to be a nonblocking request. An `EWOULDBLOCK` status would be returned if the request cannot be completed immediately.

The `MSG_TIME` flag (for datagram sockets only) causes `IO$_RECEIVE` to complete within `SO_RCVTIMEO` seconds with the `ETIMEDOUT` status (if no message is received). Use the `IO$_SETSOCKET` function to set `SO_RCVTIMEO`.

***p4* = struct *from**

For `SOCK_DGRAM` and `SOCK_RAW` sockets, the optional *from* argument is a pointer to a structure that contains the address of the socket that sent the packet following completion of the `IO$_RECEIVE` function. The structure is defined as follows:

```
struct
{
  unsigned short Length;
  struct sockaddr_inAddress;
} ;
```

The *from* argument is ignored for `SOCK_STREAM` sockets.

p5* = u_int *fromlen

For `SOCK_DGRAM` sockets, byte length (at least 18 bytes) of the buffer pointed to by the *from* argument. The *fromlen* argument is ignored for `SOCK_STREAM` sockets.

Status

ECONNRESET	Connection was reset by the peer.
EHOSTUNREACH	Host was unreachable.
EINVAL	*from* argument is invalid, or no out-of-band data was available.
ENETDOWN	Network was shut down.

ENOTCONN	Socket is not connected.
EOPNOTSUPP	Out-of-band request exists on a non-stream socket.
ETIMEDOUT	Connection timed out.
EWOULDBLOCK	Request would block.
SS$_CANCEL	Request was cancelled.
SS$_THIRDPARTY	Network is being shut down.

IO$_SEND

Sends stream data (for stream sockets), messages (for datagram sockets), or raw data to a socket.

`IO$_SEND` blocks if no buffer space is available at the socket to hold the data to be transmitted unless the socket was placed in nonblocking mode. For datagram sockets, if the message is too long to pass through the underlying protocol in a single unit, an `EMSGSIZE` status is returned, and the message is not transmitted.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_SEND, iosb, astadr, astprm, buffer,
size, flags, to, tolen, 0);
```

Arguments

chan = u_int inet-chan
Channel to the socket.

p1 = byte *buffer
Address of the user's buffer.

p2 = u_long size
Byte size of the user's buffer. The actual number of bytes sent is returned in the *iosb*. The value should not be greater than 64000 bytes.

p3 = u_long flags
Control information that affects the `IO$_SEND` function and is formed by logically ORing one or more of the following values:

```
#define    MSG_OOB              0x1/*send out-of-band data*/
#define    MSG_NONBLOCKING      0x10/*override blocking state*/
```

The `MSG_OOB` flag causes `IO$_SEND` to send out-of-band data on sockets that support this operation (e.g., `SOCK_STREAM` sockets).

The `MSG_NONBLOCKING` flag causes `IO$_SEND` to be a nonblocking request. An `EWOULDBLOCK` status would be returned if the request cannot be completed immediately. For stream sockets, some of the data may have been sent: the amount is returned in the second word of the *iosb*.

p4* = struct sockaddr_in *to

For datagram sockets, the optional *to* argument is a pointer to the address to which the packet should be transmitted. This argument is ignored for SOCK_STREAM sockets.

p5* = u_long *tolen

For datagram sockets, the optional *tolen* argument contains the byte length of the address pointed to by the *to* argument. This argument is ignored for SOCK_STREAM sockets.

Status

ECONNRESET	Connection was reset by the peer.
EDESTADDRREQ	Destination address was not specified.
EHOSTUNREACH	Host was unreachable.
EINVAL	*to* argument is invalid, or no out-of-band data was available.
EISCONN	Socket is already connected.
EMSGSIZE	Datagram was too large.
ENETDOWN	Network was shut down.
ENETUNREACH	Destination network is unreachable.
ENOTCONN	Socket is not connected.
EOPNOTSUPP	Out-of-band request exists on a non-stream socket.
EPIPE	Connection was broken.
ETIMEDOUT	Connection timed out.
EWOULDBLOCK	Request would block.

`SS$_THIRDPARTY`	Network is being shut down.

IO$_SETCHAR

Sets special device characteristics for the INET device rather than for the socket attached to it. These operations are normally used by the TCPware master server (NETCP) process only. `IO$_SETCHAR` requires LOG_IO privileges.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_SETCHAR, iosb, astadr, astprm, flags, 0,
0, 0, 0, 0);
```

Arguments

chan = u_int inet-chan
Channel to the socket.

p1 = u_long flags
Address of a longword bit mask of one or more of the values that appear in the below table. If `IO$_SETCHAR` is not called, all options are set to OFF.

Bit	Description
0	If set, makes the device permanent. If clear, makes the device temporary (default).
1	If set, makes the device shareable. If clear, makes the device nonshareable (default).
2	If set, allow the device to be handed off. (The device is not deleted when the last channel is deassigned, but is deleted the next time the last channel is deassigned.)

Status

`SS$_NOPRIV`	Argument requires LOG_IO privileges.

IO$_SETMODE | IO$M_ATTNAST

Enables an AST to be delivered to the process when out-of-band (TCP urgent) data is received on the socket. This function is similar to the UNIX SIGURG signal being delivered.

This is a once-only AST. After the AST is delivered, you must explicitly re-enable it using this function if you want the AST to be delivered when future out-of-band data is received.

Format

```
status = SYS$QIO(efn,inet-chan, IO$_SETMODE | IO$M_ATTNAST,iosb, astadr,
astprm, routine, parameter, acmode, 0, 0, 0);
```

Arguments

chan* = u_int *inet-chan
Channel to the socket.

p1* = void ****routine
Address of the AST routine to call when out-of-band data arrives on the socket. To cancel AST delivery, specify `routine` as 0.

p2* = u_long *parameter
Argument to call the AST routine.

p3* = u_long *acmode
Access mode for the AST.

IO$_SETSOCKOPT

Manipulates options associated with a socket.

The `TCPWARE_INCLUDE:SOCKET.H` file contains definitions for the socket-level options. The `IPPROTO_IP` level options defined in the `TCPWARE_INCLUDE:IN.H` file are not compatible with INETDRIVER.

Format

```
status = SYS$QIO(efn, inet-chan, IO$_SETSOCKOPT,iosb, astadr, astprm, level,
optname, optval, optlen, 0, 0);
```

Arguments

chan* = u_int *inet-chan
Channel to the socket.

p1* = u_long *level
`SOL_SOCKET` to change socket options, `IPPROTO_TCP` to change TCP options, or `IPPROTO_IP` to change IP options (which requires a SYSTEM UIC, or the SYSPRV or BYPASS privilege).

p2* = u_long *optname
Option to be manipulated. See the below tables.

Argument Values for `SOL_SOCKET` Level:

`SOL_SOCKET` Option	**Description**
`SO_BROADCAST`	Enables or disables broadcasting on the socket (ignored)
`SO_DEBUG`	Enables debugging in the protocol modules (ignored)
`SO_DONTROUTE`	Prevents routing applied to outgoing messages (ignored)
`SO_ERROR`	Returns current socket error (if any)

SO_KEEPALIVE	Keeps connections alive
SO_LINGER	Delay (in seconds) before closing a socket (ignored)
SO_OOBINLINE	Leaves received out-of-band data in line
SO_REUSEADDR	Allows local address reuse
SO_RCVBUF	Size of the internal receive buffer
SO_RCVLOWAT	(Ignored)
SO_RCVTIMEO	Receive timeout time (ignored for stream sockets)
SO_SNDBUF	Size of the internal send buffer
SO_SNDLOWAT	(Ignored)
SO_SNDTIMEO	Send timeout time (ignored for datagram sockets)
SO_TYPE	Type of socket (stream or datagram)
SO_USELOOPBACK	Bypasses hardware when possible (ignored)

Argument Values for `IPPROTO_TCP` Level:

`IPPROTO_TCP` Option	**Description**
TCP_KEEPALIVE	Determines how long an idle socket should remain open

Argument Values for `IPPROTO_IP` Level:

`IPPROTO_IP` Option	**Description**
IP_OPTIONS	Gets or sets IP options to be sent in subsequent datagrams

IP_MULTICAST_IF	Gets or sets the interface used for sending multicast datagrams
IP_MULTICAST_TTL	Gets or sets the IP time-to-live (TTL) to be sent in subsequent datagrams
IP_MULTICAST_LOOP	Gets or sets whether sent multicast datagrams should be looped back locally
IP_ADD_MEMBERSHIP	Adds a multicast group membership for an interface
IP_DROP_MEMBERSHIP	Drops a multicast group membership from an interface

***p3* = byte *optval**
Pointer to a buffer that contains the value to which the option is to be set. The format of this buffer is dependent on the option requested.

p4* = u_long *optlen
Byte length of the *optval* buffer.

Status

EADDRNOTAVAIL	Address not available for use.
EADDRINUSE	Address already in use.
EINVAL	*level* specified is invalid.
ENETDOWN	Network was shut down.
ENOBUFS	Insufficient memory for requests.
ENOPROTOOPT	Option is unknown.
ETOOMANYREFS	Too many multicast memberships requested.
SS$_THIRDPARTY	Network is being shut down.

IO$_SHUTDOWN

Causes all or part of a full-duplex connection on a socket to be shut down. Can be used to signal an end-of-file to the peer without closing the socket itself, which would also prevent further data from being received.

Format

```
status = SYS$QIO(efn, inet-chan, IO$_SHUTDOWN, iosb, astadr, astprm, how, 0,
0, 0, 0, 0);
```

Arguments

chan* = u_int *inet-chan

Channel to the socket.

p1* = u_long *how

Part of the full-duplex connection to shut down, as shown in the below table.

Value	**Description**
0	Further receive operations are not allowed
1	Further send operations are not allowed
2	Further receive and send operations are not allowed

Status

`EINVAL`	*how* specified is invalid.
`ENETDOWN`	Network was shut down.
`SS$_THIRDPARTY`	Network is being shut down.

IO$_SOCKET

Creates the desired socket type. The three currently supported types are stream sockets (`SOCK_STREAM`), datagram sockets (`SOCK_DGRAM`), and raw sockets (`SOCK_RAW`).

> **Note:** Before issuing the `IO$_SOCKET` function, an INET channel must first be assigned to the INET0: device, using `SYS$ASSIGN`.

Format

```
status = SYS$QIO(efn, inet-chan, IO$_SOCKET, iosb, astadr, astprm,
AF_INET(2), type, protocol, 0, 0, 0);
```

Arguments

chan = u_int inet-chan
Channel to the socket.

p1 = u_long addressfam = AF_INET
Must be `AF_INET`.

p2 = u_long type
Semantics of communication using the created socket. The three currently supported types are: `SOCK_STREAM` (for a TCP socket), `SOCK_DGRAM` (for a UDP socket), and `SOCK_RAW` (for a raw socket).

p3 = u_long protocol
For TCP and UDP sockets, the *`protocol`* argument value must be 0. For raw sockets, a non-zero protocol can be specified.

Status

`ENETDOWN`	Network was shut down.
`EPROTONOSUPPORT`	Requested *`addressfam`*, *`type`*, or *`protocol`* is not supported.
`SS$_THIRDPARTY`	Network is being shut down.

SYS$ASSIGN

Assigns a channel to a device.

Format

```
status = SYS$ASSIGN(char *devnam, u_int inet-chan, [u_long acmode], [char
*mbxnam]);
```

Arguments

devnam
Address of a character string descriptor pointing to the device name string.

inet-chan
Address of a word into which `SYS$ASSIGN` writes the channel number.

acmode
Optional access mode associated with the channel. The most privileged access mode used is that of the caller.

mbxnam
Optional logical mailbox associated with the device. (Not supported by INETDRIVER.)

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$CANCEL

Cancels any I/O that is pending on a socket.

The I/O will be completed with an `iosb` status of `SS$CANCEL`.

Outstanding I/O operations are automatically cancelled at image exit.

Format

```
status = SYS$CANCEL(u_int inet-chan);
```

Argument

inet-chan
Number of the channel to be cancelled.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

SYS$DASSGN

Closes a socket.

When you deassign a channel, any outstanding I/O is completed with an `iosb` status of `SS$CANCEL`.

I/O channels are automatically deassigned at image exit.

Format

```
status = SYS$DASSGN(u_int inet-chan);
```

Argument

inet-chan
Number of the channel to be de-assigned.

Status

See the *VMS System Services Reference Manual* for a complete list of status messages.

Sample Programs

The following pair of sample programs, which show the use of stream sockets with `SYS$QIO` system service calls to the INETDRIVER, are included in the `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory:

- `INETDRIVER_CLIENT.C`
- `INETDRIVER_SERVER.C`

They are functionally the same as the `TCP_SOCKET_CLIENT.C` and `TCP_SOCKET_SERVER.C` sample programs.

The client calling sequence is as follows:

1. Assign a channel for the connection (`$ASSIGN`)
2. Create a stream socket (`IO$_SOCKET`)
3. Connect to the server (`IO$_CONNECT`)
4. Exchange data (`IO$_SEND`, `IO$_RECEIVE`)
5. Close the connection (`$DASSGN`)

The server calling sequence is as follows:

1. Assign a channel to listen on (`$ASSIGN`)
2. Create a stream socket to listen on (`IO$_SOCKET`)
3. Bind the socket to an address (`IO$_BIND`)
4. Listen for incoming connections (`IO$_LISTEN`)
5. Assign a channel to accept on (`$ASSIGN`)
6. Accept the incoming connection (`IO$_ACCEPT`)
7. Exchange data (`IO$_SEND`, `IO$_RECEIVE`)
8. Close the connection (`$DASSGN`)

To build any one of these applications using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL filename
$ LINK filename
```

To build any one of these applications using VAX C, enter:

```
$ CC/VAXC filename
$ LINK filename, TCPWARE:UCX$IPC/LIB, SYS$INPUT/OPTIONS -
_$  SYS$SHARE:VAXCRTL/SHARE
```

7. FTP Library

Introduction

This chapter is for application programmers. It describes the TCPware FTP library routines.

The TCPware FTP library routines provide a programming interface to the FTP protocol. Use the FTP library routines in your own applications to provide FTP capabilities.

The following routines are included in the library:

`FTP_ACCOUNT`	Specifies the user account on the remote host
`FTP_ALLOCATE_CCB`	Allocates a connection control block (CCB)
`FTP_APPEND_FILE`	Appends a file to a remote file
`FTP_AUTH`	Requests protected authentication.
`FTP_CCC`	Requests that the command channel be clear text.
`FTP_CHECK_FEATURES`	Sends the FEAT command to the FTP server and builds a bit mask of supported FTP optional features.
`FTP_CLOSE_CONNECTION`	Closes the connection to the remote FTP server
`FTP_CREATE_DIRECTORY`	Creates a directory on the remote host
`FTP_DEALLOCATE_CCB`	Deallocates a CCB
`FTP_DELETE_DIRECTORY`	Deletes a directory on the remote host
`FTP_DELETE_FILE`	Deletes a file on the remote host

`FTP_GET_CCB`	Gets information from a CCB field
`FTP_GET_FILE`	Copies a file from the remote host
`FTP_GET_LIST`	Gets file listing on the remote host
`FTP_GET_NAME_LIST`	Gets a filename listing on the remote host
`FTP_LOGIN_USER`	Authorizes the user on the remote host
`FTP_OPEN_CONNECTION`	Opens an FTP connection
`FTP_PASSWORD`	Specifies the user password on the remote host
`FTP_PBSZ`	Specifies the protection buffer size.
`FTP_PRINT_DIRECTORY`	Returns the current directory on the remote host
`FTP_PROT`	Specifies the protection level to use for transfers
`FTP_PUT_FILE`	Copies a file to the remote host
`FTP_QUOTE`	Sends an FTP command to the remote host
`FTP_RENAME_FILE`	Renames a file on the remote host
`FTP_SET_DIRECTORY`	Sets the remote directory
`FTP_SET_DEBUG`	Sets the debugging mode
`FTP_SET_PASV`	Sets passive mode transfers
`FTP_SET_STRU`	Specifies the file structure
`FTP_SET_TYPE`	Specifies the data representation type
`FTP_USER`	Specifies the user on the remote host

These routines allow you to establish and maintain FTP connections with remote hosts that support the FTP protocol.

The TCPware FTP library routines follow the standard OpenVMS conventions for modular library routines. See the OpenVMS documentation on calling modular libraries for more information.

Because TCPware FTP library routines use asynchronous system traps (ASTs), application programs must not run with ASTs disabled for long periods of time. Also, you should not call TCPware FTP library routines at the AST level.

The TCPware FTP library routines are in the `TCPWARE_FTPLIB_SHR.EXE` shareable library. The symbolic definitions for the various CCB fields and other parameters are in the `TCPWARE_INCLUDE:FTPDEF.H` header file. While this file is written for C language, it is very easy to convert to other OpenVMS languages.

Building an FTP Client

The FTP Client sample program is provided in `TCPWARE_COMMON:[TCPWARE.EXAMPLES]FTPSAMPLE.C`.

To build using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL FTPSAMPLE.C
$ LINK FTPSAMPLE, SYS$INPUT/OPTIONS -
_$  SYS$SHARE:TCPWARE_FTPLIB_SHR/SHARE -
_$  SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
```

To build using VAX C, enter:

```
$ CC/VAXC/PREFIX=ALL FTPSAMPLE.C
$ LINK FTPSAMPLE, SYS$INPUT/OPTIONS -
_$  SYS$SHARE:TCPWARE_FTPLIB_SHR/SHARE -
_$  SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE -
_$  SYS$SHARE:VAXCRTL.EXE/SHARE
```

Connection Control Block

The connection control block (CCB) contains all the information required to establish and maintain an FTP connection. Each open connection requires a CCB.

The storage space for the CCB is allocated dynamically. Therefore, the number of simultaneous connections is limited only by your process resources. You can reuse a CCB. You can close one connection and open a new one using the same CCB.

Gain access to the CCB fields using the `FTP_GET_CCB` library routine as described in *Library Routines*.

The below table lists CCB fields and their uses:

CCB Fields	**CCB Uses**
`FTP_CCB_DC_CHAN`	Channel for the FTP data connection (unsigned word)
`FTP_CCB_DC_PN`	Port number of the data connection (unsigned word)
`FTP_CCB_FEATURE_MASK`	Longword bit mask of server features reported by the response to the FTP `FEAT` command sent by the `CHECK_FEATURES` subroutine
`FTP_CCB_FILENAME`	Name of the file causing the transfer error (character string descriptor)
`FTP_CCB_FOR_IA`	IP address of the remote host (unsigned longword)
`FTP_CCB_FOR_PN`	Remote port number of the control connection (unsigned word)
`FTP_CCB_FX_TYPE`	Data representation type (character string descriptor with a maximum length of 2); see the `FTP_SET_TYPE` routine for the possible values
`FTP_CCB_LOC_IA`	IP address of the local host (unsigned longword)
`FTP_CCB_LOC_PN`	Local port number of the control connection (unsigned word)
`FTP_CCB_LOGGED_IN`	Login status (Boolean); true if the user is successfully logged in on the remote host

`FTP_CCB_NETCHAN`	Channel for the FTP control connection (unsigned word)
`FTP_CCB_NODENAME`	Node name of the remote host (character string descriptor with a maximum length of 128)
`FTP_CCB_OPENED`	Connection status (Boolean); true if control connection is successfully opened to the remote host
`FTP_CCB_PASSWORD`	User password on the remote host (character string descriptor with a maximum length of 64 characters)
`FTP_CCB_PASV`	Boolean that indicates whether passive mode is enabled (`TRUE`) or disabled (`FALSE`).
`FTP_CCB_RPLCOD`	Server reply code (longword)
`FTP_CCB_RPLLEN`	Length of the server reply message (longword)
`FTP_CCB_RPLTXT`	Reply text received from the server (character string descriptor with a maximum length of 512 characters)
`FTP_CCB_STAT_BYTES`	Number of bytes transferred (longword)
`FTP_CCB_STAT_SECONDS`	Seconds required for the transfer (double floating point)
`FTP_CCB_STATUS`	Completion status (unsigned longword)
`FTP_CCB_STRU`	File structure (character string descriptor); see the `FTP_SET_STRU` routine for the possible values
`FTP_CCB_USERNAME`	Username on the remote host (character string descriptor with a maximum length of 64 characters)

Transferring Files

The `FTP_APPEND_FILE`, `FTP_GET_FILE`, and `FTP_PUT_FILE` library routines described in *Library Routines* have two optional arguments: *`mode`* and *`record-size`*. These options provide finer control in transferring OpenVMS files.

Using the *`mode`* argument causes the transfer mode set by `FTP_SET_TYPE` and `FTP_SET_STRU` to be ignored. The lower word of the *mode* longword specifies the primary transfer mode. The following symbols define the primary transfer mode:

`MODE_C_ASCII`	Transfers the file in ASCII format
`MODE_C_IMAGE`	Transfers the file in IMAGE mode
`MODE_C_BINARY`	Transfers .OBJ, .STB, .BIN, and .LDA files in BINARY format
`MODE_C_BLOCK`	Transfers STREAM, STREAM_LF, STREAM_CR and UNDEFINED files in BLOCK mode

The higher word of the *mode* longword defines optional transfer modes. The following symbols define the optional transfer modes:

`MODE_M_FCC`	Combined with `MODE_C_ASCII`, transfers the ASCII file with FORTRAN carriage control.
`MODE_M_APPEND`	Appends the source to a destination file. (Not supported by all servers.)
`MODE_M_VARIABLE`	Combined with `MODE_C_IMAGE`, transfers an image file in variable length recode mode, except that all records are the same length. (Applies to local output image files only.)
`MODE_M_RECORD`	Transfers the file using `STRU_R` so as to communicate the record structure during the copy. (Not supported by all servers.)
`MODE_M_RESTART`	When transferring the file in STREAM mode performs a restart from where the transfer stopped based upon file size. Requires support of the feature and the `CHECK_FEATURES` routine to be called beforehand.

`MODE_M_VMS`	Transfers the file in VMS file mode. Using `MODE_M_VMS` allows you to transfer any type of RMS file between OpenVMS systems. Note that if specifying this flag, all other flags are ignored.

Error Status Codes

To access TCPware error status codes, such as `TCPWARE_REJECTED`, define them in the code as follows:

```
globalvalue TCPWARE_REJECTED;
```

Then `LINK` with the definitions of TCPware error messages using the link option:

```
TCPWARE:SOCKLIB.OLB/INCLUDE=TCPWARE_MSGPTR
```

For example, the following code checks if the status returned by `FTP_PUT_FILE` is `TCPWARE_REJECTED` and takes the appropriate action:

```
globalvalue TCPWARE_REJECTED;
...
status = FTP_PUT_FILE(...);
if (status == TCPWARE_REJECTED)
{
  do something;
  return status;
}
```

Library Routines

This section describes each of the TCPware FTP library routines. Each function argument is described using standard OpenVMS notation for procedure arguments.

All scalar and buffer arguments are passed by reference. Strings are passed by descriptor. All function arguments must be specified, although some optional arguments may be omitted by passing a 0 (by value).

Each TCPware FTP library routine returns an unsigned longword condition value in `R0`. The standard system service return codes defined in the `$SSDEF` macro are used. Gain access to the TCPware error statuses (those beginning with `TCPWARE`) by global value.

These routines are included in the `TCPWARE_FTPLIB_SHR.EXE` shareable library.

FTP_ACCOUNT

Specifies the user account on the remote host.

Format

`FTP_ACCOUNT(u_long ccb, char *account);`

Arguments

ccb

Identifies the CCB with the active connection.

account

Name of the user account on the remote host.

Description

This routine sends the FTP `ACCT` command to specify the name of the account on the remote host.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_NEEDACCT`	Server requires an account for login
`TCPWARE_LOGINFAIL`	Login attempt failed
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_ALLOCATE_CCB

Allocates a connection control block (CCB).

Format

`FTP_ALLOCATE_CCB(u_long *ccb);`

Argument

ccb

Returns a pointer to the new CCB.

Description

This routine allocates a new CCB, initializes the resources, and returns a pointer to it. A CCB must be allocated before all the subsequent calls to the TCPware FTP library routines.

Condition Values Returned

Any condition value returned by `LIB$GET_VM` and `LIB$GET_EF` can be returned.

Example

```
#include <descrip.h>
#include <ssdef.h>
#include "ftpdef.h"
main ()
{
  $DESCRIPTOR(host, "ds.internic.net");
  $DESCRIPTOR(user, "anonymous");
  $DESCRIPTOR(pswd, "your-name@your-site");
  $DESCRIPTOR(dir, "rfc");
  $DESCRIPTOR(file, "rfc-index.txt");
  long ccb, status;
  long debug = DEBUG_REPLY;

  status = SS$_NORMAL;
  ftp_allocate_ccb(&ccb);
  .
  .
  .

  return (status);
}
```

FTP_APPEND_FILE

Appends a file to a remote file.

Format

```
FTP_APPEND_FILE(u_long ccb, char *source, [char *destination], [long mode],
[long *record-size]);
```

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

source

Source file on the local host.

destination

Destination file on the remote host. If omitted, the *source* filename and extensions are used.

mode

Transfer mode. See the *Transferring Files* section for the list of available transfer mode codes.

> **Note:** Using mode causes the transfer mode set by `FTP_SET_TYPE` and `FTP_SET_STRU` to be ignored.

record-size

Record size of the local output file when transferring in IMAGE mode.

Description

This routine sends the `APPE` command to append the local file to the file on the remote host.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_OPENIN`	Error opening a file for input
`TCPWARE_OPENDATA`	Failed to open data connection
`TCPWARE_SETPORT`	Failed to set up data connection
`TCPWARE_FILRDERR`	Error reading from or sending a file
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_AUTH

Specifies the authentication/security mechanism to be used as per RFC 2228 and RFC 4217. Currently only TLS is supported.

Format

`FTP_AUTH(u_long ccb, char *mechanism);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

mechanism

Specifies the authentication/security mechanism to use. Currently only `TLS` is supported.

Description

This routine sends an FTP `AUTH` command to the FTP server. The `FTP_AUTH()` procedure resets the data transfer parameters to the original state as specified in the RFCs.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)
`TCPWARE_IVREQUEST`	Invalid request
`TCPWARE_REQFAIL`	Request failed.

FTP_CCC

Specifies that the command channel return to clear text transmission.

Format

```
FTP_CCC(u_long ccb);
```

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

Description

This routine sends an FTP `CCC` command to the FTP server.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open

FTP_CHECK_FEATURES

Sends the `FEAT` command to the server and builds the bit mask of supported features.

Format

`FTP_CHECK_FEATURES(u_long *ccb*);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

Description

This routine sends an FTP `FEAT` command to the FTP server and interprets the response to build a bit mask of supported optional features.

Condition Values Returned

None.

FTP_CLOSE_CONNECTION

Closes the connection to the remote FTP server if one is open.

Format

`FTP_CLOSE_CONNECTION (u_long *ccb*);`

Argument

ccb

Identifies the CCB whose active FTP connection is to be closed.

Description

This routine sends an FTP `QUIT` command to the remote FTP server to close the connection and free up the resources allocated to it.

Condition Value Returned

`SS$_NORMAL`	Normal successful completion

Example

```
  status = ftp_get_file(ccb, &file, 0, 0, 0);

  if (!(status & 1))
  {
    printf("failed to get file %s", file.dsc$a_pointer);
    goto error;
  }

  error:
    ftp_close_connection(ccb);

  return(status);
```

FTP_CREATE_DIRECTORY

Creates a directory on the remote host.

Format

`FTP_CREATE_DIRECTORY(u_long *ccb*, char **directory*);`

Arguments

ccb
Identifies the CCB with the active and logged-in connection.

directory
Directory specification on the remote host.

Description

This routine sends an FTP `MKD` command that creates a specified directory on the remote server. If the pathname is relative, a subdirectory is created under the current remote directory. If the `MKD` command is rejected, the `XMKD` command is used.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_CREATEFAIL`	Failed to create the directory
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_DEALLOCATE_CCB

Deallocates a CCB.

Format

`FTP_DEALLOCATE_CCB(u_long *ccb);`

Argument

ccb

Identifies the CCB you want to deallocate.

Description

This routine deallocates a CCB that is no longer needed. The CCB is deallocated when it is fully closed. An implicit abort is performed on the connection if the CCB is still in use.

The virtual memory and event flag reserved for the CCB by the `FTP_ALLOCATE_CCB()` routine are freed when this routine is completed.

Condition Value Returned

`SS$_NORMAL`	Normal successful completion

Example

```
  status = ftp_get_file(ccb, &file, 0, 0, 0);
  if ((status & 1))
  {
    printf("failed to get file %s", file.dsc$a_pointer);
    goto error;
  }

error:
  ftp_close_connection(ccb);
```

```
error_nocon:
  ftp_deallocate_ccb(&ccb);
  return(status);
```

FTP_DELETE_DIRECTORY

Deletes a directory on the remote host.

Format

`FTP_DELETE_DIRECTORY(u_long ccb, char *directory);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

directory

Directory to be deleted on the remote host.

Description

This routine sends an FTP `RMD` command to delete a specified directory on the remote server. If the `RMD` command is rejected, the `XRWD` command is used.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_DELETEFAIL`	Failed to delete the remote directory
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_DELETE_FILE

Deletes a file on the remote host.

Format

`FTP_DELETE_FILE(u_long ccb, char *file);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

file

File specification of the file to be deleted on the remote host

Description

This routine sends an FTP `DELE` command to delete a specified file on the remote server.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_DELETEFAIL`	Failed to delete the remote file
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_GET_CCB

Gets information from a CCB field.

Format

`FTP_GET_CCB(u_long ccb,  u_long *field-code, u_long *value, int *length);`

Arguments

ccb

Identifies the CCB from which information is retrieved.

field-code

Code specifying the CCB field information you are requesting.

See *Connection Control Block* for the valid field codes and their data types. Symbols for these field codes are defined in the `TCPWARE_INCLUDE:FTPDEF.H` file.

value

Returned value of the specified CCB field. The value argument is the address of a variable that will receive the value of the CCB field. The data type of this variable depends on the field requested in *`field-code`*.

length

Returns the resulting length of the *`value`* field if the data type of the returned value is STRING.

Description

This routine returns the contents of the specified field from the CCB.

Condition Values Returned

`SS$_NORMAL`	Normal, successful completion

`SS$_BADPARAM`	Bad parameter specified

FTP_GET_FILE

Copies a file from a remote host.

Format

```
FTP_GET_FILE(u_long ccb, char *source, [char *destination], [long *mode],
[word *record-size]);
```

Arguments

ccb
Identifies the CCB with the active and logged-in connection for the file transfer.

source
Source file on the remote host.

destination
Destination file on the local host. If omitted, the *source* filename and extensions are used.

mode
Transfer mode. See *Transferring Files* for a list of available transfer mode codes.

> **Note:** Using mode causes the transfer mode set by `FTP_SET_TYPE` and `FTP_SET_STRU` to be ignored.

record-size
Record size of the local output file when transferring in IMAGE mode.

Description

This routine sends an FTP `RETR` command to transfer a remote file to the local host.

Condition Values Returned

SS$_NORMAL	Normal successful completion
TCPWARE_NONODE	Connection is not open
TCPWARE_OPENOUT	Error opening a file for output
TCPWARE_OPENDATA	Failed to open data connection
TCPWARE_SETPORT	Failed to set up data connection
TCPWARE_FILWRTERR	Error writing to or receiving a file
TCPWARE_CTRLERR	Unexpected error processing the control connection (the connection is closed)

Example

```
$DESCRIPTOR(file, "rfc-index.txt");
long ccb, status;

status = ftp_get_file(ccb, &file, 0, 0, 0);
if (!(status & 1))
{
  printf("failed to get file %s", file.dsc$a_pointer);
  goto error;
}

error:
ftp_close_connection(ccb);

return(status);
```

FTP_GET_LIST

Gets a file listing on the remote host.

Format

```
FTP_GET_LIST(u_long ccb, [char *directory], char *output);
```

Arguments

ccb
Identifies the CCB with the active and logged-in connection.

directory
Directory specification on the remote host. If omitted, the current remote directory is used.

output
Specifies the local file where the output of the remote directory listing is stored.

Description

This routine sends the FTP `LIST` command to list a remote directory and stores the output to the local file. The output is in the format of the remote operating system.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_OPENOUT`	Error opening a file for output
`TCPWARE_OPENDATA`	Failed to open data connection

`TCPWARE_SETPORT`	Failed to set up data connection
`TCPWARE_FILWRTERR`	Error writing to or receiving a file
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_GET_NAME_LIST

Gets a filename listing on the remote host.

Format

`FTP_GET_NAME_LIST(u_long ccb, [char *directory], char *output);`

Arguments

ccb
Identifies the CCB with the active and logged-in connection.

directory
Directory specification on the remote host. If omitted, the current remote directory is used.

output
Specifies the local file where the output of the remote directory listing is stored.

Description

This routine sends the FTP `NAME LIST` (`NLIST`) command to retrieve the name list of the specified remote directory and stores it in the local file. Output is a list of valid file pathnames with each name separated in separate lines. Usually, this output is more suitable for machine processing than the list obtained using `FTP_GET_LIST()`.

Condition Values Returned

See the `FTP_GET_LIST()` routine.

FTP_LOGIN_USER

Authorizes the user on the remote host.

Format

`FTP_LOGIN_USER(u_long ccb, char *username, char *password);`

Arguments

ccb
Identifies the CCB of the active network connection.

username
Username on the remote host.

password
Password of the user on the remote host.

Description

This routine sends the FTP `USER` and `PASS` commands in sequence to the remote host to log in the specified user with the specified password. The connection must have been opened previously. If there is already a user logged in and the specified username and password are identical to the current values, this routine has no effect.

The user must be logged in on the remote host using this routine or a combination of `FTP_USER` and `FTP_PASSWORD` (optionally, `FTP_ACCOUNT`) performed before calling any other routines for data transfer.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open

`TCPWARE_NEEDACCT`	Server requires an account for login
`TCPWARE_LOGINFAIL`	Login attempt failed

Example

```
#include <descrip.h>
#include <ssdef.h>
#include "ftpdef.h"

main()
{
  $DESCRIPTOR(host, "ds.internic.net");
  $DESCRIPTOR(user, "anonymous");
  $DESCRIPTOR(pswd, "your-name@your-site");
  $DESCRIPTOR(dir, "rfc");
  $DESCRIPTOR(file, "rfc-index.txt");

  long ccb, status;
  long debug = DEBUG_REPLY;

  status = SS$_NORMAL;

  ftp_allocate_ccb(&ccb);

  status = ftp_open_connection(ccb, 0, &host, 0, 0);
  if (!(status & 1))
  {
    printf("failed to make connection to %s", host.dsc$a_pointer);
    goto error_nocon;
  }

  status = ftp_login_user (ccb, &user, &pswd);

  if (!(status & 1))
  {
    printf("failed to login as %s", user.dsc$a_pointer);
    goto error;
  }

error:
  ftp_close_connection (ccb);

  return(status);
}
```

FTP_OPEN_CONNECTION

Opens an FTP connection to a remote host.

Format

`FTP_OPEN_CONNECTION(u_long ccb, [u_long *ia], [char *host-name], [u_int *port], [u_long *timeout]);`

Arguments

ccb

Identifies the CCB associated with the new connection.

ia

Internet address of the remote host to which you want to connect. The argument is the address of an unsigned longword containing the internet address in internet byte order (for example, internet address 1.2.3.4 is stored as 04030201 hex).

host-name

Host name of the remote host to which you want to connect. If the string is a valid internet address in *a.b.c.d* format, that address is used. Otherwise, the Socket Library's `gethostbyname` routine is used to determine the internet address from the host name.

port

Port number for the remote FTP server. If omitted, port number 21 is used.

timeout

Timeout time in seconds for establishing the FTP control connection. If omitted, the timeout time is 120 seconds (2 minutes).

Description

This routine opens an active FTP connection to the specified remote host. Specify either the internet address or the host name. If you specify both, the internet address is used.

If you call this routine with a CCB with an active connection and the requested remote host is the same, `SS$_WASSET` is returned and connection is maintained. If you request a different remote host on an active CCB, the existing connection is closed and a new connection is opened.

Condition Values Returned

SS$_NORMAL	Normal successful completion
SS$_WASSET	Connection to specified node already established
SS$_BADPARAM	Missing internet address or host name
SS$_UNREACHABLE	Remote node is unreachable
TCPWARE_REJECTED	Remote server rejected the connection
TCPWARE_OPENCTRL	Failed to open control connection

Example

```
#include <descrip.h>
#include <ssdef.h>
#include "ftpdef.h"

main()
{
  $DESCRIPTOR(host, "ds.internic.net");
  $DESCRIPTOR(user, "anonymous");
  $DESCRIPTOR(pswd, "your-name@your-site");
  $DESCRIPTOR(dir, "rfc");
  $DESCRIPTOR(file, "rfc-index.txt");
  long ccb, status;
  long debug = DEBUG_REPLY;

  status = SS$_NORMAL;

  ftp_allocate_ccb (&ccb);

  status = ftp_open_connection(ccb, 0, &host, 0, 0);
  if (!(status & 1))
  {
    printf("failed to make connection to %s", host.dsc$a_pointer);
    goto error_nocon;
  }
  return (status);
}
```

FTP_PASSWORD

Specifies the user password on the remote host.

Format

`FTP_PASSWORD(u_long *ccb*, char **password*);`

Arguments

ccb

Identifies the CCB with the active connection.

password

Password of the user on the remote host.

Description

This routine sends the FTP `PASS` command to specify the password of the user on the remote host. You must call this routine immediately after the `FTP_USER` routine if the latter returns a `TCPWARE_NEEDPWD` status.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_NEEDACCT`	Server requires an account for login
`TCPWARE_LOGINFAIL`	Login attempt failed
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_PBSZ

Sets the protection buffer size as specified in RFC 2228 and RFC 4217. Only `0` (zero) is supported as per RFC 4217.

Format

```
FTP_PBSZ(u_long ccb, char *size_string);
```

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

size_string

Sets the size of the protection buffer. Currently only “0” (zero) is supported as per RFC 4217.

Description

This routine sends an FTP `PBSZ` command to the FTP server.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_IVREQUEST`	Invalid request
`TCPWARE_NONODE`	Connection is not open

FTP_PRINT_DIRECTORY

Returns the current directory on the remote host.

Format

`FTP_PRINT_DIRECTORY(u_long ccb, char *directory, [int *length]);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

directory

Returns the current directory on the remote host.

length

Returns the resulting length of the *`directory`* field.

Description

This routine sends the FTP `PWD` command to retrieve the current working directory on the remote server. If the `PWD` command is rejected, the `XPWD` command is used.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_BADREPLY`	Unexpected reply from the server
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_PROT

Sets the protection level specified in RFC 2228 and RFC 4217. Only `C` (clear) and `P` (private) are supported as per RFC 4217.

Format

`FTP_PROT(u_long` *`ccb`*`, char` *`prot_level`*`);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection for the file transfer.

prot_level

Specifies the protection level to use for data transfers. Only `C` (clear) and `P` (private) are supported as per RFC 4217.

Description

This routine sends an FTP `PROT` command to the FTP server.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_IVREQUEST`	Invalid request
`TCPWARE_NONODE`	Connection is not open

FTP_PUT_FILE

Copies a file to a remote host.

Format

```
FTP_PUT_FILE(u_long ccb, char *source, [char *destination], [long *mode],
[long *record-size]);
```

Arguments

ccb
Identifies the CCB with the active and logged-in connection for the file transfer.

source
Source file on the local host.

destination
Destination file on the remote host. If omitted, the *source* filename and extensions are used.

mode
Transfer mode. See the *Transferring Files* section for a list of available transfer mode codes.

> **Note:** Using mode causes the transfer mode set by `FTP_SET_TYPE` and `FTP_SET_STRU` to be ignored.

record-size
Record size of the local output file when transferring in IMAGE mode.

Description

This routine sends the `STOR` command to copy the local file to the remote host.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_OPENIN`	Error opening a file for input
`TCPWARE_OPENDATA`	Failed to open data connection
`TCPWARE_SETPORT`	Failed to set up data connection
`TCPWARE_FILRDERR`	Error reading from or sending a file
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_QUOTE

Sends an FTP command to the remote server.

Format

`FTP_QUOTE(u_long *ccb*, char **command*);`

Arguments

ccb

Identifies the CCB with the active connection.

command

Command to be sent to the remote FTP server.

Description

This routine sends the specified literal command string to the remote FTP server. For example, sending the `HELP` command with this routine obtains the help information from the remote server (as reply messages), if the remote server supports this command.

Note that you can use this routine only for simple commands, not for commands involving data transfer.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_RENAME_FILE

Renames a file on the remote host.

Format

```
FTP_RENAME_FILE(u_long ccb, char *old-file, char *new-file);
```

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

old-file

File to rename on the remote host.

new-file

New filename on the remote host.

Description

This routine sends the FTP `RNFR` and `RNTO` commands in sequence to rename a file on the remote server.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_RENAMEFAIL`	Failed to rename the remote file
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_SET_DEBUG

Sets the debugging mode for the FTP library.

Format

`FTP_SET_DEBUG(u_long ccb, u_long *flag, [void *output-routine]);`

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

flag

Debugging flags to be set. Specify any of the following flag bits:

`DEBUG_REPLY`	Output the replies received from the remote server
`DEBUG_COMMAND`	Output the FTP commands sent to the remote server

The symbols for these flags are defined in the `TCPWARE_INCLUDE:FTPDEF.H` file.

output-routine

Address of a pointer to a routine that writes debugging text one line at a time. If omitted, `LIB$PUT_OUTPUT` is used. If you specify the routine of your own, it must have the same calling format as `LIB$PUT_OUTPUT`.

Description

This routine sets the debugging mode for the FTP library. When the debugging flags are set, the FTP library outputs the debugging messages by `LIB$PUT_OUTPUT`, or a user-specified routine.

Condition Value Returned

`SS$_NORMAL`	Normal successful completion

FTP_SET_DIRECTORY

Sets the remote directory.

Format

`FTP_SET_DIRECTORY(u_long ccb, char *directory);`

Arguments

ccb
Identifies the CCB with the active and logged-in connection.

directory
Directory specification on the remote host. If omitted, the parent directory is used.

Description

This routine sends the FTP `CWD` command to change the default directory on the remote server, and the `CUP` command to change the directory to the parent directory. If the directory specification is null, it changes the directory to the parent directory on the remote server. If the `CWD` and `CUP` commands are not accepted, the `XCWD` and `XCUP` commands are used.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_SETDEFAIL`	Failed to set default directory
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

Example

```
  status = ftp_set_directory(ccb, &dir);
  if (!(status & 1))
  {
    printf("failed to change directory to %s", dir.dsc$a_pointer);
    goto error;
  }

error:
  ftp_close_connection(ccb);
```

FTP_SET_PASV

Sets passive mode.

Format

```
FTP_SET_PASV(u_long ccb, u_long *flag);
```

Arguments

ccb

Identifies the CCB with the active and logged-in connection.

flag

Value 0 disables passive mode; value 1 enables passive mode.

Description

This routine sets `PASV` (passive) mode. If enabled, the client sends the server the `PASV` command and the client initiates data connections to the server. If disabled, the client sends the server the `PORT` command and the server initiates the data connections.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion

FTP_SET_STRU

Specifies the file structure.

Note: The mode arguments with `FTP_GET_FILE` and `FTP_PUT_FILE` cause the transfer mode set by `FTP_SET_STRU` to be ignored.

Format

```
FTP_SET_STRU(u_long ccb, char *stru);
```

Arguments

ccb

Identifies the CCB with the active connection for setting the file structure.

stru

Contains a character code that specifies the file structure. The valid types are:

`F`	File (no record structure)
`R`	Record structure
`V`	VMS structure
`O`	O VMS structure (for backward compatibility)

Description

This routine sends the FTP `STRU` command to specify the file structure for the subsequent file transfer.

Condition Values Returned

SS$_NORMAL	Normal successful completion
SS$_BADPARAM	Bad parameter
TCPWARE_NONODE	Connection is not open
TCPWARE_UNSXFRFORM	Unsupported transfer format
TCPWARE_CTRLERR	Unexpected error processing the control connection (the connection is closed)

FTP_SET_TYPE

Specifies the data representation type.

Note: The mode arguments with `FTP_GET_FILE` and `FTP_PUT_FILE` cause the transfer mode set by `FTP_SET_TYPE` to be ignored.

Format

```
FTP_SET_TYPE(u_long ccb, char *type);
```

Arguments

ccb
Identifies the CCB with the active connection.

type
Character string code that specifies the file representation type. The first character is the primary transfer mode, as follows:

A	ASCII
I	Image

EBCDIC type is not supported.

Do not use an additional character for transfer mode `I`. For transfer mode `A`, the second character must specify one of the following format control options:

N	Non-print (no vertical format information)
C	FORTRAN carriage control

TELNET format control is not supported.

Description

This routine sends an FTP `TYPE` command to specify the file representation for the subsequent file transmission. The default representation type is `AN` (ASCII transfer in non-print mode).

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`SS$_BADPARAM`	Bad parameter
`TCPWARE_NONODE`	Connection is not open
`TCPWARE_UNSTYPE`	Unsupported data representation type
`TCPWARE_CTRLERR`	Unexpected error processing the control connection (the connection is closed)

FTP_USER

Specifies the user on the remote host.

Format

```
FTP_USER(u_long ccb, char *username);
```

Arguments

ccb

Identifies the CCB with an active connection for specifying the username.

username

Username on the remote host.

Description

This routine sends an FTP `USER` command to the remote host to specify the user on the remote host. It may require a subsequent call to `FTP_PASSWORD` to complete the login. If there is already a user logged in on the specified connection, that user is logged out.

Condition Values Returned

`SS$_NORMAL`	Normal successful completion
`TCPWARE_NEEDPWD`	Server requires a password for login
`TCPWARE_LOGINFAIL`	Login attempt failed

8. Socket Library

Introduction

This chapter describes the Socket Library to use for your particular programming application.

TCPware provides a Socket Library if you are running a version of VMS earlier than 5.3 or are using the Remote Procedure Call (RPC) routines. However, Process Software does not recommend that you use the TCPware Socket Library for later versions of OpenVMS.

OpenVMS provides a C Socket Library you should use for VMS Version 5.3 and later. VMS provides a collection of VAX C, DEC C, and DEC C++ subroutines that closely emulates the UNIX socket functions.

> **Note!** The TCPware socket library is deprecated and unsupported.

See *VAX C Run Time Library Manual* or *DEC C Language Reference Manual* for information on these socket library routines.

Transitioning to the C Socket Library: Include (Header) Files

OpenVMS provides header files for its C socket library that are similar to those provided by the obsolete TCPware socket library.

To use the VMS C Socket Library header files:

- If you are transitioning an existing VAX C socket application, change any `#include` statements for TCPware's header files to reference VMS's header files. For example:

  ```
  #include "tcpware_include:netdb.h"
  ```

becomes:

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

Then compile as follows:

- On the VAX C command line:

  ```
  $ cc prog.c
  ```

- On the DEC C command line for VAX:

  ```
  $ cc /stand=vaxcprog.c
  ```

- On the DEC C command line for Alpha and I64:

  ```
  $ cc /stand=vaxc/nomember_align/assume=noalignedprog.c
  ```

- If you are porting or developing an ANSI C or C++ application, use the VMS header files as shown above. Then compile the application (in the case of DEC C, omit the `/stand=vaxc` option).

If you are developing a new program using DEC C, compile using:

```
$ cc /prefix_library_entries=all_entriesprog.c
```

Transitioning to the C Socket Library: Linking Applications

You can then link against VMS's C socket library as follows:

- For VAX C:

  ```
  $ link prog,sys$input/options tcpware:ucx$ipc/lib -
  _$ sys$share:vaxcrtl/share
  ```

- For DEC C on the VAX, Alpha and I64, and for DEC C++:

  ```
  $ link prog
  ```

Sample Programs

The following sample programs are included in the `TCPWARE_COMMON:[TCPWARE.EXAMPLES]` directory:

- `TCP_SOCKET_CLIENT.C`
- `TCP_SOCKET_SERVER.C`
- `UDP_SOCKET_CLIENT.C`
- `UDP_SOCKET_SERVER.C`

The `TCP_SOCKET_CLIENT.C` and `TCP_SOCKET_SERVER.C` pair of programs provide a self-declared ECHO server that sequentially accepts client connections and echoes back the client messages. The `UDP_SOCKET_CLIENT.C` and `UDP_SOCKET_SERVER.C` pair of programs provide a self-declared DISCARD server that can receive (and discard) datagrams from multiple clients.

These programs are functionally equivalent to the BGDRIVER sample programs in Chapter 2, *UCX Compatibility Services*.

To build any one of these applications using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL filename
$ LINK filename
```

To build any one of these applications using VAX C, enter:

```
$ CC/VAXC filename
$ LINK filename, TCPWARE:UCX$IPC/LIB, SYS$INPUT/OPTIONS -
_$  SYS$SHARE:VAXCRTL/SHARE
```

Debugging programs that use the C socket library

The logical `TCPWARE_SOCKET_TRACE` can be defined to get a trace of socket library operations and status values returned from TCPware to aid in debugging of applications. The details of the interpretation of the logical are in the table below:

number	• 1 - control operations • 2 - read operations • 4 - write operations

	These values can be ORed together to get any combination of operations.
anything else	Interpreted as a (partial) file specification with the default specification being `SYS$SCRATCH:TCPWARE_SOCKET_`*`process_name`*`.LOG` This can be useful for services that are started up by NETCU or another listening service and that create separate processes. The logical can be defined at the SYSTEM level and the socket library routines will generate a separate log file for each process. When this format is used the log consists of all three classes (control, read and write) operations.

9. TELNET Library

Introduction

This chapter is for application programmers. It describes the TELNET library routines.

The TELNET library routines provide a programming interface to the TELNET protocol. Use the TELNET library routines in your own applications to provide TELNET capabilities.

This chapter does not describe the TELNET protocol.

The following routines are included in the library:

`TEL_ABORT_CONNECTION`	Aborts a TELNET connection
`TEL_ALLOCATE_CCB`	Allocates a connection control block (CCB)
`TEL_CLOSE_CONNECTION`	Closes a TELNET connection
`TEL_CREATE_TERMINAL`	Opens and allocates a TELNET device
`TEL_DEALLOCATE_CCB`	Deallocates a CCB
`TEL_GET_CCB`	Gets the value of a CCB field
`TEL_OPEN_CONNECTION`	Opens a TELNET connection
`TEL_RECEIVE_DATA`	Receives data
`TEL_SEND_COMMAND`	Sends TELNET commands
`TEL_SEND_DATA`	Sends data
`TEL_SET_CCB`	Sets the value of a CCB field

These routines allow you to establish and maintain TELNET connections with remote hosts that support the TELNET protocol. You can establish multiple simultaneous TELNET connections; the number is limited only by the resources available to your process.

The TELNET library routines follow the standard OpenVMS conventions for modular library routines. See the OpenVMS documentation on calling modular libraries for more information.

Because TELNET library routines use asynchronous system traps (ASTs), application programs must not run with ASTs disabled for long periods of time.

The TELNET library routines are in the `TCPWARE:TELLIB.OLB` object library. The symbolic definitions for the various connection control block (CCB) fields are in the `TCPWARE_INCLUDE:_CCBFLD.H` header file. While this file is written for C, it is easy to convert to other languages.

The TELNET client sample program is provided in `TCPWARE_COMMON:[TCPWARE.EXAMPLES]TELNET_SAMPLE.C`.

To build using DEC C, enter:

```
$ CC/DECC/PREFIX=ALL TELNET_SAMPLE.C
$ LINK FTPSAMPLE, SYS$INPUT/OPTIONS TCPWARE:TELLIB/LIB -
_$ SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE
```

To build using VAX C, enter:

```
$ CC/VAXC/PREFIX=ALL TELNET_SAMPLE.C
$ LINK FTPSAMPLE, SYS$INPUT/OPTIONS TCPWARE:TELLIB/LIB -
_$ SYS$SHARE:TCPWARE_SOCKLIB_SHR/SHARE -
_$ SYS$SHARE:VAXCRTL.EXE/SHARE
```

Connection Control Block

This section describes the connection control block (CCB) that contains all the information required to establish and maintain a TELNET connection. Each open connection requires a CCB.

The storage space for the CCB is allocated dynamically. Therefore, the number of simultaneous connections is limited only by your process resources. A CCB can be reused; you can close one connection and then open a new one using the same CCB.

Note: The *`ccb-ptr`* argument in the library routines must remain in scope at a fixed address. Also, the *`ccb-ptr`* is to be used with a single CCB from the time of `TEL_ALLOCATE_CCB` to `TEL_DEALLOCATE_CCB`.

You can access the CCB fields with the `TEL_GET_CCB` and `TEL_SET_CCB` library routines as described below. The below table lists the CCB fields and their uses:

CCB Fields	**CCB Uses**
`CCB_ASTRTN`	Address of the AST routine to be called when data is received (unsigned longword). Cleared once the AST is declared. You must explicitly reset this field each time you want the AST to be used. Use with `TEL_GET_CCB` or `TEL_SET_CCB`, or with `TEL_OPEN_CONNECTION`.
`CCB_CHAN`	Channel number for the `TCP0:` device (unsigned word), defined only when a connection is open (otherwise 0). (Use the `CCB_ISOPEN` field described below to determine if a connection is open instead of checking for a non-zero channel number.) Use with `TEL_GET_CCB`.
`CCB_CMDRTN`	Address of your TELNET command processing routine that you must use with `TEL_OPEN_CONNECTION` (unsigned longword). Also use with `TEL_GET_CCB` or `TEL_SET_CCB`.
`CCB_EF`	Event flag number to set when there is received data (unsigned longword). Can also be used as an argument to `TEL_OPEN_CONNECTION`. Use event flag 0 to disable the use of an event flag. Use with `TEL_GET_CCB`.
`CCB_ISOPEN`	Connection status (unsigned byte). Value is 1 if the connection is open, 0 if not. Use with `TEL_GET_CCB`.
`CCB_LIA`	Connection's local internet address (unsigned longword), in internet byte order (for example, internet address 1.2.3.4 is stored as 04030201 hex). Valid only when a connection is open. Use with `TEL_GET_CCB`.

`CCB_LPORT`	Local port number for the connection (unsigned word). Valid only when a connection is open. Use with `TEL_GET_CCB`.
`CCB_RCVBCT`	Total byte count for the connection (unsigned longword). The counter wraps with an overflow. Use with `TEL_GET_CCB`.
`CCB_RCVBCNT`	Number of unread bytes in the internal receive buffer that reflects the amount of raw data in the internal buffer (unsigned word). May be larger than the actual number of user data bytes you read due to requirements of the TELNET protocol. Use with `TEL_GET_CCB`.
`CCB_RCVIOC`	Total count of internal network read operations performed for the connection (unsigned longword). The counter wraps with an overflow. Use with `TEL_GET_CCB`.
`CCB_RIA`	Connection's remote internet address (unsigned longword), in internet byte order (for example, internet address 1.2.3.4 is stored as 04030201 hex). Can be set only when used as an argument to `TEL_OPEN_CONNECTION`. Use with `TEL_GET_CCB`.
`CCB_RPORT`	Remote port number for the connection (unsigned word), the default being 23 (for the TELNET server). You can only set this field when specified as an argument to `TEL_OPEN_CONNECTION`. Valid only when a connection is open. Use with `TEL_GET_CCB`.
`CCB_SNDBCNT`	Number of untransmitted bytes in the internal send buffer (unsigned word) that reflects the amount of raw data in the internal buffer. May be larger than the actual number of user data bytes you send due to requirements of the TELNET protocol. Use with `TEL_GET_CCB`.
`CCB_SNDBCT`	Total count of bytes sent for the connection (unsigned longword). The counter wraps with an overflow. Use with `TEL_GET_CCB`.
`CCB_SNDIOC`	Total count of internal write operations for the connection (unsigned longword). The counter wraps with an overflow. Use with `TEL_GET_CCB`.

CCB_TIMO	Time-out value (in seconds) for the connection (unsigned longword), the default being 120 seconds (2 minutes). Can also be used as an argument to TEL_OPEN_CONNECTION. Use with TEL_GET_CCB.
CCB_UFLAGS	Communicates state information between the user's application and the library routines (unsigned longword). The below table lists the only defined bits. All other bits are reserved and must be zero. Your program should set and clear bits 0 and 1 in this field when TELNET negotiates the TRANSMIT-BINARY option. Use with TEL_GET_CCB or TEL_SET_CCB.
CCB_USER1	User-definable (unsigned longword). Use with TEL_GET_CCB or TEL_SET_CCB.
CCB_USER2	User-definable (unsigned longword). Use with TEL_GET_CCB or TEL_SET_CCB.

If you want to enable SYNCH signal processing mode, set bit 31 before opening a connection. The TELNET library routines enter this mode when they receive urgent data. They remain in this mode until they encounter the TELNET DATA MARK command and no more urgent data exists. In this mode, TEL_RECEIVE_DATA discards all data and the EC and EL commands. All other TELNET commands are passed to your command processing routine.

Bit...	**If set, means...**
0	Enables local binary mode
1	Enables remote binary mode
31	Enables SYNCH signal processing

The TELNET library routines use additional fields internally that are not accessible to application programs.

Library Routines Reference

This section describes each of the TELNET library routines.

All scalar and buffer arguments are passed by reference. Strings are passed by descriptor. You must use all function arguments, although you can omit some optional ones by passing a 0 (by value).

Each TELNET library routine returns an unsigned longword condition value in `R0` and use the standard system service return codes defined in the `$SSDEF` macro.

The function arguments are described using the following "dot" notation:

```
argument-name.access-data-type.passing-mechanism  parameter-form
```

For example, the following argument specification indicates the CCB address pointer, having modify access and a passing mechanism by reference:

```
ccb-ptr.ma.r
```

See the OpenVMS Run-Time Library documentation for a complete description of this procedure argument notation.

These routines are included in the `TCPWARE:TELLIB.OLB` object library. You must also include the Socket Library when linking.

See the beginning of this chapter for details on linking.

TEL_ABORT_CONNECTION

Aborts a connection.

Format

```
ret-status.wlc.v = TEL_ABORT_CONNECTION(u_long *ccb-ptr);
```

Argument

ccb-ptr

Address of a pointer to the connection control block (CCB) used by all the TELNET library routines to identify a connection.

Description

Aborts the TELNET connection, cancels all outstanding sends and receives, and returns the `SS$_VCBROKEN` status.

Condition Values Returned

`SS$_NORMAL`	Connection aborted (connection closed)

TEL_ALLOCATE_CCB

Allocates a connection control block (CCB).

Format

```
ret-status.wlc.v = TEL_ALLOCATE_CCB(ccb-ptr,rcv-buf-size,snd-buf-size);
```

Arguments

ccb-ptr

Address of an unsigned longword that will receive a pointer to the CCB used by all the TELNET library routines to identify a connection.

rcv-buf-size

Address of an unsigned word containing the number of bytes allocated to the internal receive buffer. There is no minimum buffer size by default. However, use at least 64 bytes as an absolute minimum, with 1024 bytes recommended to enhance performance.

snd-buf-size

Address of an unsigned word containing the number of bytes allocated to the internal send buffer. There is no minimum buffer size by default. However, use at least 64 bytes as an absolute minimum, with 1024 bytes recommended to enhance performance.

Description

Allocates memory for a CCB using the `LIB$GET_VM` routine. Memory is allocated from the default zone. The CCB and the internal buffers are contiguous in memory. An internal local event flag will also be allocated from the second local event flag cluster.

You should only access the CCB data fields using the `TEL_GET_CCB` and `TEL_SET_CCB` routines. You must allocate a CCB before calling any other TELNET library routine.

Condition Values Returned

Any condition value returned by `LIB$GET_VM` and `LIB$GET_EF`.

TEL_CLOSE_CONNECTION

Closes a TELNET connection.

Format

`ret-status.wlc.v = TEL_CLOSE_CONNECTION(ccb-ptr);`

Argument

ccb-ptr
Address of a pointer to the CCB.

Description

Call this routine when you finished sending data to the remote host or when the remote host notifies you that it closed its end of the connection.

This routine initiates a close on the local end of an open connection. For a connection to be fully closed, both ends of the connection (local and remote) must be closed. No more data can be sent or received once a connection is fully closed.

Additional data can be received until the remote end closes its side of the connection. Therefore, you must call the `TEL_RECEIVE_DATA` routine until the `SS$_VCCLOSED` status is returned.

Here are the two typical close situations:

Remote end closes first	`TEL_RECEIVE_DATA` returns the `SS$_VCCLOSED` status, then you call `TEL_CLOSE_CONNECTION` to close your end of the connection. `TEL_CLOSE_CONNECTION` returns when the connection is fully closed.
Local end closes first	You call `TEL_CLOSE_CONNECTION` to close your end of the connection. `TEL_CLOSE_CONNECTION` returns, but the remote end of the connection is still open. You must call `TEL_RECEIVE_DATA` until it returns the `SS$_VCCLOSED` status.

In general TEL_RECEIVE_DATA must return SS$_VCCLOSED. This can happen before or after you call TEL_CLOSE_CONNECTION.

Condition Values Returned

SS$_ILLSEQOP	Connection not open
SS$_NORMAL	Success, close initiated or successful
SS$_THIRDPARTY	Software was shut down (connection closed)
SS$_TIMEOUT	Connection timed out (connection closed)
SS$_VCBROKEN	Connection broken (connection closed)

TEL_CREATE_TERMINAL

Opens and allocates a connection to an NTA device so that you can use a terminal device with TELNET.

Format

```
ret-status.wlc.v = TEL_CREATE_TERMINAL(ccb-ptr, [ia], [host], cmd-rtn,
[efn], [ast-addr], [port], [timeout], [flags]);
```

Arguments

ccb-ptr
Address of a pointer to the CCB. The CCB must be in a closed state.

ia
Address of an unsigned longword containing the remote host's internet address in internet byte order (for example, internet address 1.2.3.4 is stored as 04030201 hex). If omitted or 0, the *host* argument determines the remote host.

host
Address of a text string descriptor of the remote host's host name. If the string is a valid *a.b.c.d* type internet address, that address is used. Otherwise, the Socket Library's `gethostbyname` routine determines the internet address from the host name. If omitted or a null string, the *ia* argument determines the remote host.

cmd-rtn
Address of the user's command processing routine called each time a TELNET command is received. Inputs to the command processing routine are the CCB of the connection, a buffer containing one complete command, and a buffer byte count.

efn
Address of an unsigned longword containing the event flag to use. The event flag is set whenever data is available in the receive buffer, and cleared when the last byte of data is removed. It is up to you to allocate the event flag if necessary. You must never set or clear the event flag. If omitted, the previous value of this field is used; if 0, the field is cleared. If no event flag is specified, you will have to use another method, such as an AST routine, to determine when data is received.

ast-adr

Address of an AST routine to be called when data is received. This AST routine is declared when received data is available. You must set the *ast-adr* each time you want to be notified of received data. Use the TEL_SET_CCB routine to set the *ast-adr* after a connection is open.

A pointer to the CCB is passed to the AST routine by reference as the AST argument. You can use the CCB_USER1 and CCB_USER2 fields if you want to pass arguments to the AST routine.

port

Address of an unsigned word containing the 16-bit port number for the connection (normally 23). Supplied for use in special applications where the remote server is not a standard TELNET server. If omitted or 0, the default value 23 is used.

timeout

Address of an unsigned longword with the number of seconds to wait on the connection before timeout. If omitted or 0, the default value 120 (2 minutes) is used.

Description

Call this routine when you want to open and allocate a connection to an NTA device so that you can use a terminal device with TELNET.

TEL_DEALLOCATE_CCB

Deallocates a CCB.

Format

```
ret-status.wlc.v = TEL_DEALLOCATE_CCB(ccb-ptr);
```

Argument

ccb-ptr

Address of a pointer to the CCB.

Description

Gets rid of a CCB you no longer need. The CCB is deallocated when it is fully closed. An implicit abort is performed on the connection if the CCB is still in use.

The virtual memory and event flag reserved for the CCB by the `TEL_ALLOCATE_CCB` routine is freed when this routine completes.

Condition Values Returned

`SS$_NORMAL`	Success

TEL_GET_CCB

Gets information from a CCB field.

Format

`*ret-status.wlc.v* = TEL_GET_CCB(*ccb-ptr*, *field-code*, *value*);`

Arguments

ccb-ptr

Address of a pointer to the CCB. The CCB for the connection does not need to be open unless otherwise specified.

field-code

Address of an unsigned word containing the symbolic value for the CCB field. The symbolic definitions for the CCB fields are in the `TCPWARE_INCLUDE:_CCBFLD.H` file.

value

Address of a variable that receives the value of the CCB field. The data type of this variable depends on the field requested in *`field-code`*.

Description

The value of the CCB field you requested is returned in the argument value. The data type of *value* should be the same as the field you requested.

Condition Values Returned

`SS$_BADPARAM`	Bad *`field-code`* specified
`SS$_NORMAL`	Normal, successful completion

TEL_OPEN_CONNECTION

Opens a TELNET connection to a remote host.

Format

```
ret-status.wlc.v = TEL_OPEN_CONNECTION(ccb-ptr, [ia], [host], cmd-rtn,
[efn], [ast-adr], [port], [timeout]);
```

Arguments

ccb-ptr
Address of a pointer to the CCB.

ia
Address of an unsigned longword containing the remote host's internet address in internet byte order (for example, internet address 1.2.3.4 is stored as 04030201 hex). If omitted or 0, the *host* argument determines the remote host name.

host
Address of a text string descriptor of the remote host's host name. If the string is a valid *a.b.c.d* type internet address, that address is used. Otherwise, the Socket Library's `gethostbyname` routine determines the internet address from the host name. If omitted or a null string, the *ia* argument determines the remote host.

cmd-rtn
Address of the user's command processing routine called each time a TELNET command is received. Inputs to the command processing routine are the CCB of the connection, a buffer containing one complete command, and a buffer byte count.

efn
Address of an unsigned longword containing the event flag to use. The event flag is set whenever data is available in the receive buffer, and cleared when the last byte of data is removed. It is up to you to allocate the event flag if necessary. You must never set or clear the event flag. If omitted, the previous value of this field is used; if 0, the field is cleared. If no event flag is specified, you will have to use another method, such as an AST routine, to determine when data is received.

ast-adr
Address of an AST routine to be called when data is received. This AST routine is declared when received data is available. You must set the *ast-adr* each time you want to be notified of received data. Use the `TEL_SET_CCB` routine to set the *ast-adr* after a connection is open.

A pointer to the CCB is passed to the AST routine by reference as the AST argument. You can use the `CCB_USER1` and `CCB_USER2` fields if you want to pass arguments to the AST routine.

port
Address of an unsigned word containing the 16-bit port number for the connection (normally 23). Supplied for use in special applications where the remote server is not a standard TELNET server. If omitted or 0, the default value 23 is used.

timeout
Address of an unsigned longword with the number of seconds to wait on the connection before timeout. If omitted or 0, the default value 120 (2 minutes) is used.

Description

Opens an active TELNET connection to the remote host specified in *ia* or *host*. A network read operation is automatically initiated.

Specify either the internet address or host name. If you specify both, the internet address is used.

See the *TCPware Management Guide* for details on internet addresses and hostnames.

A connection must be opened before you can send or receive data or commands.

Condition Values Returned

`SS$_BADPARAM`	Invalid I/O channel, missing internet address or host name, or no route exists to the specified internet address
`SS$_NORMAL`	Connection is open
`SS$_NOSUCHNODE`	*ia* was not specified, and *host* was not found by `gethostbyname`

SS$_THIRDPARTY	Software was shut down (connection closed)
SS$_TIMEOUT	Connection timed-out (connection closed)
SS$_VCBROKEN	Connection broken (connection closed)

Any condition value returned by the `$ASSIGN` and `$QIO` system services.

TEL_RECEIVE_DATA

Receives data from a remote host.

Format

`ret-status.wlc.v = TEL_RECEIVE_DATA(ccb-ptr, buffer-size, buffer, byte-count);`

Arguments

ccb-ptr
Address of a pointer to the CCB.

The *ccb-ptr* variable must remain in scope at a fixed address. Also, the *ccb-ptr* is to be used with a single CCB from the time of `TEL_ALLOCATE_CCB` to `TEL_DEALLOCATE_CCB`.

buffer-size
Address of an unsigned word containing the number of bytes you are willing to receive.

buffer
Address of the first byte of the buffer. The buffer must be at least *buffer-size* bytes in length.

byte-count
Address of an unsigned word variable that receives the length of the data in the buffer.

Description

Call this routine whenever data is available. You can use ASTs or event flags to determine when data is available. You must also call this routine after you initiated a close from the local end, as the remote host may still be open and sending data. When the remote host closes, `TEL_RECEIVE_DATA` returns a status of `SS$_VCCLOSED`.

If you are using ASTs, you must set the AST address each time you want to be notified by an AST that data is available. This is typically done before returning from your AST routine.

See `TEL_SET_CCB()/`

`TEL`_SET_CCB on how to set the AST address or event flag number.

Do not use this routine to poll for data since that would waste CPU time.

Pairs of IAC characters (ASCII 255) are translated to a single IAC, and a NUL character (ASCII 0) following a carriage return is removed as dictated by the TELNET protocol. When in remote binary mode (bit 1 is set in `CCB_UFLAGS`) a NULL following a carriage return is not removed.

This routine ensures that TELNET commands and data are processed in the order in which they are received. It does this by copying TELNET data to your buffer until your buffer is full, there is no more data, or a TELNET command is encountered. If a TELNET command is encountered and data was copied to your buffer, it is not processed until the next call to `TEL_RECEIVE_DATA()`, at which time any additional data following the TELNET command or commands is also returned.

When the *`byte-count`* argument is 0, all data (and commands) have been processed. If the remote end closes the connection, a `SS$_VCCLOSED` status is returned after the last byte is transferred. You must call `TEL_CLOSE_CONNECTION()` to fully close the connection.

Condition Values Returned

`SS$_ILLSEQOP`	Connection not open
`SS$_NORMAL`	Success, data was copied to internal buffer
`SS$_THIRDPARTY`	Software was shut down (connection closed)
`SS$_TIMEOUT`	Connection timed-out (connection closed)
`SS$_VCBROKEN`	Connection broken (connection closed)
`SS$_VCCLOSED`	Connection closed by remote host (local end still open)

TEL_SEND_COMMAND

Sends TELNET commands to the remote host. Commands include option commands and control functions (such as `BREAK` and `AYT`).

Format

`ret-status.wlc.v = TEL_SEND_COMMAND(ccb-ptr, buffer, byte-count);`

Arguments

ccb-ptr
Address of a pointer to the CCB.

buffer
Address of the first byte of your data. The commands must be complete and correct. Command data *must* include the IAC character(s) where appropriate.

byte-count
Address of an unsigned word containing the number of bytes in the command buffer.

Description

This routine is similar to the `TEL_SEND_DATA()` routine. The only difference is that no processing is done to the command data. The buffer is transmitted with IAC and CR characters left as is.

Condition Values Returned

`SS$_ILLSEQOP`	Connection not open
`SS$_NORMAL`	Success, data was copied to internal buffer
`SS$_THIRDPARTY`	Software was shut down (connection closed)

`SS$_TIMEOUT`	Connection timed-out (connection closed)
`SS$_VCBROKEN`	Connection broken (connection closed)

TEL_SEND_DATA

Sends data to the remote host.

Format

`ret-status.wlc.v = TEL_SEND_DATA(ccb-ptr, buffer, byte-count);`

Arguments

ccb-ptr
Address of a pointer to the CCB.

buffer
Address of the first byte of your data.

byte-count
Address of an unsigned word containing the number of bytes in the data buffer.

Description

Sends the data in your buffer to the remote host. This routine will not return until all of the data is copied to the internal transmit buffer.

Usually data is immediately copied to the internal buffer, and control is returned to your application program. However, if the internal transmit buffer is full, `TEL_SEND_DATA` ()waits until there is room in the internal buffer before copying the data and returning. Buffer space becomes available as data is delivered to the remote host.

IAC characters (ASCII 255) in your buffer are doubled and carriage returns not followed by line feeds have a NULL character (ASCII 0) inserted following the carriage return as dictated by the TELNET protocol. When in local binary mode (bit 0 is set in `CCB_UFLAGS`) a NULL character is not inserted after a carriage return.

Condition Values Returned

`SS$_ILLSEQOP`	Connection not open

SS$_NORMAL	Success, data was copied to internal buffer
SS$_THIRDPARTY	Software was shut down (connection closed)
SS$_TIMEOUT	Connection timed-out (connection closed)
SS$_VCBROKEN	Connection broken (connection closed)

TEL_SEND_URGENT

Sends TELNET commands to the remote host using TCP urgent notification. Commands include option commands and control functions (such as `BREAK` and `AYT`).

Format

`ret-status.wlc.v = TEL_SEND_URGENT(ccb-ptr, buffer, byte-count);`

Arguments

ccb-ptr
Address of a pointer to the CCB.

buffer
Address of the first byte of your data. The commands must be complete and correct. Command data *must* include the IAC character(s) where appropriate.

byte-count
Address of an unsigned word containing the number of bytes in the command buffer.

Description

This routine is similar to the `TEL_SEND_COMMAND()` routine. The only difference is that `TEL_SEND_URGENT()` sends data using TCP urgent notification.

Condition Values Returned

`SS$_ILLSEQOP`	Connection not open
`SS$_NORMAL`	Success, data was copied to internal buffer
`SS$_THIRDPARTY`	Software was shut down (connection closed)

`SS$_TIMEOUT`	Connection timed-out (connection closed)
`SS$_VCBROKEN`	Connection broken (connection closed)

TEL_SET_CCB

Sets the value of a CCB field.

Format

```
ret-status.wlc.v = TEL_SET_CCB(ccb-ptr, field-code, value);
```

Arguments

ccb-ptr

Address of a pointer to the CCB. The CCB does not need to be open.

field-code

Address of an unsigned word containing the symbolic value for the CCB field. The symbolic definitions for the CCB fields are in the `TCPWARE_INCLUDE:CCBFLD.H` file.

value

Address of a variable that receives the value of the CCB field. The data type of this variable depends on the field requested in *`field-code`*.

> **Note:** When you set the `CCD_ASTRTN` or the `CCB_CMDRTN` field, make sure that value is the address of the address of the routine.

Description

The CCB field you requested is set to the value specified in *value*. The data type of `value` should be the same as the field you specified.

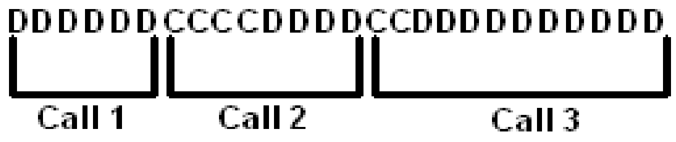
Condition Values Returned

`SS$_BADPARAM`	Bad *`field-code`* specified
`SS$_NORMAL`	Normal, successful completion

User Command Processing

The user command processing routine is a routine that you write to process received TELNET commands. TELNET commands include option-negotiating commands (such as `WILL`, `WONT`, `DO`, and `DONT`) and control functions (such as `AYT`, `EL`, and `BREAK`).

The `TEL_RECEIVE_DATA` routine calls your processing routine to process TELNET commands. TELNET commands are processed before any data is returned in the `TEL_RECEIVE_DATA` call. For example, the data stream shown in the below figure is returned to you in three calls to `TEL_RECEIVE_DATA`.



`D` represents data bytes and `C` represents TELNET commands. Your command processing routine is called four times at the beginning of call 2 and twice at the beginning of call 3. This ensures that any change in the way data following a TELNET command is to be interpreted can go into effect before the data is processed. Also, if data needs to be included in the data stream in place of the TELNET command, it can be inserted before the beginning of the data buffer returned by the `TEL_RECEIVE_DATA` routine.

Your routine should have the following call format:

```
your-routine (ccb-ptr.ma.r, buffer.rbu.ra, byte-count.rwu.r)
```

The routine is called with the following inputs:

- CCB pointer, by reference
- Address of the command buffer, as an array of bytes
- Size of the command buffer, by reference to an unsigned word

There are no outputs or return values.

One complete command at a time is passed to your command processing routine. Commands are passed with the leading IAC character removed from them. For example, the command IAC *`value`* is passed as *`value`*; IAC `DO ECHO` is passed as `DO ECHO`, and IAC `SB` *`subnegotiation`* `IAC SE` is passed as `SB`. The *`subnegotiation`* command data is returned as is. No processing of IAC characters is done.

10. SNMP Extendible Agent API Routines

Introduction

This chapter is for application programmers. It describes the Application Programming Interface (API) routines required for an application program to export private Management Information Bases (MIBs) using the TCPware SNMP agent.

To be able to use your private Management Information Base (MIB) with TCPware's SNMP agent, develop a shareable image that exports the following application programming interface routines, in addition to routines you may need to access the MIB variables:

`SnmpExtensionInit`	Called by the SNMPD agent after startup to initialize the MIB subagent
`SnmpExtensionInitEx`	Registers multiple subtrees with the subagent (called by the SNMPD agent at startup only if implemented)
`SnmpExtensionQuery`	Completes the MIB subagent query (called by the SNMPD agent to handle a get, getnext, or set request)
`SnmpExtensionTrap`	Sends an enterprise-specific trap (called by the SNMPD agent when the subagent alerts the agent that a trap needs to be sent)

The SNMP shareable images need to be configured for the SNMP agent to interact with them.

See the *Configuration* chapter of the *Installation & Configuration Guide* for details on configuring the SNMP agent.

SNMP subagent developers should use the include file `SNMP_COMMON.H` found in the `TCPWARE_INCLUDE` directory. This file defines the data structures the API uses.

For details on TCPware's SNMP agent, see Chapter 10, in the *Management Guide*.

Requirements

You require the following before using the SNMP extendible agent API routines:

- Working knowledge of SNMP; specifically, the following RFCs:
  - RFC 1155, *Structure and Identification of Management Information for TCP/IP-based Internets*
  - RFC 1157, *A Simple Network Management Protocol (SNMP)*
  - RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*
- Working knowledge of OpenVMS shareable images

Linking the Extension Agent Image

To link the Extension Agent Image you need to create an option file:

VAX

```
!Note: Exclude SnmpExtensionInitEx if it is not needed.
!See the definition of this routine.
!
UNIVERSAL=SnmpExtensionInit, -
SnmpExtensionQuery, -
SnmpExtensionTrap, -
SnmpExtensionInitEx
SYS$SHARE:VAXCRTL/SHARE
!
!List your object/library files here
```

Alpha and Integrity

```
!Note: Exclude SnmpExtensionInitEx if it is not needed.
!See the definition of this routine.
!
SYMBOL_VECTOR=( SnmpExtensionInit=PROCEDURE, -
SnmpExtensionQuery=PROCEDURE, -
SnmpExtensionTrap=PROCEDURE, -
SnmpExtensionInitEx=PROCEDURE)
!
!List your object/library files here
```

Your link statement should then look like this:

```
$ LINK /SHARE=image-name option-file/OPT
```

image-name is the name of the shareable image you want to build, and *option-file* is the option file mentioned above.

Installing the Extension Agent Image

You should copy the shareable image you build for your SNMP subagent to the SYS$SHARE directory.

> **CAUTION!** Since the shareable image is loaded into the same process address space as the SNMPD server, an access violation by the subagent shareable image can crash the server application. Ensure the integrity of your shareable image by testing it thoroughly. Shareable image errors can also corrupt the server's memory space or may result in memory or resource leaks.

Sample Code and Data Structures

Sample code is provided in the SYS$COMMON:[TCPWARE.EXAMPLES] directory in the files SNMP_SUBAGENT.C and SNMP_SUBAGENT.H.

SNMP_SUBAGENT.H also defines the following data structures found in the subroutines:

- AsnOBJID
- RFC1157VarBindList

Debugging Code

SNMP subagent developers can use a debug logical, TCPWARE_SNMP_DEBUG to set certain debug masks. Define the logical as follows and use the *mask* values from the below table:

```
$ DEFINE SYSTEM TCPWARE_SNMP_DEBUG mask
```

Mask Value	Description
0010	Raw SNMP input

0020	Raw SNMP output
0040	ASN.1 encoded message input
0080	ASN.1 encoded message output
1000	SNMP Subagent Developer debug mask (prints events and statuses)

Subroutine Reference

The following pages include the subroutine descriptions.

SnmpExtensionInit

Initializes the SNMP subagent and registers the subagent in the SNMPD agent. The subagent calls this routine at startup.

Format

`status = SnmpExtensionInit(int` *`trap-alert-routine`*`, unsigned long` *`time-zero-reference`*`, unsigned long *`*`trap-event`*`, AsnOBJID *`*`supported-view`*`)`

Return Values

This routine returns `TRUE` if the subagent was successfully initialized; `FALSE` if initialization failed.

Arguments

`trap-alert-routine`
Address of the routine the subagent should call when it is ready to send a trap.

`time-zero-reference`
Time reference the SNMP agent provides, in hundredths of a second. Use C routines `time()` and `difftime()` to calculate MIB uptime (in hundredths of a second).

`trap-event`
This parameter is reserved for future use.

`supported-view`
Prefix of the MIB tree the subagent supports.

SnmpExtensionInitEx

Registers multiple MIB subtrees with agent.

This routine is called multiple times, once for each MIB subtree that needs to be registered. If the routine passes back the first or next MIB subtree, return with `TRUE`. If all the MIB subtrees were passed back, return with `FALSE`.

> **Note:** Only implement this routine if you have multiple MIB subtrees in your extendible agent. The TCPware SNMP agent executes this routine if it exists and overwrites MIB information set by `SnmpExtensionInit`.

Format

`status = SnmpExtentionInitEx(AsnOBJID *supported-view);`

Return Values

Returns `TRUE` if returning the first or next MIB subtree, `FALSE` if all of the MIB subtrees have been passed back.

Arguments

supported-view
Prefix of the MIB tree the subagent supports.

Example

```
int SnmpExtensionInitEx(AsnOBJID *supportedView)
{
    int view1[] = {1, 3, 6, 1, 4, 1, 12, 2, 1 };
    int view2[] = {1, 3, 6, 1, 4, 1, 12, 2, 2 };
    int view3[] = {1, 3, 6, 1, 4, 1, 12, 2, 5 };
    static int whichView = 0;
    switch (whichView++)
    {
    case 0:
      supportedView->idLength = 9;
      memcpy (supportedView->ids, view1, 9* sizeof (int));
      break;
    case 1:
      supportedView->idLength = 9;
      memcpy (supportedView->ids, view2, 9* sizeof (int));
      break;
    case 2:
      supportedView->idLength = 9;
      memcpy (supportedView->ids, view3, 9* sizeof (int));
      break;
    default:
      return (0);
    }
    return (1);
}
```

SnmpExtensionQuery

Queries the SNMP subagent to get or set a variable in the MIB tree served by the subagent. This routine is called by the SNMPD agent to handle a `get`, `getnext`, or `set` request.

Format

`status = SnmpExtensionQuery (unsigned char *`*`request-type`*`, RFC1157VarBindList` *`var-bind-list`*`, int` *`error-status`*`,` *`int error-index`*`);`

Return Values

Returns `TRUE` if the operation successfully complete, `FALSE` if the operation could not be carried out by the subagent; use `error-status` and `error-index` to provide more information.

Arguments

request-type

Identifies the type of request: `GET`, `SET`, or `GET NEXT`. These values are defined in `TCPWARE_ROOT:[TCPWARE.INCLUDE]SNMP_COMMON.H`

var-bind-list

The list of name-value pairs used in the request. For a `GET` request the value is filled by the subagent and for a `SET` request, the value is be used to change the current variable value in the subagent. (The `VarBindList` structure is defined in RFC 1157 - see `SNMP_SUBAGENT.H`.)

error-status

Status of a failed operation. See `SNMP_COMMON.H` for error value names.

error-index

The index of the variable in the variable binding list for which the operation failed.

SnmpExtensionTrap

Sends a trap from the subagent. If the subagent wants to send a trap, it must first call the `trap-alert-routine` (see the `SnmpExtensionInit` routine). The `trap-alert-routine` should be called with two parameters (`oid` *`ids`*, `oid` *`idlength`*). For example:

If Process Software's DNS process wants to send trap information to all the communities that are interested then the DNS server must be running and the *`objectids`* passed are `1,3,6,1,4,1,105,1,2,1,1,1,3,1`, and the length of `14`.

- `1,3,6,1,4,1` is the default prefix
- `105` is the enterprise ID for Process Software
- `1,2,1,1,1` are the MIB object IDs for the DNS process
- `3,1` are the *`objectids`* for `DNSUpTrap`

The SNMP agent `trap-alert-routine` creates a table of all received trap MIBs. For each of these entries, the agent then calls the subagent's `SnmpExtensionTrap` routine when it is ready to send the trap. Note that the SNMP agent calls the subagent from inside the `trap-alert-routine`.

Format

```
status = SnmpExtensionTrap(AsnOBJID *enterprise, int generic-trap, int
*specific-trap, int *time-stamp, RFC1157VarBindList var-bind-list);
```

Return Values

Returns `TRUE` if there are more traps to be generated; `FALSE` if there are no more traps to be generated.

Arguments

enterprise

The prefix of the MIB for the enterprise sending the trap. (See the `SNMP_SUBAGENT.H` file.)

generic-trap

The generic enterprise trap ID.

specific-trap
The enterprise-specific trap number.

Note: Since an enterprise can have many traps, the combination of enterprise ID, generic trap, and specific trap should give a unique identification for a trap.

time-stamp
The time at which the trap was generated.

var-bind-list
The list of name-value pairs. This list contains name and value of the MIB variable for which the trap is generated.

11. ONC RPC Fundamentals

Introduction

TCPware provides two sets of ONC RPC Services for network programming:

- ONC RPC Services to be used with the DEC C Socket Library for DEC C
- ONC RPC Services to be used with TCPware's Socket Library for VAX C or DEC C

This chapter is for RPC programmers. It provides basic information you need to know before using ONC RPC Services to write distributed applications, including:

- What ONC RPC Services are
- What components are in ONC RPC Services
- How ONC RPC clients and servers communicate
- Important ONC RPC concepts and terms

What Are ONC RPC Services?

ONC RPC Services are a set of software development tools that allow you to build distributed applications on OpenVMS systems. These services are part of TCPware.

TCPware provides two types of ONC RPC Services:

- **ONC** RPC used with VAX C and the TCPware Socket Library
- RPC **XDR** used with DEC C and the DEC C Socket Library

The bold letters in the above list show the conventions this book uses to distinguish between the two services.

TCPware Implementation

ONC RPC Services are based on the Open Network Computing Remote Procedure Call (RPC) protocols developed by Sun Microsystems, Inc. These protocols are defined in the following Requests for Comments (RFCs):

- *RPC: Remote Procedure Call Protocol Specification, Version 2* (RFC 1057)
- *XDR: External Data Representation Standard* (RFC 1014)

Distributed Applications

A distributed application executes different parts of its programs on different hosts in a network. Computers on the network share the processing workload, with each computer performing the tasks for which it is best equipped.

For example, a distributed database application might consist of a central database running on a VMS server and numerous client workstations. The workstations send requests to the server. The server carries out the requests and sends the results back to the workstations. The workstations use the results in other modules of the application.

RPCs allow programs to invoke procedures on remote hosts as if the procedures were local. ONC RPC Services hides the networking details from the application.

ONC RPC Services facilitates distributed processing because it relieves the application programmer of performing low-level network tasks such as establishing connections, addressing sockets, and converting data from one machine's format to another.

Components of ONC RPC Services

ONC RPC Services comprises the following components:

- Run-time libraries (RTLs)
- RPCGEN compiler
- Port Mapper
- RPCINFO command

Run-Time Libraries (RTLs)

XDR: ONC RPC Services provides a single shareable RTL. The library contains:

- ONC RPC client and server routines
- XDR routines

ONC: ONC RPC Services provides two shareable RTLs, one for D_float numbers and one for G_float numbers. Both libraries contain:

- ONC RPC client and server routines

- XDR routines
- Additional management routines that are unique to ONC RPC Services

The *ONC RPC RTL Management Routines*, Chapter 16, and the chapters that follow it describe the RTLs in detail.

RPCGEN Compiler

RPCGEN is a compiler that creates the network interface portion of a distributed application. It effectively hides from the programmer the details of writing and debugging low-level network interface code. The *RPCGEN Compiler*, Chapter 14, describes how to use RPCGEN.

Port Mapper

The Port Mapper helps ONC RPC client programs connect to ports that are being used by ONC RPC servers. A Port Mapper runs on each host that implements ONC RPC Services. These steps summarize how the Port Mapper works:

1. ONC RPC servers register with the Port Mapper by telling it which ports they are using.
2. When an ONC RPC client needs to reach a particular server, it supplies the Port Mapper with the numbers of the remote program and program version it wants to reach. The client also specifies a transport protocol (UDP or TCP). *(Identifying Remote Programs and Procedures* provides details on these numbers.)
3. The Port Mapper provides the correct port number for the requested service. This process is called binding.

Once binding has taken place, the client does not have to call the Port Mapper for subsequent calls to the same server. A service can register for different ports on different hosts. For example, a server can register for port 800 on Host A and port 1000 on Host B. The Port Mapper is itself an ONC RPC server and uses the ONC RPC RTL. It uses the UDPA and TCPA protocols for transports. The Port Mapper plays an important role in disseminating messages for broadcast RPC. The Port Mapper is part of the Network Control Process (NETCP). See the *Broadcast RPC* section for details.

RPCINFO Command

Use the RPCINFO command to:

- Request a listing of all programs that are registered with the Port Mapper.
- Call the null routine of any program.

You enter this command at the DCL prompt. (See *RPCINFO Utility* in Chapter 13, *Building Distributed Applications*, for details.)

Client-Server Relationship

In ONC RPC, the terms client and server do not describe particular hosts or software entities. Rather, they describe the roles of particular programs in a given transaction. Every ONC RPC transaction has a client and a server. The client is the program that calls a remote procedure; the server is the program that executes the procedure on behalf of the caller.

A program can be a client or a server at different times. The program's role merely depends on whether it is making the call or servicing the call.

External Data Representation (XDR)

External Data Representation (XDR) is a standard that solves the problem of converting data from one machine's format to another.

ONC RPC Services uses the XDR data description language to describe and encode data. Although similar to the C language, XDR is not a programming language. It merely describes the format of data, using implicit typing. *XDR: External Data Representation Standard (*RFC 1014) defines the XDR language.

ONC RPC Processing Flow

Remote and local procedure calls share some similarities. In both cases, a calling process makes arguments available to a procedure. The procedure uses the arguments to compute a result, then returns the result to the caller. The caller uses the results of the procedure and resumes execution.

The below diagram shows the underlying processing that makes a remote procedure call different from a local call.

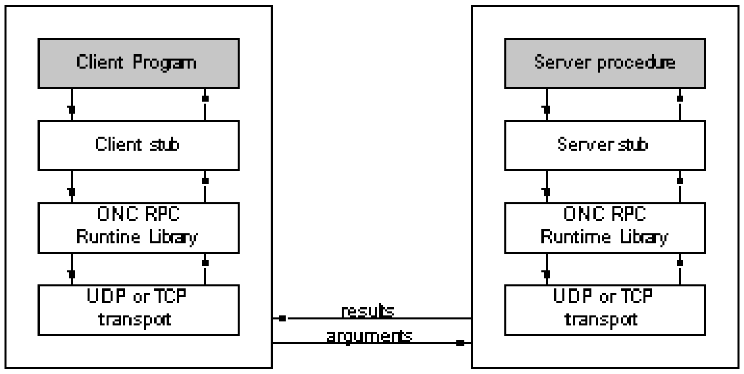
The following steps describe the processing flow during a remote procedure call:

1. The client program passes arguments to the client stub procedure. (See Chapter 14, *RPCGEN Compiler*, for details on how to create stubs.)
2. The client stub marshals the data by:
    - Calling the XDR routines to convert the arguments from the local representation to XDR

- Placing the results in a packet

   Using ONC RPC RTL calls, the client stub sends the packet to the UDP or TCP layer for transmission to the server.

3. The packet travels on the network to the server, up through the layers to the server stub.
4. The server stub un-marshals the packet by converting the arguments from XDR to the local representation. Then it passes the arguments to the server procedure.



Local Calls versus Remote Calls

This section describes some of the ways in which local and remote procedure calls handle system crashes, errors, and call semantics.

Handling System Crashes

Local procedure calls involve programs that reside on the same host. Therefore, the called procedure cannot crash independently of the calling program.

Remote procedure calls involve programs that reside on different hosts. Therefore, the client program does not necessarily know when the remote host has crashed.

Handling Errors

If a local procedure call encounters a condition that prevents the call from executing, the local operating system usually tells the calling procedure what happened.

If a remote procedure call cannot be executed for some reason (e.g., errors occur on the network or remote host), the client might not be informed of what happened. You may want to build a signaling or condition-handling mechanism into the application to inform the client of such errors.

ONC RPC returns certain types of errors to the client, such as those that occur when it cannot decode arguments. The RPC server must be able to return processing-related errors, such as those that occur when arguments are invalid, to the client. However, the RPC server may not return errors during batch processing or broadcast RPC.

Call Semantics

Call semantics determine how many times a procedure executes.

Local procedures are guaranteed to execute once and only once.

Remote procedures have different guarantees, depending on which transport protocol is used.

XDR: The TCP transport guarantees execution once and only once as long as the server does not crash. The UDP transport guarantees execution at least once. It relies on the XID cache to prevent a remote procedure from executing multiple times.

ONC: The TCP and TCPA transports guarantee execution once and only once as long as the server does not crash. The UDP and UDPA transports guarantee execution at least once. They rely on the XID cache to prevent a remote procedure from executing multiple times.

See *XID Cache* for details on the XID cache.

Programming Interface

The ONC RPC RTL is the programming interface to RPC. You may think of this interface as containing multiple levels.

The ONC RPC RTL reference chapters describe each routine.

The sample programs listed in the *ONC RPC Sample Programs*, Chapter 19, show how ONC RPC routines are used at each level.

High-Level Routines

The higher-level RPC routines provide the simplest RPC programming interface. These routines call lower-level RPC routines using default arguments, effectively hiding the networking details from the application programmer.

When you use high-level routines, you sacrifice control over such tasks as client authentication, port registration, and socket manipulation, but you gain the benefits of using a simpler programming interface. Programmers using high-level routines can usually develop applications faster than they can using low-level RPC routines.

You can use the RPCGEN compiler only when you use the highest-level RPC programming interface.

Mid-Level Routines

The mid-level routines provide the most commonly used RPC interface. They give the programmer some control over networking tasks, but not as much control as the low-level routines permit.

For example, you can control memory allocation, authentication, ports, and sockets using mid-level routines.

The mid-level routines require you to know procedure, program, and version numbers, as well as input and output types. Output data is available for future use. You can use the `registerrpc` and `callrpc` routines.

Low-Level Routines

The low-level routines provide the most complicated RPC interface, but they also give you the most control over networking tasks such as client authentication, port registration, and socket manipulation. These routines are used for the most sophisticated distributed applications.

ONC: These routines also allow you to use the TCPA and UDPA transports, as described below.

Transport Protocols

XDR and ONC RPC Services use the transport protocols listed in the below tale. The RPC client and server must use the same transport protocol for a given transaction.

Protocols	**Characteristics**
UDP (XDR and ONC)	Unreliable datagram service Connectionless Used for broadcast RPC Maximum broadcast message size in either direction on an Ethernet line: 1500

UDPA (ONC only)	Execution is guaranteed at least once (see *XID Cache*) Calls cannot be processed in batch
TCP (XDR and ONC) TCPA (ONC only)	Reliable Connection-oriented Can send an unlimited number of bytes per RPC call Execution is guaranteed once and only once Calls can be processed in batch No broadcasting

Note: For XDR, you must use the DEC C Socket Library with ONC RPC Services. For ONC, you must use the TCPware Socket Library with ONC RPC Services.

XID Cache

The XID cache stores responses the server has sent. When the XID cache is enabled, the server does not have to recreate every response to every request. Instead, the server can use the responses in the cache. Thus, the XID cache saves computing resources and improves the performance of the server.

XDR: Only the UDP transports can use the XID cache. The reliability of the TCP transport generally makes the XID cache unnecessary. UDP is inherently unreliable.

ONC: Only the UDP, UDPA, and TCPA transports can use the XID cache. The reliability of the TCP and TCPA transports generally makes the XID cache unnecessary. UDP is inherently unreliable.

The below table shows how the XID caches differ for the UDP and UDPA/TCPA transports.

UDP Transport	**UDPA/TCPA Transports**

Places every response in the XID cache	Allows the server to specify which responses are to be cached, using the `svcudpa_enablecache` and `svctcpa_enablecache` routines
XID cache cannot be disabled	Requires you to disable the XID cache after use

Cache Entries

Each entry in the XID cache contains:

- The encoded response that was sent over the network.
- The internet address of the client that sent the request.
- The transaction ID that the client assigned to the request.

Cache Size

You determine the size of the XID cache. Consider these factors:

- How many clients are using the server.
- Approximately how long the cache should save the responses.
- How much memory you can allocate. Each entry requires about 8Kbytes.

The more active the server is, the less time the responses remain in the cache.

Execution Guarantees

As explained earlier in *Local Calls Versus Remote Calls*, remote procedures have different execution guarantees, depending on which transport protocol is used. The XID cache affects the execution guarantee.

XDR: The TCP transport guarantees execution once and only once as long as the server does not crash. The UDP transport guarantees execution at least once. If the XID cache is enabled, a UDP procedure is unlikely to execute more than once.

ONC: The TCP and TCPA transports guarantee execution once and only once as long as the server does not crash. The UDP and UDPA transports guarantee execution at least once. If the XID cache is enabled, a UDP or UDPA procedure is unlikely to execute more than once.

Enabling XID Cache

XDR: Use the `svcudp_enablecache` routine to enable the XID cache. This routine is described in the ONC RPC RTL reference chapters.

ONC: Use the `svcudp_enablecache`,`svcudpa_enablecache` and `svctcpa_enablecache` routines to enable the XID cache. Use the `svcudpa_freecache` and `svctcpa_freecache` routines to disable the cache for a UDPA/TCPA server. These routines are described in the ONC RPC RTL reference chapters.

Not enabling the XID cache saves memory.

Active Cache

The active cache maintains a list of active requests that the server is working on. All UDPA servers use the active cache. A UDP server does not need an active cache because it can work on only one request at a time.

XDR: TCP servers do not need an active cache because they do not receive duplicate requests.

ONC: TCP and TCPA servers do not need an active cache because they do not receive duplicate requests. When a UDPA server receives a request, it searches the active cache for a match. If no match is found, the server places the request in the active cache and processes it. If a match is found, the server ignores the new request because it is already processing the request. When the server sends a response, it removes the request from the active cache and may add it to the XID cache.

Broadcast RPC

Broadcast RPC allows the client to send a broadcast call to all Port Mappers on the network and wait for multiple replies from ONC RPC servers.

For example, a host might use a broadcast RPC message to inform all hosts on a network of a system shutdown.

The below table shows the differences between normal RPC and broadcast RPC.

Normal RPC	**Broadcast RPC**
Client expects one answer	Client expects many answers

Can use TCP or UDP	Requires UDP
Server always responds to errors	Server does not respond to errors; Client does not know when errors occur
Port Mapper is desirable, but not required if you use fixed port numbers	Requires Port Mapper services

Broadcast RPC sends messages to only one port - the Port Mapper port - on every host in the network. On each host, the Port Mappers pass the messages to the target ONC RPC server. The servers compute the results and send them back to the client. See *Broadcast RPC Sample Programs* in Chapter 20, *ONC RPC Sample Programs*, for a list of sample programs using broadcast RPC.

ONC RPC Batch Facilities

Normally, an ONC RPC client sends a remote procedure call, stops processing, and waits for the server to reply. Some remote procedure calls, however, do not require a reply or acknowledgment. In these cases, the client wastes time waiting for the server to respond.

ONC RPC batch facilities solve this problem by allowing the client to send many remote procedure calls without waiting for replies.

ONC RPC Services performs batching by placing the client's messages to a particular server sequentially in a pipeline. The server knows it does not have to respond to these messages. The client sends a normal RPC call at the end of the batch sequence to "flush" the pipeline and let the server know there are no more batch calls.

Batching decreases the amount of communication overhead used by the client and server. The client can place many call messages in a buffer and send them to the server in one system call. The client can generate new calls while the server processes previous calls.

Batch Requirements

All ONC RPC batch calls must meet these requirements (see *Batch RPC Sample Programs* in Chapter 20, *ONC RPC Sample Programs*, for an example of batching):

- Specify that the result of the call is to be decoded by the XDR routine at address zero

- Have a timeout of zero
- Use the TCP transport

Identifying Remote Programs and Procedures

The ONC RPC client must uniquely identify the remote procedure it wants to reach. Therefore, all remote procedure calls must contain these three fields:

- A remote program number
- The version number of the remote program
- A remote procedure number

Remote Program Numbers

A remote program is a program that implements at least one remote procedure. Remote programs are identified by numbers that you assign during application development. Use the table below to determine which program numbers are available. The numbers are in groups of hexadecimals.

Range	**Purpose**
0 to 1FFFFFFF	Defined and administered by Sun Microsystems. Should be identical for all sites. Use only for applications of general interest to the Internet community.
20000000 to 3FFFFFFF	Defined by the client application program. Site-specific. Use primarily for new programs.
40000000 to 5FFFFFFF	Use for applications that generate program numbers dynamically.
60000000 to FFFFFFFF	Reserved for the future. Do not use.

Remote Version Numbers

Multiple versions of the same program may exist on a host or network. Version numbers distinguish one version of a program from another. Each time you alter a program, remember to increment its version number.

Remote Procedure Numbers

A remote program may contain many remote procedures. Remote procedures are identified by numbers that you assign during application development. Follow these guidelines when assigning procedure numbers:

- Use 1 for the first procedure in a program. (Procedure 0 should do nothing and require no authentication to the server.)
- For each additional procedure in a program, increment the procedure number by one.

Additional Terms

Before writing RPC applications, you should be familiar with the below terms.

XDR and ONC	
Term	**Definition**
Channel	An OpenVMS term referring to a logical path that connects a process to a physical device, allowing the process to communicate with that device. A process requests OpenVMS to assign a channel to a device. Refer to HP’s documentation for more information on channels.
Client handle	Information that uniquely identifies the server to which the client is sending the request. Consists of the server's host name, program number, program version number, and transport protocol. See the following routines in the *ONC RPC RTL Client Routines*, Chapter 16:

XDR	**ONC**

Term	Definition	Term	Definition

Client handle	`authnone_create`
	`authunix_create`
	`authunix_create_default`
	`clnt_create`
	`clnttcp_create`
	`clntudp_create`
	`clnt_perror`
		Client handle	`authnone_create`
			`authunix_create`
			`authunix_create_default`
			`clnt_create`
			`clnttcp_create`
			`clntudp_create`
			`clnt_call`
			`clnt_control`
			`clnt_destroy`
			`clnt_freeres`
			`clnt_geterr`
			`clnt_perror`

XDR and ONC

Term	Definition
Port	An abstract point through which a datagram passes from the host layer to the application layer protocols.

XDR

Term	Definition

Server handle	Information that uniquely identifies the server. Content varies according to the transport being used. See the following routines in Chapter 18, *ONC RPC RTL Server Routines*:
	
	`svcudp_create` `svctcp_create` `svc_destroy`
	`svc_freeargs` `svc_getargs` `svc_getcaller`
	`svc_register` `svc_sendreply` `svcerr_ routines`

ONC

Term	Definition

Server handle	Information that uniquely identifies the server. Content varies according to the transport being used. See the following routines in Chapter 18, *ONC RPC RTL Server Routines*:
	
	`svcudp_create` `svcudpa_create` `svctcp_create`
	`svctcpa_create` `svc_destroy` `svc_freeargs`
	`svc_getargs` `svc_register`
	`svc_sendreply` `svcerr_ routines`

XDR and ONC

Term	**Definition**
Socket	An abstract point through which a process gains access to the Internet. A process must open a socket and bind it to a specific destination. Note: The TCPware Socket Library must be used with ONC RPC Services.

12. Building Distributed Applications with RPC

Introduction

This chapter is for RPC programmers. It explains:

- What components a distributed application contains
- How to use ONC RPC to develop a distributed application, step by step
- How to use the RPCINFO utility

Distributed Application Components

The below table lists the components of a distributed application.

Component	**Description**
Main program (client)	An ordinary main program that calls a remote procedure as if local
Network interface	Client and server stubs, header files, XDR routines for input arguments and results
Server procedure	Carries out the client's request (at least one is required)

These components may be written in any high-level language. The ONC RPC Run-Time Library (RTL) routines are written in C language.

What You Need to Do

The following steps summarize what you need to do to build a distributed application:

1. Design the application.
2. Write an RPC interface definition. Compile it using `RPCGEN`, then edit the output files as necessary. (This step is optional. An RPC interface definition is not required. If you do not write one, proceed to step 3.)
3. Write any necessary code that `RPCGEN` did not generate.
4. Compile the `RPCGEN` output files, server procedures, and main program using the appropriate language compiler(s).
5. Link the object code, making sure you link in the ONC RPC RTL.
6. Start the Port Mapper on the server host.
7. Execute the client and server programs.

Step 1: Design the Application

You must write a main (client) program and at least one server procedure. The network interface, however, may be hand-written or created by `RPCGEN`. The network interface files contain client and server stubs, header files, and XDR routines. You may edit any files that `RPCGEN` creates.

When deciding whether to write the network interface yourself, consider these factors:

Is execution time critical?	Your hand-written code may execute faster than code that `RPCGEN` creates.
Which RPC interface layer do you want to use?	`RPCGEN` permits you to use only the highest layer interface. If you want to use the lower layers, you must write original code. The *ONC RPC Fundamentals,* Chapter 12, describes the characteristics of each RPC interface layer.
Which transport protocol do you want to use?	

ONC: If you use an asynchronous transport (UDPA or TCPA), you must either write original code for the server stubs or edit the `RPCGEN` output.

You may write your own XDR programs, but it is usually best to let `RPCGEN` handle these.

Step 2: Write and Compile the Interface Definition

An interface definition is a program the `RPCGEN` compiler accepts as input. The *RPCGEN Compiler*, Chapter 14, explains exactly what interface definitions must contain.

Interface definitions are optional. If you write the all of the network interface code yourself, you do not need an interface definition.

You must write an interface definition if you want `RPCGEN` to generate network interface code.

After compiling the interface definition, edit the output file(s).

If you are not writing an interface definition, skip this step and proceed to step 3.

Step 3: Write the Necessary Code

Write any necessary code that `RPCGEN` did not create for you. The below table lists the texts you may use as references.

Reference	**Purpose**
RFC 1057	Defines the RPC language. Use for writing interface definitions.
RFC 1014	Defines the XDR language. Use for writing XDR filter routines.
The *ONC RPC RTL Client Routines* chapter and those that follow	Defines each routine in the ONC RPC RTL. Use for writing stub procedures and XDR filter routines.

Building a Structure

If an input argument or result is not an integer, you need to create a structure for it in the `RPCGEN` input file. `RPCGEN` converts the structure to C format and creates XDR code to encode and decode it.

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI.X` file provides a sample interface definition containing a structure.

Step 4: Compile All Files

Compile the `RPCGEN` output files, server procedures, and main program separately using the appropriate language compiler(s):

XDR: DEC C (VAX, Alpha and Integrity):

```
$ CC /STANDARD=RELAXED /WARNING=DISABLE=(IMPLICITFUNC) filename.C
```

ONC: VAX C:

```
$ CC filename.C
```

ONC: DEC C (VAX):

```
$ CC /STANDARD=VAXC filename.C
```

ONC: DEC C (Alpha and Integrity):

```
$ CC /STANDARD=VAXC /NOMEMBER_ALIGN /ASSUME=NOALIGN filename.C
```

FORTRAN (VAX):

```
$ FORTRAN filename.FOR
```

FORTRAN (Alpha and Integrity):

```
$ FORTRAN /NOALIGN /WARNING=(DECLARATIONS,ALIGN) filename.FOR
```

Step 5: Link the Object Code

Link the object code files. Make sure you link in the ONC RPC RTL. Use the following command:

XDR: DEC C (VAX, Alpha and Integrity):

```
$ LINK filenames, SYS$INPUT /OPTIONS
UCX$RPCXDR_SHR /SHARE
SYS$SHARE:DECC$SHR /SHARE
Ctrl+Z
```

ONC: VAX:

```
$ LINK filenames, SYS$INPUT /OPTIONS
SYS$SHARE:VAXCRTL/SHARE
SYS$SHARE:TCPWARE_RPCLIB_SHR/SHARE
Ctrl+Z
```

ONC: Alpha and Integrity:

```
$ LINK filenames, SYS$INPUT /OPTIONS
UCX$RPCXDR_SHR /SHARE
SYS$SHARE:DECC$SHR /SHARE
Ctrl+Z
```

After entering the command, press **Ctrl+Z**.

To avoid repetitive data entry, you may create an OpenVMS command procedure to execute these commands.

Step 6: Start the Port Mapper

The Port Mapper must be running on the server host. If it is not running, use the `NETCU ADD SERVICE` command to start it. See Chapter 2, *NETCU Commands* of the *NETCU Command Reference* manual for details on this command.

Step 7: Execute the Client and Server Programs

Perform these steps:

1. Run the server program interactively to debug it, or using the `/DETACHED` qualifier. Refer to the OpenVMS documentation for details.
2. Run the client main program.

Using Asynchronous Transports

ONC: ONC RPC provides two asynchronous transport protocols: TCPA and UDPA. These protocols allow you to write multi-threaded servers that can process multiple requests in parallel.

Only an asynchronous service can benefit from using an asynchronous transport.

For example, you would use an asynchronous transport for a service that performs a lot of asynchronous file I/O by issuing QIOs. You would not use an asynchronous transport for a service that performs a lot of synchronous file I/O.

Client processes cannot use TCPA and UDPA.

The asynchronous transport protocols are specific to TCPware.

The *ONC RPC Fundamentals*, Chapter 12, explains the differences between each transport protocol.

Writing an Asynchronous Server

ONC: This section explains how to write an asynchronous server.

Before You Begin

1. Decide how many threads the server will support. The number of threads determines the number of requests the server can handle in parallel. The server can parallel process as many requests as it has threads.
2. Choose the TCPA and/or UDPA transport protocol. (A server can support both.)
3. Determine:
   - The size of the XID cache. Generally, this is at least the number of UDPA or TCPA threads.
   - Which procedures, if any, the XID cache will contain responses for.

Writing the Code

ONC: Write a program that performs the following steps:

1. To set up the server:
   a. Call `svcudpa_create` and/or `svctcpa_create` for each thread. Save the return values for later use. Use the `svc_getchan` routine after the first call and specify the returned value in subsequent calls.
   b. If you are enabling the XID cache, call `svcudpa_enablecache` and/or `svctcpa_enablecache` for each thread. Use the result of the first call to `svcudpa_enablecache/svctcpa_enablecache` as input to successive calls to that routine, so that all threads use the same cache.
   c. Call the `svc_register` routine once for each transport to register the service.
2. Put the main code in "hibernation" by calling `SYS$HIBER` instead of `svc_run`. `SYS$HIBER` is an OpenVMS system service that accepts no input arguments.
3. To shut down the server:
   a. Perform any shutdown steps that are specific to your server.
   b. Call `svctcpa_shutdown` once for all TCPA threads.
   c. Call `svcudpa_shutdown` once for all UDPA threads.
   d. Call `svc_destroy` once for each thread.

How Asynchronous Transports Affect Memory

ONC: Asynchronous transports use more memory than synchronous transports because each service has more than one thread.

When TCPA receives requests greater than 4Kbytes, it uses significantly more memory than TCP uses for the same size requests. TCP reads in 4Kbytes of data, processes the data, then reads more data as necessary. TCPA reads all of the data before calling the server dispatch routine.

Asynchronous System Traps

ONC: All UDPA and TCPA servers use asynchronous system traps (ASTs). Refer to the *Guide to VMS Programming Resources* for complete information on ASTs.

When using ASTs, follow these guidelines:

- Do not permit the main program to disable ASTs for long periods of time. If the program disables ASTs before it calls `SYS$HIBER`, the server does not respond to requests.
- The AST quota for the server process must allow at least one AST for each thread.
- The `dispatch` routine is called as a user-mode AST. This means a program cannot do synchronous waiting when an AST is required to wake up the program.
- Only one AST can be active at a time.

RPCINFO Utility

`RPCINFO` is an ONC RPC utility that allows you to:

- Request a listing of all programs registered with a Port Mapper.
- Call the NULL routine of any program

`RPCINFO` supports both the UDP and TCP protocols.

Requesting a Program Listing

To request a listing of all programs that are registered with the Port Mapper, enter the `RPCINFO` command in the following format at the DCL prompt:

```
RPCINFO -p [-u | -t][host-name]
```

`-p`	Calls the Port Mapper.

-u	Uses the UDP transport to send the request. This is the default if you do not specify a transport.
-t	Uses the TCP transport to send the request.
host-name	Specifies the domain name of the host on which the Port Mapper resides. If you omit this parameter, RPCINFO uses the name of the local host.

Below is an example:

```
$ rpcinfo -p hermes
   Program  Version  Protocol   Port
   -------  -------  --------   ----
    100000        2       udp    111  rpcbind
    100000        2       tcp    111  rpcbind
    100005        1       udp    2049 mountd
```

Calling a NULL Routine

To call the NULL routine of a program, enter the RPCINFO command in the following format at the DCL prompt:

```
RPCINFO [-u | -t] host-name program[version]
```

-u	Uses the UDP transport to send the request. If you do not specify a trans port, this is the default.
-t	Uses the TCP transport to send the request.
host-name	Specifies the domain name of the target host.
program	Specifies the program number of the target program.
Version	Specifies the version number of the target program. If you omit the version, the default is 1.

For example, suppose you enter the following command:

```
$ RPCINFO ETA 100000 2
```

The following message displays if the call completes successfully:

```
Version 2 of program 100000 successfully called
```

13. RPCGEN Compiler

Introduction

This chapter is for RPC programmers.

What Is RPCGEN?

RPCGEN is the RPC Protocol Compiler. This compiler creates the network interface portion of a distributed application, effectively hiding from the programmer the details of writing and debugging low-level network interface code.

You are not required to use RPCGEN when developing a distributed application. If speed and flexibility are critical to your application, you can write the network interface code yourself, using ONC RPC Run-Time Library (RTL) calls where they are needed.

Compiling with RPCGEN is one step in developing distributed applications. See Chapter 13, *Building Distributed Applications*, for a complete description of the application development process.

RPCGEN allows you to use the highest layer of the RPC programming interface. The *ONC RPC Fundamentals,* Chapter 12, provides details on these layers.

Software Requirements

XDR: The following software must be installed on your system before you can use RPCGEN:

- VMS Version 5.5-2 or later
- DEC C compiler Version 3.2 or later

ONC: The following software must be installed on your system before you can use RPCGEN:

- VMS Version 5.5-2 or later
- VAX C compiler Version 3.0 or later

Input Files

The RPCGEN compiler accepts as input programs called *interface definitions*, written in RPC Language (RPCL), an extension of XDR language. RFC 1057 and RFC 1014 describe these languages in detail.

An interface definition must always contain the following information:

- Remote program number
- Version number of the remote program
- Remote procedure number(s)
- Input and output arguments

The below example shows a sample interface definition from the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]PRINT.X` file.

```
/*
** RPCGEN input file for the print file RPC batching example.
**
** This file is used by RPCGEN to create the files PRINT.H and PRINT_XDR.C
** The client and server files were developed from scratch.
*/

const MAX_STRING_LEN = 1024;    /* maximum string length */

/*
** This is the information that the client sends to the server
*/
struct a_record
{
  string  ar_buffer< MAX_STRING_LEN>;
};

program PRINT_FILE_PROG
{
  version PRINT_FILE_VERS_1
  {
    void   PRINT_RECORD( a_record) = 1;
    u_long SHOW_COUNT( void) = 2;
  } = 1;
} = 0x20000003;

/* end file PRINT.X */
```

The default extension for RPCGEN input files is `.X`.

You do not need to call the ONC RPC RTL directly when writing an interface definition. RPCGEN inserts the necessary library calls in the output file.

Output Files

RPCGEN output files contain code in C language. The below table lists the RPCGEN output files and summarizes their purpose. You can edit RPCGEN output files during application development. The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory provides sample RPCGEN output files.

File	**Purpose**
Client and server stub calls	Interface between the network and the client and server programs. Stubs use RPC RTL to communicate with the network.
XDR routines	Convert data from a machine's local data format to XDR format, and vice versa.
Header	Contains common definitions, such as those needed for any structures being passed.

Invoking RPC explains how to request specific output files.

The below table shows the conventions you should use to name output files.

File	**Output Filename**
Client stub	`*inputname*_CLNT.C`
Server stub	`*inputname*_SVC.C`
Header file	`*inputname*.H`
XDR filter routines	`*inputname*_XDR.C`

`inputname` is the name of the input file. For example, if the input file is `TEST.X`, the server stub is `TEST_SVC.C`.

When you use the RPCGEN command to create all output files at once, RPCGEN creates the output filenames listed in the above table by default. When you want to create specific kinds of output files, you must specify the names of the output files in the command line.

Preprocessor Directives

RPCGEN runs the input files through the C preprocessor before compiling. You can use the macros listed in the below table with the `#ifdef` preprocessor directive to indicate that specific lines of code in the input file are to be used only for specific RPCGEN output files.

File	**Macro**
Client stub	`RPC_CLNT`
Server stub	`RPC_SVC`
Header file	`RPC_HDR`
XDR filter routines	`RPC_XDR`

Invoking RPCGEN

This section explains how to invoke RPCGEN to create:

- All output files at once
- Specific output files
- Server stubs for either the TCP or UDP transport

Creating All Output Files at Once

This command creates all four RPCGEN output files at once:

```
$ RPCGEN input
```

Where *`input`* is the name of the file containing the interface definition.

In the following example, RPCGEN creates the output files `PROGRAM.H`, `PROGRAM_CLNT.C`, `PROGRAM_SVC.C`, and `PROGRAM_XDR.C`:

```
$ RPCGEN PROGRAM.X
```

Creating Specific Output Files

This command creates only the RPCGEN output file that you specify:

```
RPCGEN {-c |-h | -l | -m}[-o output]input
```

`-c`	Creates an XDR filter file (`_XDR.C`)
`-h`	Creates a header file (`.H`)
`-l`	Creates a client stub (`_CLNT.C`)
`-m`	Creates a server stub (`_SVC.C`) that uses both the UDP and TCP transports
`-o`	Specifies an output file (or the terminal if no output file is given)
`output`	Name of the output file
`input`	Name of an interface definition file with a `.X` extension

Follow these guidelines:

- Specify just one output file (`-c`, `-h`, `-l`, or `-m`) in a command line.
- If you omit the output file, RPCGEN sends output to the terminal screen.

Examples:

- `RPCGEN -h PROGRAM`

  RPCGEN accepts the file `PROGRAM.X` as input and sends the header file output to the screen, because no output file is specified.

- `RPCGEN -l -o PROGRAM_CLNT.C PROGRAM.X`

  RPCGEN accepts the `PROGRAM.X` file as input and creates the `PROGRAM_CLNT.C` client stub file.

- `RPCGEN -m -o PROGRAM_SVC.C PROGRAM.X`

  RPCGEN accepts the `PROGRAM.X` file as input and creates the `PROGRAM_SVC.C` server stub file. The server can use both the UDP and TCP transports.

Creating Server Stubs for TCP or UDP Transports

This command creates a server stub file for either the TCP or UDP transport:

```
RPCGEN -s {udp | tcp}[-o output]input
```

`-s`	Creates a server (`_SVC.C`) that uses either the UDP or TCP transport (with `-s`, you must specify either `udp` or `tcp`; do not also use `-m`)
`udp`	Creates a UDP server
`tcp`	Creates a TCP server
`-o`	Specifies an output file (or the terminal if no output file is given)
`output`	Name of the output file
`input`	Name of an interface definition file with a .X extension

If you omit the output file, RPCGEN sends output to the terminal screen.

In this example, RPCGEN accepts the `PROGRAM.X` file as input and creates the `PROGRAM_SVC.C` output file, containing a TCP server stub:

```
$ RPCGEN -s tcp -o PROGRAM_SVC.C PROGRAM.X
```

Error Handling

RPCGEN stops processing when it encounters an error. It indicates which line the error is on.

Restrictions

RPCGEN does not support the following:

- The syntax `int x, y;` . You must write this as `int x; int y;`
- Asynchronous transports

14. RPC RTL Management Routines

Introduction

This chapter is for RPC programmers. It introduces RPC Run-Time Library (RTL) conventions and documents the management routines in the RPC RTL. These routines are the programming interface to RPC.

Management Routines

There are two types of services with RTL:

- ONCRPC used with VAX C and the TCPware Socket Library
- RPCXDR used with DEC C and the HP Socket Library

The bold letters in the above list show the conventions this book uses to distinguish between the two services.

The RPC RTL contains:

- RPC management routines
- **DEC C:** RPC client and server routines for the UDP and TCP transport layers
- **VAX C:** RPC client and server routines for the UDP, UDPA, TCP, and TCPA transport layers
- **DEC C:** On VAX, Alpha and I64 systems, RPC provides a single shareable image accessed via the `UCX$RPCXDR_SHR` logical. This shareable image contains routines for all of the DEC C floating-point types. The correct routines will automatically be called based on the compiler options used to compile the RPC application. See the DEC C documentation for how to use the floating-point compiler options.
- **VAX C:** On VAX systems, RPC provides two shareable RTLs:
  - A `D_float` library, for standard double-precision real numbers between 10^{-38} and 10^{+38}. This library is in the `SYS$SHARE:TCPWARE_RPCLIB_SHR.EXE` file.
  - A `G_float` library, for double-precision real numbers between 10^{-308} and $10^{+308.}$ This library is in the `SYS$SHARE:TCPWARE_RPCLIBG_SHR.EXE` file.

- **DEC C:** On Alpha and I64 systems, ONC RPC provides three shareable RTLs:
  - A `D_float` library, for standard double-precision real numbers between 10^{-38} and 10^{+38}. This library is in the `SYS$SHARE:TCPWARE_RPCLIBD_SHR.EXE` file.
  - A `G_float` library, for double-precision real numbers between 10^{-308} and $10^{+308.}$ This library is in the `SYS$SHARE:TCPWARE_RPCLIB_SHR.EXE` file.
  - A `T_float` library, for IEEE double-precision real numbers between 10^{-308} and $10^{+308.}$ This library is in the `SYS$SHARE:TCPWARE_RPCLIBT_SHR.EXE` file.
- **VAX C:** Invoke these libraries by using the appropriate qualifiers when you compile your application programs. See your HP VAX documentation for instructions on compiling.

Chapter 13, *Building Distributed Applications with RPC*, explains how to link in the RPC RTL.

Routine Name Conventions

In this chapter, all routines are documented according to their standard UNIX names. Routines that are unique to TCPware have UNIX-style names.

If you are writing code in C language, you may use the routine names used in this chapter. If you are writing code in a different language, however, you must use the TCPware names defined in the `SYS$COMMON:[TCPWARE.INCLUDE.RPCOLD]:ONCRPC_FUNC.H` file. These names all begin with the letters `ONCRPC`.

Header Files

All RPC programs include the file named `RPC.H`. Locations for this file are:

- **VAX C**: `SYS$COMMON:[TCPWARE.INCLUDE.RPCOLD]: RPC.H`
- **DEC C**: `UCX$RPC:RPC.H`

The `RPC.H` file includes the files listed in the below table.

Filename	**Purpose**
Pertains to DEC C and VAX C	
`AUTH.H`	Used for authentication.

`AUTH_UNIX.H`	Contains XDR definitions for UNIX-style authentication.
`CLNT.H`	Contains various RPC client definitions.
`IN.H`	Defines structures for the internet and socket addresses (`in_addr` and `sockaddr_in`). This file is part of the C Socket Library.
`RPC_MSG.H`	Defines the RPC message format.
`SVC.H`	Contains various RPC server definitions.
`SVC_AUTH.H`	Used for server authentication.
`TYPES.H`	Defines UNIX C data types.
`XDR.H`	Contains various XDR definitions.
Pertains to VAX C only	
`ONCRPC_CONST.H`	Defines RPC characteristics and other constants.
`ONCRPC_FUNC.H`	Maps ONCRPC routine names with their UNIX counterparts.
`ONCRPC_STRUCT.H`	Defines structures for the RPC client and server counters.
Pertains to DEC C only	
`NETDB.H`	Defines structures and routines to parse /etc/rpc.

There is an additional header file not included by `RPC.H` that is used by `xdr_pmap` and `xdr_pmaplist` routines. The file name is `pmap_prot.h`, and the location is:

VAX C: `SYS$COMMON:[TCPWARE.INCLUDE.RPCOLD]:PMAP_PROT.H`
DEC C: `UCX$RPC:PMAP_PROT.H`

Boolean Values

Many ONC RPC routines return `TRUE` or `FALSE` values. In C, `FALSE` is zero, and `TRUE` is any other value.

TCPware/Sun Implementation Differences

ONC RPC services are based on the Open Network Computing Remote Procedure Call protocols originally developed by Sun Microsystems. This section lists the ways in which the TCPware's implementation of ONC RPC services differs from Sun's implementation of RPC.

- **DEC C:** TCPware provides the following management routines:
  - `get_myaddress`
  - `getrpcbynumber`
  - `getrpcport`
- **VAX C:** TCPware provides the following management routines:
  - `ONCRPC_GET_CHAR`
  - `ONCRPC_SET_CHAR`
  - `ONCRPC_GET_STATS`

  These routines allow you to retrieve and maintain information that describes how a process is using ONC RPC. Sun does not provide these routines.
- **VAX C:** TCPware does not support the following Sun routines:
  - `svcstdio_create`
  - `svcraw_create`
  - `clntraw_create`

  These routines deal with transports that the OpenVMS environment does not support.
- The `svcfd_create` routine provided by TCPware supports only TCP sockets. The Sun version supports file descriptors, including `stdin` and `stdout`.
- In TCPware, the global variable `svc_fdset` contains an array of structures, where each element is a socket pointer and a service handle. Sun implements this variable as a bit mask with an associated array of service handles.
- The `authunix_create_default` routine provided by TCPware creates credentials based on the VAX C `geteuid` and `getegid` routines.

- TCPware provides the `pmap_freemaps` routine to free the memory that was allocated by the `pmap_getmaps` routine. Sun requires the programmer to know the internals of the `pmaplist` structure and free the memory himself.
- TCPware provides the `xdr_netobj` routine. This routine encodes and decodes `netobj`, an aggregate data structure that is opaque and contains a counted array of 1024 bytes.
- TCPware provides the `xdr_netobj` routine. This routine encodes and decodes `netobj`, an aggregate data structure that is opaque and contains a counted array of 1024 bytes.
- **ONC:** TCPware provides asynchronous transports, with the following routines:
    - svctcpa_create
    - svctcpa_getxdrs
    - svcudpa_enablecache
    - svctcpa_shutdown
    - svcudpa_bufcreate
    - svcudpa_freecache
    - svctcpa_enablecache
    - svcudpa_create
    - svcudpa_getxdrs
    - svctcpa_freecache
    - svcudpa_shutdown

  Sun does not provide asynchronous transports.

- **VAX C:** TCPware provides the following macros:
    - `svc_getchan`
    - `svc_getport`

  Sun does not provide these macros.

- The TCPware RPCGEN compiler gives the input file a default extension of `.X` if no extension is specified. The Sun RPCGEN compiler requires you to enter the `.X` extension.
- The TCPware RPCGEN compiler accepts input only from a file, not from the terminal. The Sun RPCGEN compiler accepts both types of input.
- The TCPware RPCINFO command supports the TCP and UDP protocol for any request. The Sun version supports only the UDP protocol when you use RPCINFO to request a Port Mapper listing.

Management Routines

RPC management routines retrieve and maintain information that describes how a process is using RPC. This section describes each management routine and function in detail. The following information is provided for each routine:

- Format
- Arguments
- Description
- Diagnostics, or status codes returned, if any

get_myaddress

Returns the internet address of the local host.

Format

```
void get_myaddress(struct sockaddr_in *addr);
```

Argument

addr

Address of a `sockaddr_in` structure that will be loaded with the host internet address. The port number is always set to `htons(PMAPPORT)`.

Description

The `get_myaddress` routine returns the internet address of the local host without doing any name translation or DNS lookups.

---

getrpcbynumber

Gets an RPC entry. (DEC C only.)

Format

`struct rpcent *getrpcbynumber(int` *`number`*`)`

Argument

number

Program name or number.

Description

The `getrpcbynumber` routine returns a pointer to an object with the following structure containing the broken-out fields of a line in the RPC program number database.

```
struct rpcent
{
  char *r_name;        /* name of server for this RPC program */
  char **r_aliases;    /* alias list */
  long r_number;       /* RPC program number */
};
```

The members of this structure are:

`r_name`	Name of the server for this RPC program
`r_aliases`	Zero-terminated list of alternate names for the RPC program
`r_number`	RPC program number for this service

The `getrpcbynumber` routine sequentially searches from the beginning of the file until a matching RPC program name or program number is found, or until an EOF is encountered.

Diagnostics

A NULL pointer is returned on EOF or error.

getrpcport

Gets an RPC port number. (DEC C only.)

Format

`int getrpcport(char *host, int prognum, int versnum, int proto)`

Arguments

host

Host running the RPC program.

prognum

Program number.

proto

Protocol name. Must be `IPPROTO_TCP` or `IPPROTO_UDP`.

Description

The `getrpcport` routine returns the port number for version *`versnum`* of the RPC program *`prognum`* running on *`host`* and using protocol *`proto`*.

It returns 0 if it cannot contact the portmapper, or if *`prognum`* is not registered. If *`prognum`* is registered but not with *`versnum`*, it still returns a port number (for some version of the program), indicating that the program is indeed registered. The version mismatch is detected on the first call to the service.

ONCRPC_GET_CHAR

Returns the characteristic values of an RPC client or server process. (VAX C only.)

Format

`u_long ONCRPC_GET_CHAR(u_long code, void *value)`

Arguments

code

Characteristic being returned. The following text describes each code.

`RPCCHAR_ _AC_SIZE` - Alters the number of entries in the active cache. This code is for UDPA transports only. If you try to set `RPCCHAR__AC_SIZE` when a UDPA transport is active, then `RPC_SET_CHAR` returns the `SS$_DEVACTIVE` error code. The type is `u_short *value`. The default is 20.

`RPCCHAR_ _CHECKSUM` - Enables or disables checksums for outgoing packets. The receiver checks packets if the sender generates a checksum. Disabling checksums improves performance but reduces data integrity. This code is for UDPA servers only. Valid values are `RPCCKSUM__ENABLE` and `RPCCKSUM__DISABLE`. The type is `u_long *value`. The default is `RPCCKSUM__ENABLE`.

`RPCCHAR_ _DEBUG` - Enables the printing of messages that indicate what RPC is doing. All logging messages go to `SYS$OUTPUT`. The type is `u_long *value`. The default is 0.

These are the mask values for `RPCCHAR__DEBUG`:

`RPCDBG_ _XDR`	Prints a message indicating which XDR routines are being used.
`RPCDBG_ _XID`	Prints a message each time the XID cache is referenced. The message indicates the type of operation being per formed on the XID cache. For UDP and UDPA servers only.
`RPCDBG_ _ACTIVE_CA`	Prints a message each time the active cache is referenced. The message indicates the type of operation being per formed on the active cache. For UDPA servers only.

RPCDBG_ _GENERAL	Prints general messages about the activities of RPC RTL routines.
RPCDBG_ _RAW_RCV	Prints, in hexadecimal and ASCII, the contents of packets that were received.
RPCDBG_ _RAW_SEND	Prints, in hexadecimal and ASCII, the contents of packets that were sent.
RPCDBG_ _AUTH	Prints authentication processing information.
RPCDBG_ _MEMORY	Tracks memory allocation for the RPC RTL.

`RPCCHAR_ _DEFPORTS` - If an RPC program does not specify a port to use, RPC assigns it a port. The `RPCCHAR_ _DEFPORTS` code determines whether RPC tries to use privileged ports (600 to 1023) or non-privileged ports (1024 and greater). The type is `u_long *value`. Values are `RPCPORTS_ _PRIVILEGE` and `RPCPORTS_NORMAL. RPCPORTS_PRIVILEGE` is the default, which means the application uses a privileged port if it has sufficient privileges, otherwise it uses a non-privileged port.

`RPCCHAR_ _FATALRTN` - Calls an error-handling routine when the TCPA or UDPA transports detect a fatal error. The OpenVMS error status code is passed to the error-handling routine. If `*value` is zero, the default value is used. The type is `void (**value)(u_long status)`. The default is `SYS$EXIT`.

value
Address where the routine places the characteristic value.

Description

The characteristic values are defined as constants in the `RPC_CONST.H` file. Each process using the RPC library has its own copy of these values. The `ONCRPC_GET_CHAR` routine retrieves these values.

Example

```
u_long debug;
```

```
oncrpc_get_char( RPCCHAR__DEBUG, &debug);
printf( "The debugging value is %08X", debug);
```

This example prints a message that shows the present debugging value for RPC. The message goes to `SYS$OUTPUT`.

Diagnostics

`SS$_NORMAL`	Routine executed successfully.
`SS$_BADPARAM`	*`code`* is invalid.
`SS$_ACCVIO`	*`value`* is a null address.

ONCRPC_GET_STATS

Returns counters for memory usage, the RPC server, or the RPC client. (VAX C only.)

Format

`u_long ONCRPC_GET_STATS(u_long code, u_char *buffer)`

Arguments

code

These codes are valid:

`RPCSTAT_ _ZERO`	Zeros out the client or server counters.
`RPCSTAT_ _CLIENT`	Retrieves client counters.
`RPCSTAT_ _SERVER`	Retrieves server counters.
`RPCSTAT_ _MEMORY`	Retrieves memory counters.

The below example shows how to use the `RPCSTAT_ _ZERO` code in combination with the other codes to zero-out the client and server counters after they are retrieved. You cannot zero-out memory counters.

buffer

Address of the structure to receive the requested counters. These structures are defined in the `RPC_STRUCT.H` file. The length of the buffer equals the size of the structures. These are the structures:

```
/*
** Statistics structure (server)
*/
typedef struct
{
  time_tzero_time;                  /* # seconds since zeroed*/
  u_longrecvs,                      /* # receives*/
  recv_errs,                        /* # bad receives*/
  xmits,                          /* # transmits*/
  xmit_errs,                      /* # transmit errors*/
  xerr_badlen                     /* # calls w/body too small*/
  xerr_nullrecv,                  /* # empty calls*/
  xerr_auth_weak,                 /* # weak auth errors*/
  xerr_auth_other,                /* # other auth errors*/
  xerr_decode,                      /* # decode errors
  xerr_noproc,                        /* # no procedure errors*/
  xerr_noprog,                        /* # no program errors*/
  xerr_novers,                        /* # no matching version errors*/
  xerr_systemerr,                     /* # other system errors*/
  xid_hits,                           /* # replies sent from xid cache*/
  xid_saves,                          /* # replies cached*/
  duprcvs;                            /* # calls found in active cache*/
} svc_counters;

/*
** Statistics structure (client)
*/
typedef struct
{
  time_t             zero_time;         /* # seconds since zeroed*/
  u_long             recvs,             /* # receives */
                     recv_errs,         /* # receive errors*/
                     badxid,            /* # xid mismatches*/
                     xmits,             /* # transmits*/
                     xmit_errs          /* # transmit errors*/
                     newcred,           /* # new credentials (always 0)*/
                     retrans,           /* # retransmissions*/
                     timeout,           /* # timeouts*/
                     wait;              /* (always 0)*/
} clnt_counters;

/*
** Memory statistics structure
*/
typedef struct
{
  u_long             no_mallocs,         /* # times memory was allocated*/
                     no_frees,           /* # times memory was freed*/
                     mem_in_use;         /* # bytes of memory in use*/
} mem_counters;
```

Description

The `ONCRPC_GET_STATS` routine returns counters for this process only.

Example

```
clnt_counters cstats;
oncrpc_get_stats( RPCSTAT__CLIENT | RPCSTAT__ZERO, &cstats);
/* cstats now contains the client statistics */
```

This example retrieves client counters, then zeros them out.

Diagnostics

`SS$_NORMAL`	Routine successfully returned the counters.
`SS$_BADPARAM`	*`code`* is invalid.
`SS$_ACCVIO`	*`buffer`* is a null address.

ONCRPC_SET_CHAR

Defines the values of characteristics for each RPC client and server process. (VAX C only.)

Format

`u_long ONCRPC_SET_CHAR(u_long` *`code`*`,` *`void *value`*`)`

Arguments

code

Characteristic being set. See the `ONCRPC_GET_CHAR` routine for a description of each code.

value

Address of the characteristic value.

Description

Use the `ONCRPC_SET_CHAR` routine to define characteristic values for RPC processes. Each RPC process has its own values. Codes and values are defined as constants in the `RPC_CONST.H` file.

Example

```
void exit_routine (u_long status)
{
  exit( status);
}

main()
{
  void (*fatal_routine)();

  fatal_routine = exit_routine;
  /* fatal_routine is the address of exit_routine */
  oncrpc_set_char( RPCCHAR__FATALRTN, &fatal_routine);
}
```

Sets the exit routine to be called when the TCPA or UDPA transport detects a fatal error.

Diagnostics

`SS$_NORMAL`	Routine executed successfully.
`SS$_ACCVIO`	*`value`* is a null address.
`SS$_BADPARAM`	*`code`* is invalid.
`SS$_DEVACTIVE`	A process tried to change the size of the active cache while the UDPA transport was active.

15. ONC RPC RTL Client Routines

Introduction

This chapter is for RPC programmers. It documents the client routines in the ONC RPC Run-Time Library (RTL). These routines are the programming interface to ONC RPC.

Common Arguments

Many client, Port Mapper, and server routines use the same arguments.

The below table lists these arguments and defines their purpose. Arguments that are unique to each routine are documented together with their respective routines in this and the following chapters

Argument	**Purpose**
`args_ptr`	Address of the buffer to contain the decoded RPC arguments.
`auth`	RPC authentication client handle created by the `authnone_create`, `authunix_create`, or `authunix_create_default` routine.
`clnt`	Client handle returned by any of the client create routines.
`in`	Input arguments for the service procedure.
`inproc`	XDR routine that encodes input arguments.
`out`	Results of the remote procedure call.

`outproc`	XDR routine that decodes output arguments.
`procnum`	Number of the service procedure.
`prognum`	Program number of the service program.
`protocol`	Transport protocol for the service. Must be `IPPROTO_UDP` or `IPPROTO_TCP`.
`s`	String containing the message of your choice. The routines append an error message to this string.
`sockp`	Socket to be used for this remote procedure call. If *`sockp`* is `RPC_ANYSOCK`, the routine creates a new socket and defines *`sockp`*. The `clnt_destroy`() routine closes the socket. If *`sockp`* is a value other than `RPC_ANYSOCK`, the routine uses this socket and ignores the internet address of the server.
`versnum`	Version number of the service program.
`xdr_args`	XDR procedure that describes the RPC arguments.
`xdrs`	Structure containing XDR encoding and decoding information.
`xprt`	RPC server handle.

Client Routines

The client routines are called by the client main program or the client stub procedures.

The following sections describe each client routine in detail.

auth_destroy

A macro that destroys authentication information associated with an authentication handle.

Format

```
void auth_destroy(AUTH *auth);
```

Argument

auth

RPC authentication client handle created by the `authnone_create`, `authunix_create`, or `authunix_create_default` routine.

Description

Use `auth_destroy` to free memory that was allocated for authentication handles. This routine undefines the value of *`auth`* by deallocating private data structures.

Do not use this memory space after `auth_destroy` has completed. You no longer own it.

authnone_create

Creates and returns a null RPC authentication handle for the client process.

Format

```
AUTH *authnone_create();
```

Arguments

None.

Description

This routine is for client processes that require no authentication. RPC uses it as a default when it creates a client handle.

authunix_create

Creates and returns an RPC authentication handle for the client process. Use this routine when the server requires UNIX-style authentication.

Format

```
AUTH *authunix_create(char *host, int uid,int gid,int len,int gids);
```

Arguments

host
Address of the name of the host that created the authentication information. This is usually the local host running the client process.

uid
User ID of the person who is executing this process.

gid
User's group ID.

len
Number of elements in the `*gids` array.

gids
Address of the array of groups to which the user belongs.

Description

Since the client does not validate the *uid* and *gid*, it is easy to impersonate an unauthorized user. Choose values the server expects to receive. The application must provide OpenVMS-to-UNIX authorization mapping.

You can use a Socket Library lookup routine to get the host name.

authunix_create_default

Calls the `authunix_create` routine and provides default values as arguments.

Format

`AUTH *authunix_create_default();`

Arguments

See below.

Description

Like the `authunix_create` routine, `authunix_create_default` provides UNIX-style authentication for the client process. However, `authunix_create_default` does not require you to enter any arguments. Instead, this routine provides default values for the arguments used by `authunix_create`, listed in the below table.

Argument	**Default Value**
host	local host domain name
uid	`getuid( )`
gid	`getgid( )`
len	0
gids	0

This routine is provided to ensure compatibility with ONC RPC. You can replace this call with `authunix_create` and provide appropriate values.

Example

```
auth_destroy(client->cl_auth);
client->cl_auth = authunix_create_default();
```

This example overrides the `authnone_create` routine, where *`client`* is the value returned by the `clnt_create`, `clntraw_create`, `clnttcp_create`, or `clntudp_create` routine.

callrpc

Calls the remote procedure identified by the routine's arguments.

Format

```
int callrpc (char *host, u_long prognum, u_long versnum, u_long procnum,
xdrproc_t inproc, u_char *in, xdrproc_t outproc, u_char *out);
```

Arguments

host

Host where the procedure resides.

prognum*, *versnum*, *procnum*, *inproc*, *in*, *outproc*, *out

See the *Common Arguments* section for a description of the above arguments.

Description

The `callrpc` routine performs the same functions as the `clnt_create`, `clnt_call`, and `clnt_destroy` routines.

Since the `callrpc` routine uses the UDP transport protocol, messages can be no larger than 8Kbytes. This routine does not allow you to control timeouts or authentication.

If you want to use the TCP transport, use the `clnt_create` or `clnttcp_create` routine.

Diagnostics

The `callrpc` routine returns zero if it succeeds, and the value of `enum clnt_stat` cast to an integer if it fails.

You can use the `clnt_perrno` routine to translate failure status codes into messages.

clnt_broadcast

Broadcasts a remote procedure call to all local networks, using the broadcast address.

Format

```
enum clnt_stat clnt_broadcast(u_long prognum, u_long versnum, u_long
procnum, xdrproc_t inproc, u_char *in, xdrproc_t outproc, u_char *out,
resultproc_t eachresult);
```

Arguments

prognum, versnum, procnum, inproc, in, outproc, out

See the *Common Arguments* section for a description of the above arguments.

eachresult

Each time `clnt_broadcast` receives a response, it calls the *`eachresult`* routine. If *`eachresult`* returns zero, `clnt_broadcast` waits for more replies. If *`eachresult`* returns a nonzero value, `clnt_broadcast` stops waiting for replies. The *`eachresult`* routine uses this form:

```
int eachresult(u_char *out, sockaddr_in *addr)
```

`out`	Contains the results of the remote procedure call, in the local data format.
`*addr`	Address of the host that sent the results.

Description

The `clnt_broadcast` routine performs the same functions as the `callrpc` routine. However, `clnt_broadcast` sends a message to all local networks, using the broadcast address. The `clnt_broadcast` routine uses the UDP protocol.

The below table indicates how large a broadcast message can be.

Line	**Maximum Size**
Ethernet	1500 bytes

proNet	2044 bytes

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]SYSINFO.C` file provides a sample program using `clnt_broadcast`.

Diagnostics

This routine returns diagnostic values defined in the `CLNT.H` file for `enumclnt_stat`.

clnt_call

A macro that calls a remote procedure.

Format

`enum clnt_stat clnt_call(CLIENT *clnt, u_long procnum, xdrproc_t inproc, u_char *in, xdrproc_t outproc, u_char *out, struct timeval tout);`

Arguments

clnt*, *procnum*, *inproc*, *in*, *outproc*, *out

See the *Common Arguments* section for a description of the above arguments.

tout

Time allowed for the results to return to the client, in seconds and microseconds. If you use the `clnt_control` routine to change the `CLSET_TIMEOUT` code, this argument is ignored.

Description

Use the `clnt_call` `routine` after using `clnt_create`. After you have finished with the client handle, use the `clnt_destroy` routine. You can use the `clnt_perror` routine to print messages for any errors that occurred.

Diagnostics

This routine returns diagnostic values defined in the `CLNT.H` file for `enumclnt_stat`.

clnt_control

A macro that changes or retrieves information about an RPC client process.

Format

`bool_t clnt_control(CLIENT *clnt, u_long code, void *info);`

Arguments

clnt

Client handle returned by any of the client create routines.

code

Code listed in the below table:

Code	**Type**	**Purpose**
`CLSET_TIMEOUT`	`struct timeval`	Set total timeout
`CLGET_TIMEOUT`	`struct timeval`	Get total timeout
`CLSET_RETRY_TIMEOUT`*	`struct timeval`	Set retry timeout
`CLGET_RETRY_TIMEOUT`*	`struct timeval`	Get retry timeout
`CLGET_SERVER_ADDR`	`struct sockaddr_in`	Get server address
* Valid only for the UDP transport protocol.		

The `timeval` is specified in seconds and microseconds. The total timeout is the length of time that the client waits for a reply. The default total timeout is 25 seconds.

The retry time is the length of time that UDP waits for the server to reply before transmitting the request. The default retry timeout is 5 seconds. You might want to increase the retry time if your network is slow.

For example, suppose the total timeout is 10 seconds and the retry time is five seconds. The client sends the request and waits five seconds. If the client does not receive a reply, it sends the request again. If the client does not receive a reply within five seconds, it does not send the request again.

If you use `CLSET_TIMEOUT` to set the timeout, the `clnt_call` routine ignores the timeout parameter it receives for all future calls.

`info`
Address of the information being changed or retrieved.

Diagnostics

This routine returns `TRUE` if it succeeds, and `FALSE` if it fails.

clnt_create

Creates an RPC client handle.

Format

```
CLIENT *clnt_create(char *host, u_long prognum, u_long versnum, char
*proto);
```

Arguments

host
Address of the string containing the name of the remote host where the server is located.

prognum, versnum
See the *Common Arguments* section for a description of the above arguments.

proto
Address of a string containing the name of the transport protocol. Valid values are `UDP` and `TCP`. The *ONC RPC Fundamentals* chapter explains the advantages and disadvantages of each transport protocol.

Description

The `clnt_create` routine creates an RPC client handle for *`prognum`*. An RPC client handle is a structure containing information about the RPC client. The client can use the UDP or TCP transport protocol.

This routine uses the Port Mapper. You cannot control the local port.

The default sizes of the send and receive buffers are 8800 bytes for the UDP transport, and 4000 bytes for the TCP transport.

The retry time for the UDP transport is five seconds.

Use the `clnt_create` routine instead of the `callrpc` or `clnt_broadcast` routines if you want to use one of the following:

- The TCP transport
- An authentication other than null

- More than one active client at the same time

You can also use clntraw_create to use the IP protocol, clnttcp_create to use the TCP protocol, or clntudp_create to use the UDP protocol.

The clnt_create routine uses the global variable rpc_createerr. rpc_createerr is a structure that contains the most recent service creation error. Use rpc_createerr if you want the client program to handle the error. The value of rpc_createerr is set by any RPC client creation routine that does not succeed.

The rpc_createerr variable is defined in the CLNT.H file.

Example

The TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_CLNT_CALL.C file provides a sample program that uses clnt_create.

Diagnostics

The clnt_create routine returns the address of the client handle, or zero (if it could not create the client handle).

If the clnt_create routine fails, you can use the clnt_pcreateerror or clnt_spcreateerror routines to obtain diagnostic information.

clnt_destroy

A macro that destroys an RPC client handle.

Format

`void clnt_destroy(CLIENT *clnt);`

Argument

clnt

Client handle returned by any of the client create routines.

Description

The `clnt_destroy` routine destroys the client's RPC handle by deallocating all memory related to the handle. The client is undefined after the `clnt_destroy` call.

If the `clnt_create` routine had previously opened a socket, this routine closes the socket. Otherwise, the socket remains open.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_CLNT_CALL.C` file provides a sample program that uses `clnt_destroy`.

clnt_freeres

A macro that frees the memory that was allocated when the RPC results were decoded.

Format

`bool_t clnt_freeres(CLIENT *clnt, xdrproc_t xdr_res, char *res_ptr);`

Arguments

clnt
Client handle returned by any of the client create routines.

xdr_res
Address of the XDR procedure that describes the RPC results.

res_ptr
Address of the RPC results.

Description

The `clnt_freeres` routine calls the `xdr_free` routine.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_CLNT_CALL.C` file provides a sample program that uses `clnt_freeres`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

clnt_geterr

A macro that returns an error code indicating why an RPC call failed.

Format

`void clnt_geterr(CLIENT *clnt, struct rpc_err *errp);`

Arguments

clnt

Client handle returned by any of the client create routines.

errp

Address of the structure containing information that indicates why an RPC call failed. This information is the same as `clnt_stat` contains, plus one of the following: the C error number, the range of server versions supported, or authentication errors.

Description

This routine is primarily for internal diagnostic use.

Example

```
#define PROGRAM         1
#define VERSION         1

  CLIENT *clnt;
  struct rpc_err  err;

  clnt = clnt_create("server name", PROGRAM, VERSION, "udp");

  /* calls to RPC library */

  clnt_geterr(clnt, &err);
```

This example creates a UDP client handle and performs some additional RPC processing. If an RPC call fails, `clnt_geterr` returns the error code.

clnt_pcreateerror / clnt_spcreateerror

Return a message indicating why RPC could not create a client handle.

Format

```
void clnt_pcreateerror(char *s);
char *clnt_spcreateerror(char *s);
```

Argument

s

String containing the message of your choice. The routines append an error message to this string.

Description

The `clnt_pcreateerror` routine prints a message to `SYS$OUTPUT`.

The `clnt_spcreateerror` routine returns the address of a string. Use this routine if:

- You want to save the string.
- You do not want to use `printf` to print the message.
- The message format is different from the one that `clnt_perrno` supports.

The `clnt_spcreateerror` routine overwrites the string it returns, unless you save the results.

Use these routines when the `clnt_create`, `clntraw_create`, `clnttcp_create`, or `clntudp_create` routine fails.

clnt_perrno / clnt_sperrno

Return a message indicating why the `callrpc` or `clnt_broadcast` routine failed to create a client handle.

Format

```
void clnt_perrno(enum clnt_stat stat);
char *clnt_sperrno(enum clnt_stat stat);
```

Argument

`stat`
Appropriate error condition. Values for *`stat`* are defined in the `CLNT.H` file.

Description

The `clnt_perrno` routine prints a message to `SYS$OUTPUT`.

The `clnt_sperrno` routine returns the address of a string. Use this routine instead if:

- You want to save the string.
- You do not want to use `printf` to print the message.
- The message format is different from the one that `clnt_perrno` supports.

To save the string, copy it into your own memory space.

clnt_perror / clnt_sperror

Return a message if the `clnt_call` routine fails.

Format

```
void clnt_perror(CLIENT *clnt, char *s);
char *clnt_sperror(CLIENT *clnt, char *s);
```

Arguments

clnt, s

See the *Common Arguments* section for a description of the above arguments.

Description

Use these routines after `clnt_call`.

The `clnt_perror` routine prints an error message to `SYS$OUTPUT`.

The `clnt_sperror` routine returns a string. Use this routine if:

- You want to save the string.
- You do not want to use `printf` to print the message.
- The message format is different from the one that `clnt_perror` supports.

The `clnt_sperror` routine overwrites the string with each call. Copy the string into your own memory space if you want to save it.

clntraw_create

Returns an RPC client handle. The remote procedure call uses the IP transport.

Format

`CLIENT *clntraw_create(struct sockaddr_in *addr, u_long prognum, u_long versnum, int *sockp, u_long sendsize, u_long recvsize);`

Arguments

addr, prognum, versnum
See the *Common Arguments* section for a description of the above arguments.

sockp
Socket to be used for this remote procedure call. *sockp* can specify the local address and port number. If *sockp* is `RPC_ANYSOCK`, then a port number is assigned. The example shown for the `clntudp_create` routine shows how to set up *sockp* to specify a port. See *Common Arguments* for a description of *sockp* and `RPC_ANYSOCK`.

addr
Internet address of the host on which the server resides.

sendsize
Size of the send buffer. If you enter a value less than 100, then 4000 is used as the default.

recvsize
Size of the receive buffer. If you enter a value less than 100, then 4000 is used as the default.

Description

The `clntraw_create` routine creates an RPC client handle for *addr*, *prognum*, and *versnum*. The client uses the IP transport. The routine is similar to the `clnt_create` routine, except `clnttcp_create` allows you to specify a socket and buffer sizes. If you specify the port number as zero by using *addr*`->sin_port`, the Port Mapper provides the number of the port on which the remote program is listening.

The transport used to pass messages to the service is actually a buffer within the process's address space, so the corresponding RPC server should live in the same address space (see also `svcraw_create`). This allows simulation of RPC and getting RPC overheads, such as round-trip times, without kernel interference.

The `clnttcp_create` routine uses the global variable `rpc_createerr`, which is a structure that contains the most recent service creation error. Use `rpc_createerr` if you want the client program to handle the error. The value of `rpc_createerr` is set by any RPC client creation routine that does not succeed. The `rpc_createerr` variable is defined in the `CLNT.H` file.

Diagnostics

The `clntraw_create` routine returns the address of the client handle, or zero (if it could not create the client handle). If the routine fails, use the `clnt_pcreateerror` or `clnt_spcreateerror` routine to obtain additional diagnostic information.

clnttcp_create

Returns an RPC client handle. The remote procedure call uses the TCP transport.

Format

```
CLIENT *clnttcp_create(struct sockaddr_in *addr, u_long prognum, u_long
versnum, int *sockp, u_long sendsize, u_long recvsize);
```

Arguments

addr*, *prognum*, *versnum

See the *Common Arguments* section for a description of the above arguments.

sockp

Socket to be used for this remote procedure call. *sockp* can specify the local address and port number. If *sockp* is `RPC_ANYSOCK`, then a port number is assigned. The example shown for the `clntudp_create` routine shows how to set up *sockp* to specify a port. See *Common Arguments* for a description of *sockp* and `RPC_ANYSOCK`.

addr

Internet address of the host on which the server resides.

sendsize

Size of the send buffer. If you enter a value less than 100, then 4000 is used as the default.

recvsize

Size of the receive buffer. If you enter a value less than 100, then 4000 is used as the default.

Description

The `clnttcp_create` routine creates an RPC client handle for *addr*, *prognum*, and *versnum*. The client uses the TCP transport. The routine is similar to the `clnt_create` routine, except `clnttcp_create` allows you to specify a socket and buffer sizes. If you specify the port number as zero by using *addr*`->sin_port`, the Port Mapper provides the number of the port on which the remote program is listening.

The `clnttcp_create` routine uses the global variable `rpc_createerr`. `rpc_createerr` is a structure that contains the most recent service creation error. Use `rpc_createerr` if you want the client program to handle the error. The value of `rpc_createerr` is set by any RPC client creation routine that does not succeed. The `rpc_createerr` variable is defined in the `CLNT.H` file.

Diagnostics

The `clnttcp_create` routine returns the address of the client handle, or zero (if it could not create the client handle). If the routine fails, use the `clnt_pcreateerror` or `clnt_spcreateerror` routine to obtain additional diagnostic information.

---

clntudp_create / clntudp_bufcreate

Returns an RPC client handle. The remote procedure call uses the UDP transport.

Format

```
CLIENT *clntudp_create (struct sockaddr_in *addr, u_long prognum, u_long
versnum, struct timeval wait, int *sockp);

CLIENT *clntudp_bufcreate (struct sockaddr_in *addr, u_long prognum, u_long
versnum, struct timeval wait, int *sockp, u_long sendsize, u_long recvsize);
```

Arguments

addr
Internet address of the host on which the server resides.

prognum, versnum, sockp
See the *Common Arguments* section for a description of the above arguments.

wait
Time interval the client waits before resending the call message. This value changes the `CLSET_RETRY_TIMEOUT` code. The `clnt_call` routine uses this value.

sendsize
Size of the send buffer. If you enter a value less than 100, then 4000 is used as the default.

recvsize
Size of the receive buffer. If you enter a value less than 100, then 4000 is used as the default.

Description

These routines create an RPC client handle for *`addr`*, *`prognum`*, and *`versnum`*. The client uses the UDP transport protocol.

If you specify the port number as zero by using *`addr`*`->sin_port`, the Port Mapper provides the number of the port on which the remote program is listening.

Note: Use the `clntudp_create` routine only for procedures that handle messages shorter than 8K bytes. Use the `clntudp_bufcreate` routine for procedures that handle messages longer than 8K bytes.

The `clntudp_create` routine uses the global variable `rpc_createerr`. `rpc_createerr` is a structure that contains the most recent service creation error. Use `rpc_createerr` if you want the client program to handle the error. The value of `rpc_createerr` is set by any RPC client creation routine that does not succeed.

The `rpc_createerr` variable is defined in the CLNT.H file.

Example

```
main()
{
  int     sock;
  u_long  prog = PROGRAM, vers = VERSION;
  CLIENT  *clnt;
  struct sockaddr_in      local_addr, remote_addr;
  struct timeval  timeout = { 35, 0}, retry = { 5, 0};

  remote_addr.sin_family = AF_INET;
  remote_addr.sin_port = 0;  /* consult the remote port mapper */
  remote_addr.sin_addr.s_addr = 0x04030201; /* internet addr 1.2.3.4 */

  local_addr.sin_family = AF_INET;
  local_addr.sin_port = 12345;                /* use port 12345 */
  local_addr.sin_addr.s_addr = 0x05030201;    /* internet addr 1.2.3.5 */

  sock = socket(AF_INET, SOCK_DGRAM, 0);

  /* bind the socket to the local addr */
  bind(sock, &local_addr, sizeof( local_addr));

  /* create a client that uses the local IA and port given above */
  clnt = clntudp_create(&remote_addr, prog, vers, retry, &sock);

  /* use a connection timeout of 35 seconds, not the default */
  clnt_control(clnt, CLSET_TIMEOUT, &timeout);
  /*call the server here*/
}
```

This example defines a socket structure, binds the socket, and creates a UDP client handle.

Diagnostics

These routines return the address of the client handle, or zero (if they cannot create the client handle).

If these routines fail, you can obtain additional diagnostic information by using the `clnt_pcreateerrror` or `clnt_spcreateerror` routine.

16. ONC RPC RTL Port Mapper Routines

Introduction

This chapter is for RPC programmers. It documents the port mapper routines in the ONC RPC Run-Time Library (RTL). These routines are the programming interface to ONC RPC.

Port Mapper Routines

Port Mapper routines provide a simple callable interface to the Port Mapper. They allow you to request Port Mapper services and information about port mappings. The below table summarizes the purpose of each Port Mapper routine.

Routine	**Purpose**
`pmap_freemaps`	Frees memory that was allocated by the `pmap_getmaps()` routine.
`pmap_getmaps`	Returns a list of Port Mappings for the specified host.
`pmap_getport`	Returns the port number on which a specified service is waiting.
`pmap_rmtcall`	Requests the Port Mapper on a remote host to call a procedure on that host.
`pmap_set`	Registers a remote service with a remote port.
`pmap_unset`	Unregisters a service so it is no longer mapped to a port.

Port Mapper Arguments

Port Mapper routines use many of the same arguments as client routines.

See the table in the first section of the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Routine Descriptions

The following sections describe each Port Mapper routine in detail.

pmap_freemaps

Frees memory that was allocated by the `pmap_getmaps` routine.

Format

```
void pmap_freemaps(struct pmaplist *list);
```

Argument

list

Address of a structure containing the list returned by the `pmap_getmaps` routine.

Description

Call the `pmap_freemaps` routine when the list returned by `pmap_getmaps` is no longer needed. Do not call `pmap_freemaps` to free a list that you created.

pmap_getmaps

Returns a list of port mappings for the specified host.

Format

```
struct pmaplist *pmap_getmaps(struct sockaddr_in *addr);
```

Argument

addr
Address of a structure containing the internet address of the host whose Port Mapper is being called.

Description

The `pmap_getmaps` routine returns a list of current RPC server-to-Port Mappings on the host at *`addr`*. The list structure is defined in the `PMAP_PROT.H` file.

The RPCINFO command uses this routine.

Diagnostics

If an error occurs (for example, `pmap_getmaps` cannot get a list of Port Mappings, the internet address is invalid, or the remote Port Mapper does not exist), the routine returns either NULL or the address of the list.

pmap_getport

Returns the port number on which a specified service is waiting.

Format

```
u_short pmap_getport(struct sockaddr_in *addr, u_long prognum, u_long
versnum, u_long protocol);
```

Arguments

addr

Address of a structure containing the internet address of the remote host on which the server resides.

prognum, versnum, protocol

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Diagnostics

If the requested mapping does not exist or the routine fails to contact the remote Port Mapper, the routine returns either the port number or zero.

The `pmap_getport` routine uses the global variable `rpc_createerr`. `rpc_createerr` is a structure that contains the most recent service creation error. Use `rpc_createerr` if you want the service program to handle the error. The value of `rpc_createerr` is set by any RPC server creation routine that does not succeed.

The `rpc_createerr` variable is defined in the `CLNT.H` file.

pmap_rmtcall

Requests the Port Mapper on a remote host to call a procedure on that host.

Format

`enum clnt_stat pmap_rmtcall(struct sockaddr_in *addr, u_long prognum, u_long versnum, u_long procnum, xdrproc_t inproc, u_char *in, xdrproc_t outproc, u_char *out, struct timeval tout, u_long *portp);`

Arguments

addr
Address of a structure containing the internet address of the remote host on which the server resides.

prognum, versnum, procnum, inproc, in, outproc, out
See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

tout
Time allowed for the results to return to the client, in seconds and microseconds.

portp
Address where `pmap_rmtcall` will write the port number of the remote service.

Description

The `pmap_rmtcall` routine allows you to get a port number and call a remote procedure in one call. The routine requests a remote Port Mapper to call a *`prognum`*, *`versnum`*, and *`procnum`* on the Port Mapper's host. The remote procedure call uses the UDP transport.

If `pmap_rmtcall` succeeds, it changes *`portp`* to contain the port number of the remote service.

After calling the `pmap_rmtcall` routine, you may call the `clnt_perrno` routine.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_CLNT_RMTCALL.C` file provides a sample program using `pmap_rmtcall`.

Diagnostics

This routine returns diagnostic values defined in the `CLNT.H` file for `enumclnt_stat`.

pmap_set

Registers a remote service with a remote port.

Format

`bool_t pmap_set(u_long` *`prognum`*`, u_long` *`versnum`*`, u_long` *`protocol`*`, u_short` *`port`*`);`

Arguments

prognum, versnum, protocol

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

port

Remote port number.

Description

The `pmap_set` routine calls the local Port Mapper to tell it which *`port`* and *`protocol`* the *`prognum`*, *`versnum`* is using.

You are not likely to use `pmap_set`, because `svc_register` calls it.

Diagnostics

The `pmap_set` routine returns `TRUE` if it succeeds, and `FALSE` if it fails.

pmap_unset

Unregisters a service so it is no longer mapped it to a port.

Format

`bool_t pmap_unset(u_long` *`prognum`*`, u_long` *`versnum`*`);`

Arguments

`prognum, versnum`

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Description

The `pmap_unset` routine calls the local Port Mapper and, for all protocols, removes the *`prognum`* and *`versnum`* from the list that maps servers to ports.

You are not likely to use `pmap_unset`, because `svc_unregister` calls it.

Example

The `GETSYI_PROC_A.C` and `GETSYI_SVC.C` files provide sample programs using the `pmap_unset` routine.

These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

The `pmap_unset` routine returns `TRUE` if it succeeds, `FALSE` if it fails.

17. ONC RPC RTL Server Routines

Introduction

This chapter is for RPC programmers. It documents the server routines in the ONC RPC Run-Time Library (RTL). These routines are the programming interface to ONC RPC.

Server Routines

The server routines are called by the server program or the server stub procedures. The below table lists each server routine and summarizes its purpose.

Routine	**Purpose**
`registerrpc`	Performs creation and registration tasks for server.
`svc_destroy`	Macro that destroys RPC server handle.
`svc_freeargs`	Macro that frees memory allocated when RPC arguments were decoded.
`svc_getargs`	Macro that decodes RPC arguments.
`svc_getcaller`	Macro that returns address of client that called server.
`svc_getchan`	Macro that returns channel of server handle.
`svc_getport`	Macro that returns port associated with server handle.
`svc_getreqset`	Reads data for each server connection.

`svc_register`	Adds specified server to list of active servers, and registers service program with Port Mapper.
`svc_run`	Waits for RPC requests and calls `svc_getreqset` routine to dispatch to appropriate RPC service program.
`svc_sendreply`	Sends results of remote procedure call to client.
`svc_unregister`	Calls Port Mapper to unregister specified program and version for all protocols.
`svcerr_auth`	Sends error code when server cannot authenticate client.
`svcerr_decode`	Sends error code to client if server cannot decode arguments.
`svcerr_noproc`	Sends error code to client if server cannot implement requested procedure.
`svcerr_noprog`	Sends error code to client when requested program is not registered with Port Mapper.
`svcerr_progvers`	Sends error code to client when requested program is registered with Port Mapper, but requested version is not registered.
`svcerr_systemerr`	Sends error code to client when server encounters error not handled by particular protocol.
`svcerr_weakauth`	Sends error code to client when server cannot perform remote procedure call because it received insufficient (but correct) authentication parameters.
`svcfd_create`	Returns address of structure containing server handle for specified TCP socket.
`svctcp_create`	Returns address of server handle that uses TCP transport.
`svctcpa_create`	Returns address of server handle that uses TCPA transport.
`svctcpa_enablecache`	Enables XID cache for specified TCPA transport server.

`svctcpa_freecache`	Deallocates TCPA XID cache.
`svctcpa_getxdrs`	Returns XDR structure associated with server handle.
`svctcpa_shutdown`	Cancels all outstanding I/O on channel associated with server handle.
`svcudp_bufcreate`	Returns address of server handle that uses UDP transport. For procedures that pass messages longer than 8Kbytes.
`svcudp_create`	Returns address of server handle that uses UDP transport. For procedures that pass messages shorter than 8Kbytes.
`svcudp_enablecache`	Enables XID cache for specified UDP transport server.
`svcudpa_bufcreate`	Returns address of server handle that uses UDPA transport. For procedures that pass messages longer than 8Kbytes.
`svcudpa_create`	Returns address of server handle that uses UDPA transport. For procedures that pass messages shorter than 8Kbytes.
`svcudpa_enablecache`	Enables XID cache for specified UDPA transport server.
`svcudpa_freecache`	Deallocates UDPA XID cache.
`svcudpa_getxdrs`	Returns XDR structure associated with server handle.
`svcudpa_shutdown`	Cancels all outstanding I/O on channel associated with the server handle.
`xprt_register`	Adds UDP or TCP server socket to list of sockets.
`xprt_unregister`	Removes UDP or TCP server socket from list of sockets.

Routine Descriptions

The following sections describe each server routine in detail.

registerrpc

Performs creation and registration tasks for the server.

Format

```
int registerrpc(u_long prognum, u_long versnum, u_long procnum,
u_char *(*procname) (), xdrproc_t inproc, xdrproc_t outproc);
```

Arguments

prognum*, *versnum*, *procnum*, *inproc*, *outproc

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

procname

Address of the routine that implements the service procedure. The routine uses the following format:

```
u_char *procname(out);
u_char *out;
```

where `out` is the address of the data decoded by `outproc`.

Description

The `registerrpc` routine performs the following tasks for a server:

- Creates a UDP server handle.
- Calls the `svc_register` routine to register the program with the Port Mapper.
- Adds `prognum`, `versnum`, and `procnum` to an internal list of registered procedures. When the server receives a request, it uses this list to determine which routine to call.

A server should call `registerrpc` for every procedure it implements, except for the NULL procedure.

Example

The GETSYI_SVC_REG.C file provide a sample program using the registerrpc routine. This file is in the TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC] directory.

Diagnostics

The registerrpc routine returns zero if it succeeds, and -1 if it fails.

svc_destroy

Macro that destroys the RPC server handle.

Format

```
void svc_destroy(SVCXPRT *xprt);
```

Argument

xprt

RPC server handle.

Description

The `svc_destroy` routine destroys *`xprt`* by deallocating private data structures. After this call, *`xprt`* is undefined.

If the server creation routine received `RPC_ANYSOCK` as the socket, `svc_destroy` closes the socket. Otherwise, you must close the socket.

Example

The `TCPWARE_ROOT[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file provides a sample program using the `svc_destroy` routine.

svc_freeargs

Macro that frees the memory that was allocated when the RPC arguments were decoded.

Format

`bool_t svc_freeargs (SVCXPRT *xprt, xdrproc_t xdr_args, char *args_ptr);`

Arguments

xprt*, *xdr_args*, *args_ptr

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Description

The `svc_freeargs` routine calls the `xdr_free` routine.

Example

The `GETSYI_PROC_A.C` and `GETSYI_SVC.C` files provide sample programs that use the `svc_freeargs` routine. These files are in the `TCPWARE:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

svc_getargs

Macro that decodes the RPC arguments.

Format

`bool_t svc_getargs(SVCXPRT *xprt, xdrproc_t xdr_args, u_char *args_ptr);`

Arguments

xprt, xdr_args, args_ptr

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Example

The `GETSYI_PROC_A.C` and `GETSYI_SVC.C` files provide sample programs that use the `svc_getargs` routine.

These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

svc_getcaller

Macro that returns the address of the client that called the server.

Format

```
struct sockaddr_in *svc_getcaller(SVCXPRT *xprt);
```

Argument

xprt

RPC server handle.

svc_getchan

Macro that returns the channel associated with the server handle.

Format

```
u_short svc_getchan(SVCXPRT *xprt);
```

Argument

xprt
RPC server handle.

Description

Use `svc_getchan` when multiple servers are listening on the same channel and port.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file provides a sample program that uses `svc_getchan`.

svc_getport

Macro that returns the port associated with the server handle.

Format

```
u_short svc_getport(SVCXPRT *xprt);
```

Argument

xprt
RPC server handle.

Description

Use `svc_getport` when you want to know what port the server is listening on. You can use this macro with synchronous and asynchronous transports.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file provides a sample program that uses `svc_getport`.

svc_getreqset

Reads data for each server connection.

Format

`void svc_getreqset(int rdfds);`

Argument

rdfds

Address of the read socket descriptor array. This array is returned by the `select` routine.

Description

The server calls `svc_getreqset` when it receives an RPC request. The `svc_getreqset` routine reads in data for each server connection, then calls the server program to handle the data.

The `svc_getreqset` routine does not return a value. It finishes executing after all *rdfds* sockets have been serviced.

You are unlikely to call this routine directly, because the `svc_run` routine calls it. However, there are times when you cannot call `svc_run`. For example, suppose a program services RPC requests and reads or writes to another socket at the same time. The program cannot call `svc_run`. It must call `select` and `svc_getreqset`.

The `svc_getreqset` routine is for servers that implement custom asynchronous event processing, do not use the `svc_run` routine.

You may use the global variable `svc_fdset` with `svc_getreqset`. The `svc_fdset` variable lists all sockets the server is using. It contains an array of structures, where each element is a socket pointer and a service handle. It uses the following format:

```
struct sockarr svc_fdset [MAXSOCK +1];
```

This is how to use `svc_fdset`: first, copy the socket handles from `svc_fdset` into a temporary array that ends with a zero. Pass the array to the `select` routine. The `select` routine overwrites the array and returns it. Pass this array to the `svc_getreqset` routine.

You may use `svc_fdset` when the server does not use `svc_run`.

The svc_fdset variable is not compatible with UNIX.

Example

```
#define MAXSOCK         10

  int readfds[ MAXSOCK+1],    /* sockets to select from */
        i, j;

  for (i = 0, j = 0; i < MAXSOCK; i++)
    if ((svc_fdset[i].sockname != 0) && (svc_fdset[i].sockname != 1))
      readfds[j++] = svc_fdset[i].sockname;

  readfds[j] = 0;                 /* list of sockets ends w/ a zero */
  switch (select( 0, readfds, 0, 0, 0))
  {
    case -1:      /* an error happened */
    case 0:       /* time out */
      break;
    default:      /* 1 or more sockets ready for reading */
      errno = 0;
      ONCRPC_SVC_GET_REQSET( readfds);
      if (errno == ENETDOWN || errno == ENOTCONN)
        sys$exit (SS$_THIRDPARTY);
  }
```

svc_register

Adds the specified server to a list of active servers, and registers the service program with the Port Mapper.

Format

```
bool_t svc_register(SVCXPRT *xprt, u_long prognum, u_long versnum, void
(*dispatch) (), u_long protocol);
```

Arguments

xprt*, *prognum*, *versnum

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

dispatch

Routine that `svc_register` calls when the server receives a request for *`prognum`*, *`versnum`*. This routine determines which routine to call for each server procedure. This routine uses the following form:

```
void dispatch(struct svc_req *request, SVCXPRT *xprt)
```

The `svc_getreqset` and `svc_run` routines call *`dispatch`*.

protocol

Must be `IPPROTO_UDP`, `IPPROTO_TCP`, or zero. Zero indicates that you do not want to register the server with the Port Mapper.

Example

The `GETSYI_PROC_A.C` and `GETSYI_SVC.C` files provide sample programs that use the `svc_register` routine.

These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

The `svc_register` routine returns `TRUE` if it succeeds and `FALSE` if it fails.

svc_run

Waits for RPC requests and calls the `svc_getreqset` routine to dispatch to the appropriate RPC service program.

Format

```
void svc_run();
```

Arguments

None.

Description

The `svc_run` routine calls the `select` routine to wait for RPC requests. When a request arrives, `svc_run` calls the `svc_getreqset` routine. Then `svc_run` calls `select` again.

The `svc_run` routine never returns.

You may use the global variable `svc_fdset` with `svc_run`. See the `svc_getreqset` routine for more information on `svc_fdset`.

Examples

These files contain sample programs that use `svc_run`:

- `GETSYI_SVC.C`
- `GETSYI_SVC_REG.C`
- `PRINT_SVC.C`
- `SYSINFO_SVC.C`

These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

svc_sendreply / svc_sendreply_dq

Sends the results of a remote procedure call to the client.

Format

XDR ONC:

```
bool_t svc_sendreply(SVCXPRT *xprt, xdrproc_t outproc, u_char *out);
```

ONC:

```
bool_t svc_sendreply_dq(SVCXPRT *xprt, xdrproc_t outproc, u_char *out);
```

Arguments

`xprt, outproc, out`

See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Description

Both routines send the results of a remote procedure call to the client.

The `svc_sendreply_dq` routine, however, does not queue a read and is for UDPA and TCPA servers only.

Examples

These files contain sample programs that use `svc_sendreply`:

- `SYSINFO_SVC.C`
- `PRINT_SVC.C`
- `GETSYI_PROC_A.C`
- `GETSYI_SVC.C`

These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

These routines return `TRUE` if they succeed and `FALSE` if they fail.

svc_unregister

Calls the Port Mapper to unregister the specified program and version for all protocols. The program and version are removed from the list of active servers.

Format

```
void svc_unregister(u_long prognum, u_long versnum);
```

Arguments

prognum, versnum
See the *Common Arguments* section in the *ONC RPC RTL Client Routines* chapter for a list of these arguments.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file contains a sample program that uses the `svc_unregister` routine.

svcerr_auth
svcerr_decode
svcerr_noproc
svcerr_noprog
svcerr_progvers
svcerr_systemerr
svcerr_weakauth

Sends various error codes to the client process.

Format

```
void svcerr_auth(SVCXPRT *xprt, enum auth_stat why);
void svcerr_decode(SVCXPRT *xprt);
void svcerr_noproc(SVCXPRT *xprt);
void svcerr_noprog(SVCXPRT *xprt);
void svcerr_progvers(SVCXPRT *xprt, u_long low-vers, u_long high-vers);
void svcerr_systemerr(SVCXPRT *xprt);
void svcerr_weakauth(SVCXPRT *xprt);
```

Arguments

xprt

RPC server handle.

why

Error code defined in the `AUTH.H` file.

low-vers

Lowest version number in the range of versions that the server supports.

high-vers

Highest version in the range of versions that the server supports.

Description

svcerr_auth
See `svc_getreqset`. Calls `svcerr_auth` when it cannot authenticate a client. The `svcerr_auth` routine returns an error code (*`why`*) to the caller.

svcerr_decode
Sends an error code to the client if the server cannot decode the arguments.

svcerr_noproc
Sends an error code to the client if the server does not implement the requested procedure.

svcerr_noprog
Sends an error code to the client when the requested program is not registered with the Port Mapper. Generally, the Port Mapper informs the client when a server is not registered. Therefore, the server is unlikely to use this routine.

svcerr_progvers
Sends an error code to the client when the requested program is registered with the Port Mapper, but the requested version is not registered.

svcerr_systemerr
Sends an error code to the client when the server encounters an error that is not handled by a particular protocol.

svcerr_weakauth
Sends an error code to the client when the server cannot perform a remote procedure call because it received insufficient (but correct) authentication parameters. This routine calls the `svcerr_auth` routine. The value of *`why`* is `AUTH_TOOWEAK`, which means "access permission denied."

svcfd_create

Returns the address of a structure containing a server handle for the specified TCP socket.

Format

```
SVCXPRT *svcfd_create(int sock, u_long sendsize, u_long recvsize);
```

Arguments

sock
Socket number. Do not specify a file descriptor.

sendsize
Size of the send buffer. If you enter a value less than 100, then 4000 is used as the default.

recvsize
Size of the receive buffer. If you enter a value less than 100, then 4000 is used as the default.

Description

The `svcfd_create` routine returns the address of a server handle for the specified TCP socket. This handle cannot use a file. The server calls the `svcfd_create` routine after it accepts a TCP connection.

Diagnostics

This routine returns zero if it fails.

svcraw_create

Creates a server handle for memory-based RPC for simple testing and timing.

Format

```
SVCXPRT svcraw_create();
```

Argument

None.

Description

The `svcraw_create` routine creates a toy RPC service transport, to which it returns a pointer. The transport is really a buffer within the process's address space, so the corresponding client should live in the same address space.

This routine allows simulation of and acquisition of RPC overheads (such as round trip times) without any kernel interference.

Diagnostics

This routine returns NULL if it fails.

svctcp_create

Returns the address of a server handle that uses the TCP transport.

Format

`SVCXPRT *svctcp_create(int sock, u_long sendsize, u_long recvsize);`

Arguments

sock

Socket for this service. The `svctcp_create` routine creates a new socket if you enter `RPC_ANYSOCK`. If the socket is not bound to a TCP port, `svctcp_create` binds it to an arbitrary port.

sendsize

Size of the send buffer. If you enter a value less than 100, then 4000 bytes is used as the default.

recvsize

Size of the receive buffer. If you enter a value less than 100, then 4000 bytes is used as the default.

Examples

The `PRINT_SVC.C` and `GETSYI_SVC.C` files provides sample programs that use `svctcp_create`. These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

The `svctcp_create` routine returns either the address of the server handle, or zero (if it could not create the server handle).

svctcpa_create

Returns the address of a server handle that uses the TCPA transport.

Format

`SVCXPRT *svctcpa_create(u_short` *`channel`*`, u_short` *`port`*`, u_long` *`sendsize`*`, u_long` *`recvsize`*`);`

Arguments

channel

If you enter `RPC_ANYCHAN` (defined in the `SVC.H` file), the `svctcpa_create` routine assigns a channel and sets the local port to the *`port`* value. If you enter any other value, `svctcpa_create` ignores the *`port`* value.

Multiple server handles may use the same channel if you specify `RPC_ANYCHAN` and a port number on the first call to `svctcpa_create`, and if you specify the assigned channel with any port number on subsequent calls to `svctcpa_create`. (Use `svc_getchan` to obtain the channel. Note that for TCPA, this is not really a channel, just a unique identifier.)

All server handles that use the same channel should use the same XID cache.

port

Number of the TCP port on which the server will listen. If you enter RPCANYPORT, then RPC assigns a port.

sendsize

Size of the send buffer. If you enter a value less than 100, then 4000 bytes is used as the default.

recvsize

Size of the receive buffer. If you enter a value less than 100, then 4000 bytes is used as the default.

Examples

The `GETSYI_PROC_A.C` file contains a sample program that uses `svctcpa_create`. This file is in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

The `svctcpa_create` routine returns either the address of the server handle, or zero (if it could not create the server handle).

svctcpa_enablecache

Enables the XID cache for the specified TCPA transport server.

Format

`void *svctcpa_enablecache(SVCXPRT *`*`xprt`*`, void *`*`cacheaddr`*`, u_long `*`size`*`, reply_id *`*`reqlst`*`);`

Arguments

xprt
RPC server handle.

cacheaddr
Address of the XID cache. If *`cacheaddr`* is zero, this routine allocates a cache with *`size`* number of entries. All TCPA transports that use this cache must have the same size buffers. The first time you call `svctcpa_enablecache`, specify zero as the *`cacheaddr`*. The second time you call `svctcpa_enablecache`, specify the address that `svctcpa_enablecache` returned on the previous call as the *`cacheaddr`*. All server handles that use a channel should use the same XID cache.

size
Number of entries in the cache. You may estimate this number based on how active the server is, and on how long you want to retain old replies.

reqlst
Address of an array of structures containing a list of procedures for which replies are to be cached. The array is terminated by `prognum==0`. This is the structure:

```
typedef struct
{
   u_long prognum, versnum, procnum;
} reply_id
```

If this address is zero, the server saves all replies in the XID cache.

Description

Call the `svctcpa_enablecache` routine after each TCPA server handle is created. The server places all appropriate outgoing responses in the XID cache. The cache can be used to improve the performance of the server, for example, by preventing the server from recalculating the results or sending incorrect results. You can disable the cache by calling the `svctcpa_freecache` routine. The *ONC RPC Fundamentals,* Chapter 12, provides more information on the XID cache.

Diagnostics

The `svctcpa_enablecache` routine returns either the address of the cache, or zero if an error occurs.

svctcpa_freecache

Deallocates the TCPA XID cache.

Format

```
void svctcpa_freecache(void *cacheaddr);
```

Argument

cacheaddr
Address of the TCPA XID cache.

Description

The `svc_destroy` routine calls the `svctcpa_freecache` routine for every server handle, after all servers that reference the cache have been destroyed.

The *ONC RPC Fundamentals*, Chapter 12, provides more information on the XID cache.

svctcpa_getxdrs

Returns the XDR structure associated with the server handle.

Format

```
XDRS *svctcpa_getxdrs(SVCXPRT *xprt);
```

Argument

xprt

RPC server handle.

svctcpa_shutdown

Cancels all outstanding I/O on the channel associated with the server handle.

Format

`void svctcpa_shutdown(SVCXPRT *`*`xprt`*`);`

Argument

xprt

RPC server handle.

Description

The `svctcpa_shutdown` routine cancels all I/O on the channel associated with *`xprt`* and flags the server as shutting down. The server then begins the shutdown process. Call this routine only once for a channel before calling `svc_destroy` to destroy individual server handles.

This routine affects all TCPA handles that are using the same channel.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file contains a sample program that uses `svctcpa_shutdown`.

svcudp_create / svcudp_bufcreate

Returns the address of a server handle that uses the UDP transport.

Format

```
SVCXPRT *svcudp_create(int sock);

SVCXPRT *svcudp_bufcreate(int sock, u_long sendsize, u_long recvsize);
```

Arguments

sock
Socket for this service. The `svcudp_create` routine creates a new socket if you enter `RPC_ANYSOCK`. If the socket is not bound to a UDP port, the `svcudp_create` routine binds it to an arbitrary port.

sendsize
Size of the send buffer. The minimum size is 100 bytes. The maximum size is 65468, the maximum UDP packet size. If you enter a value less than 100, then 4000 is used as the default.

recvsize
Size of the receive buffer. The minimum size is 100 bytes. The maximum size is 65000, the maximum UDP packet size. If you enter a value less than 100, then 4000 is used as the default.

Description

Use the `svc_create` routine only for procedures that pass messages shorter than 8 KB long. Use the `svcudp_bufcreate` routine for procedures that pass messages longer than 8 KB.

Examples

The `SYSINFO_SVC.C` and `GETSYI_SVC.C` files contain sample programs that use `svcudp_create`. These files are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

Diagnostics

These routines return either a server handle, or zero (if they could not create the server handle).

svcudp_enablecache

Enables the XID cache for the specified UDP transport server.

Format

`bool_t svcudp_enablecache(SVCXPRT *xprt, u_long size);`

Arguments

xprt

RPC server handle.

size

Number of entries permitted in the XID cache. You may estimate this number based on how active the server is, and on how long you want to retain old replies.

Description

Use the `svcudp_enablecache` routine after a UDP server handle is created. The server places all outgoing responses in the XID cache. The cache can be used to improve the performance of the server, for example, by preventing the server from recalculating the results or sending incorrect results.

You cannot disable the XID cache for UDP servers.

The *ONC RPC Fundamentals*, Chapter 12, provides more information on the XID cache.

Example

```
#define FALSE   0
#define UDP_CACHE_SIZE  10

  SVCXPRT *udp_xprt;

  udp_xprt = svcudp_create(RPC_ANYSOCK);
  if (svcudp_enablecache(udp_xprts, UDP_CACHE_SIZE) == FALSE)
    printf("XID cache was not enabled");
  else
    printf("XID cache was enabled");
```

Diagnostics

This routine returns `TRUE` if it enables the XID cache, and `FALSE` if the cache was previously enabled or an error occurs.

svcudpa_create / svcudpa_bufcreate

Returns the address of a server handle that uses the UDPA transport.

Format

```
SVCXPRT *svcudpa_create(u_short channel, u_short port);

SVCXPRT *svcudpa_bufcreate(u_short channel, u_short port, u_long sendsize,
u_long recvsize);
```

Arguments

channel
If you enter `RPC_ANYCHAN` (defined in the `SVC.H` file), then the `svcudpa_bufcreate` routine assigns the channel and sets the local port to the *`port`* value. If you enter any other value, then `svcudpa_bufcreate` ignores the *`port`* value. Multiple server handles may use the same channel if you specify `RPC_ANYCHAN` and a port number on the first call to `svcudpa_create`, and if you specify the assigned channel with any port number on subsequent calls to `svcudpa_create`. All server handles that use the same channel should use the same XID cache.

port
Number of the UDP port on which the server will listen. All servers that use the same port should use the same channel. If you enter `RPCANYPORT`, then RPC assigns the port.

sendsize
Size of the send buffer. If you enter a value less than 100, then 4000 is used as the default.

recvsize
Size of the receive buffer. If you enter a value less than 100, then 4000 is used as the default.

Description

Both routines return the address of a structure containing a UDPA server handle. The `svcudpa_create` routine limits the call to 8 KB of data. The `svcudpa_bufcreate` routine allows you to define the buffer sizes.

See *Using Asynchronous Transports* in Chapter 13, *Building Distributed Applications with RPC*, for more information on writing asynchronous transports.

Example

`TCPWARE_ROOT:[TCPWARE.EXAMPLE].RPC]GETSYI_PROC_A.C` provides a sample program and procedure that use `svcudpa_create`.

Diagnostics

These routines return the address of the server handle, or zero (if they could not create the server handle).

svcudpa_enablecache

Enables the XID cache for the specified UDPA transport server.

Format

```
void *svcudpa_enablecache(SVCXPRT *xprt, void *cacheaddr, u_long size,
reply_id *reqlst);
```

Arguments

xprt
RPC server handle.

cacheaddr
Address of the XID cache. If *`cacheaddr`* is zero, this routine allocates a cache with *`size`* number of entries. All UDPA transports that use this cache must have the same size buffers.

The first time you call `svcudpa_enablecache`, specify zero as the *`cacheaddr`*. The second time you call `svcudpa_enablecache`, specify the address that `svcudpa_enablecache` returned on the previous call as the *`cacheaddr`*.

All server handles that use a channel should use the same XID cache.

size
Number of entries in the cache. You may estimate this number based on how active the server is, and on how long you want to retain old replies.

reqlst
Address of an array of structures containing a list of procedures for which replies are to be cached. The array is terminated by `prognum==0`. This is the structure:

```
typedef struct
{
  u_long prognum, versnum, procnum;
} reply_id;
```

If this address is zero, the server saves all replies in the XID cache.

Description

Call the `svcudpa_enablecache` routine after each UDPA server handle is created. The server places all appropriate outgoing responses in the XID cache.

The cache can be used to improve the performance of the server, for example, by preventing the server from recalculating the results or sending incorrect results. You can disable the cache by calling the `svcudpa_freecache` routine.

The *ONC RPC Fundamentals*, Chapter 12, provides more information on the XID cache.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file contains a sample program that uses the `svcudpa_enablecache` routine.

Diagnostics

The `svcudpa_enablecache` routine returns either the address of the cache, or zero if an error occurs.

svcudpa_freecache

Deallocates the UDPA XID cache.

Format

```
void svcudpa_freecache(void *cacheaddr);
```

Argument

cacheaddr

Address of the UDPA XID cache.

Description

The `svc_destroy` routine calls the `svcudpa_freecache` routine for every server handle, after all servers that reference the cache have been destroyed.

The *ONC RPC Fundamentals*, Chapter 12, provides more information on the XID cache.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file contains a sample program that uses `svcudpa_freecache`.

svcudpa_getxdrs

Returns the XDR structure associated with the server handle.

Format

```
XDRS *svcudpa_getxdrs(SVCXPRT *xprt);
```

Argument

xprt
RPC server handle.

svcudpa_shutdown

Cancels all outstanding I/O on the channel that is associated with the server handle.

Format

```
void svcudpa_shutdown(SVCXPRT *xprt);
```

Argument

xprt

RPC server handle.

Description

The `svcudpa_shutdown` routine cancels all I/O on the channel associated with *`xprt`* and flags the server as shutting down. The server then begins the shutdown process. Call this routine only once for a channel, before calling `svc_destroy` to destroy individual servers.

This routine affects all UDPA handles that are using the same channel.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_PROC_A.C` file contains a sample program that uses `svcudpa_shutdown`.

xprt_register

Adds a TCP or UDP server socket to a list of sockets.

Format

```
void xprt_register(SVCXPRT *xprt);
```

Argument

xprt
RPC server handle.

Description

The `xprt_register` and `xprt_unregister` routines maintain a list of sockets. This list ensures that the correct server is called to process the request. The `xprt_register` routine adds the server socket to the `svc_fdset` variable, which also stores the server handle that is associated with the socket. The `svc_run` routine passes the list of sockets to the `select` routine. The `select` routine returns to `svc_run` a list of sockets that have outstanding requests.

You are unlikely to call this routine directly because `svc_register` calls it.

xprt_unregister

Removes a TCP or UDP server socket from a list of sockets.

Format

```
void xprt_unregister(SVCXPRT *xprt);
```

Argument

xprt
RPC server handle.

Description

This list of sockets ensures that the correct server is called to process the request. See the `xprt_register` routine for a description of how this list is maintained.

You are unlikely to call this routine directly because `svc_unregister` calls it.

18. ONC RPC RTL XDR Routines

Introduction

This chapter is for RPC programmers. It documents the XDR routines in the ONC RPC Run-Time Library (RTL). These routines are the programming interface to ONC RPC.

XDR Routines

This section explains what XDR routines do and when you would call them. It also provides quick reference and detailed reference sections describing each XDR routine.

What XDR Routines Do

Most XDR routines share these characteristics:

- They convert data in two directions: from the host's local data format to XDR format (called encoding or marshalling), or the other way around (called decoding or unmarshalling).
- They use `xdrs`, a structure containing instructions for encoding, decoding, and deallocating memory.
- They return a Boolean value to indicate success or failure.

Some XDR routines allocate memory while decoding an argument. To free this memory, call the `xdr_free()` routine after the program is done with the decoded value.

The below table shows the order in which XDR routines perform encoding and decoding.

Client	**Server**

1. Encodes arguments 2. Decodes results 3. Frees results from memory	1. Decodes arguments 2. Encodes results 3. Frees arguments from memory

When to Call XDR Routines

Under most circumstances, you are not likely to call any XDR routines directly. The `clnt_call` and `svc_sendreply` routines call the XDR routines.

You would call the XDR routines directly only when you write your own routines to convert data to or from XDR format.

Quick Reference

The below table lists the XDR routines that encode and decode data.

This routine...	**Encodes and decodes...**
`xdr_array`	Variable-length array
`xdr_bool`	Boolean value
`xdr_bytes`	Bytes
`xdr_char`	Character
`xdr_double`	Double-precision floating point number
`xdr_enum`	Enumerated type
`xdr_float`	Floating point value

`xdr_hyper`	VAX quad word to an XDR hyper-integer, or the other way
`xdr_int`	Four-byte integer
`xdr_long`	Longword
`xdr_opaque`	Contents of a buffer (treats the data as a fixed length of bytes and does not attempt to interpret them)
`xdr_pointer`	Pointer to a data structure
`xdr_reference`	Pointer to a data structure (the address must be non-zero)
`xdr_short`	Two-byte unsigned integer
`xdr_string`	Null-terminated string
`xdr_u_char`	Unsigned character
`xdr_u_hyper`	VAX quad word to an XDR unsigned hyper-integer
`xdr_u_int`	Four-byte unsigned integer
`xdr_u_long`	Unsigned longword
`xdr_u_short`	Two-byte unsigned integer
`xdr_union`	Union
`xdr_vector`	Vector (fixed length array)
`xdr_void`	Nothing
`xdr_wrapstring`	Null-terminated string

The below table lists the XDR routines that perform various support functions.

This routine...	**Does this...**
`xdr_free`	Deallocates a data structure from memory
`xdrmem_create`	Creates a memory buffer XDR stream
`xdrrec_create`	Creates a record-oriented XDR stream
`xdrrec_endofrecord`	Marks the end of a record
`xdrrec_eof`	Goes to the end of the current record, then verifies whether any more data can be read
`xdrrec_skiprecord`	Goes to the end of the current record
`xdrstdio_create`	Initializes a `stdio` stream

The below table lists the upper layer XDR routines that support RPC.

This routine...	**Encodes and decodes...**
`xdr_accepted_reply`	Part of an RPC reply message after the reply is accepted
`xdr_authunix_parms`	UNIX-style authentication information
`xdr_callhdr`	Static part of an RPC request message header (encoding only)
`xdr_callmsg`	RPC request message
`xdr_netobj`	Data in the `netobj` structure
`xdr_opaque_auth`	Authentication information
`xdr_pmap`	Port Mapper parameters
`xdr_pmaplist`	List of Port Mapping data

`xdr_rejected_reply`	Part of an RPC reply message after the reply is rejected
`xdr_replymsg`	RPC reply header; it then calls the appropriate routine to convert the rest of the message

Routine Descriptions

The following sections describe each XDR routine in detail.

xdr_accepted_reply

Converts an RPC reply message from local format to XDR format, or the other way around.

Format

```
bool_t xdr_accepted_reply(XDR *xdrs, struct accepted_reply *ar);
```

Arguments

xdrs

Address of a structure containing XDR encoding and decoding information.

ar

Address of the structure containing the RPC reply message.

Description

The `xdr_replymsg` routine calls the `xdr_accepted_reply` routine.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_array

Converts a variable-length array from local format to XDR format, or the other way around.

Format

`bool_t xdr_array(XDR *`*`xdrs`*`, u_char **`*`addrp`*`, u_long *`*`sizep`*`, u_long `*`maxsize`*`, u_long `*`elsize`*`, xdrproc_t `*`elproc`*`);`

Arguments

`xdrs`
Address of a structure containing XDR encoding and decoding information.

`addrp`
Address of the address containing the array being converted. If *`addrp`* is zero, then `xdr_array` allocates `((*`*`sizep`*`)*`*`elsize`*`)` number of bytes when it decodes.

`sizep`
Address of the number of elements in the array.

`maxsize`
Maximum number of elements the array can hold.

`elsize`
Size of each element, in bytes.

`elproc`
XDR routine that handles each array element.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_authunix_parms

Converts UNIX-style authentication information from local format to XDR format, or the other way around.

Format

```
bool_t xdr_authunix_parms(XDR *xdrs, struct authunix_parms *aupp);
```

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

aupp
UNIX-style authentication information being converted.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_bool

Converts a boolean value from local format to XDR format, or the other way around.

Format

```
bool_t xdr_bool(XDR *xdrs, bool_t *bp);
```

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

bp
Address of the boolean value.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_bytes

Converts bytes from local format to XDR format, or the other way around.

Format

```
bool_t xdr_bytes(XDR *xdrs, u_char **cpp, u_long *sizep, u_long maxsize);
```

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

cpp
Address of the address of the buffer containing the bytes being converted. If `*cpp` is zero, `xdr_bytes` allocates *`maxsize`* bytes when it decodes.

sizep
Address of the actual number of bytes being converted.

maxsize
Maximum number of bytes that can be used. The server protocol determines this number.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_callhdr

Encodes the static part of an RPC request message header.

Format

`bool_t xdr_callhdr(XDR *`*`xdrs`*`, struct rpc_msg *`*`chdr`*`);`

Arguments

`xdrs`
Address of a structure containing XDR encoding and decoding information.

`chdr`
Address of the data being converted.

Description

The `xdr_callhdr` routine converts the following fields: transaction ID, direction, RPC version, server program number, and server version. It converts the last four fields once, when the client handle is created.

The `clnttcp_create` and `clntudp_create` routines call the `xdr_callhdr` routine.

Diagnostics

This routine always returns `TRUE`.

xdr_callmsg

Converts an RPC request message from local format to XDR format, or the other way around.

Format

`bool_t xdr_callmsg(XDR *xdrs, struct rpc_msg *cmsg);`

Arguments

xdrs

Address of a structure containing XDR encoding and decoding information.

cmsg

Address of the message being converted.

Description

The `xdr_callmsg` routine converts the following fields: transaction ID, RPC direction, RPC version, program number, version number, procedure number, client authentication.

The `pmap_rmtcall`, `svc_sendreply`, and `svc_sendreply_dq` routines call `xdr_callmsg`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_char

Converts a character from local format to XDR format, or the other way around.

Format

```
bool_t xdr_char(XDR *xdrs, char *cp);
```

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

cp
Address of the character being converted.

Description

This routine provides the same functionality as the `xdr_u_char` routine.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_double

Converts a double-precision floating point number between local and XDR format.

Format

`bool_t xdr_double(XDR *xdrs, double *dp);`

Arguments

xdrs
Pointer to an XDR stream handle created by one of the XDR stream handle creation routines.

dp
Pointer to the double-precision floating point number.

Description

This routine provides a filter primitive that translates between double-precision numbers and their external representations. It is actually implemented by four XDR routines:

`xdr_double_D`	Converts VAX D format floating point numbers
`xdr_double_G`	Converts VAX G format floating point numbers
`xdr_double_T`	Converts IEEE T format floating point numbers
`xdr_double_X`	Converts IEEE X format floating point numbers

You can reference these routines explicitly or you can use compiler settings to control which routine is used when you reference the `xdr_double` routine.

VAX

If you use...	**link your program with...**

VAX C `D_float` RTL	`TCPWARE_RPCLIB_SHR.EXE`
VAX C `G_float` RTL	`TCPWARE_RPCLIBG_SHR.EXE`

ALPHA and I64

If you use...	**link your program with...**
DEC C `D_float` RTL	`TCPWARE_RPCLIBD_SHR.EXE`
DEC C `G_float` RTL	`TCPWARE_RPCLIB_SHR.EXE`
DEC C `T_float` RTL	`TCPWARE_RPCLIBT_SHR.EXE`

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_enum

Converts an enumerated type from local format to XDR format, or the other way around.

Format

```
bool_t xdr_enum(XDR *xdrs, enum_t *ep);
```

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

ep

Address containing the enumerated type.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_float

Converts a floating point value from local format to XDR format, or the other way around.

Format

```
bool_t xdr_float(XDR *xdrs, float *fp);
```

Arguments

xdrs

Pointer to an XDR stream handle created by one of the XDR stream handle creation routines.

fp

Pointer to a single-precision floating point number.

Description

This routine provides a filter primitive that translates between double-precision numbers and their external representations. It is actually implemented by two XDR routines:

`xdr_float_F`	Converts VAX F format floating point numbers
`xdr_float_S`	Converts IEEE T format floating point numbers

You can reference these routines explicitly or you can use compiler settings to control which routine is used when you reference the `xdr_float` routine.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_free

Deallocates a data structure from memory.

Format

```
void xdr_free(xdrproc_t proc, u_char *objp);
```

Arguments

proc
XDR routine that describes the data structure.

objp
Address of the data structure.

Description

Call this routine after decoded data is no longer needed. Do not call it for encoded data.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_hyper

Converts a VAX quad word to an XDR hyper-integer, or the other way around.

Format

```
bool_t xdr_hyper(XDR *xdrs, quad *ptr);
```

Arguments

xdrs

Address of a structure containing XDR encoding and decoding information.

ptr

Address of the structure containing the quad word. The quad word is stored in standard VAX quad word format, with the low-order longword first in memory.

Description

This routine provided the same functionality as the `xdr_u_hyper()` routine.

Diagnostics

This routine returns TRUE if it succeeds and FALSE if it fails.

xdr_int

Converts one four-byte integer from local format to XDR format, or the other way around.

Format

```
bool_t xdr_int(XDR *xdrs, int *ip);
```

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

ip
Address containing the integer.

Description

This routine provides the same functionality as the `xdr_u_int`, `xdr_long`, and `xdr_u_long` routines.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_long

Converts one longword from local format to XDR format, or the other way around.

Format

```
bool_t xdr_long(XDR *xdrs, u_long *lp);
```

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

lp

Address containing the longword.

Description

This routine provides the same functionality as the `xdr_u_long`, `xdr_int`, and `xdr_u_int` routines.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_netobj

Converts data in the `netobj` structure from the local data format to XDR format, or the other way around.

Format

`bool_t xdr_netobj(XDR *xdrs, netobj *ptr);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

ptr
Address of the following structure:

```
typedef struct
{
   u_long n_len;
   byte *n_bytes;
} netobj;
```

This structure defines the data being converted.

Description

The `netobj` structure is an aggregate data structure that is opaque and contains a counted array of 1024 bytes.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_opaque

Converts the contents of a buffer from the local data format to XDR format, or the other way around. This routine treats the data as a fixed length of bytes and does not attempt to interpret them.

Format

```
bool_t xdr_opaque(XDR *xdrs, char *cp, u_long cnt);
```

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

cp

Address of the buffer containing opaque data.

cnt

Byte length.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_opaque_auth

Converts authentication information from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_opaque_auth(XDR *xdrs, struct opaque_auth *ap);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

ap
Address of the authentication information. This data was created by the `authnone_create`, `authunix_create`, or `authunix_create_default` routine.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_pmap

Converts Port Mapper parameters from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_pmap(XDR *xdrs, struct pmap *regs);
```

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

regs

Address of a structure containing the program number, version number, protocol number, and port number. This is the data being converted.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_pmaplist

Converts a list of Port Mapping data from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_pmaplist(XDR *xdrs, struct pmaplist **rpp);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

rpp
Address of the address of the structure containing Port Mapper data. If this routine is used to decode a Port Mapper listing, `rpp` is set to the address of the newly allocated linked list of structures.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_pointer

Converts a recursive data structure from the local data format to XDR format, or the other way around.

Format

`bool_t xdr_pointer(XDR *`*`xdrs`*`, u_char **`*`objpp`*`, u_long `*`obj_size`*`,`
`xdrproc_t `*`xdr_obj`*`);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

objpp
Address of the address containing the data being converted. May be zero.

obj_size
Size of the data structure in bytes.

xdr_obj
XDR routine that describes the object being pointed to. This routine can describe complex data structures, and these structures may contain pointers.

Description

An XDR routine for a data structure that contains pointers to other structures, such as a linked list, would call the `xdr_pointer` routine. The `xdr_pointer` routine encodes a pointer from an address into a Boolean. If the Boolean is `TRUE`, the data follows the Boolean.

Example

```
bool_t xdr_pointer(XDR *xdrs, char **objpp, longw obj_size, xdrproc_t
xdr_obj)
{
  bool_t  more_data;
  /*
   * determine if the pointer is a valid address (0 is invalid)
   */
  if ( *objpp != NULL)
    more_data = TRUE;
  else
    more_data = FALSE;

  /*
   * XDR the flag
   * If we are decoding, then more_data is overwritten.
   */
  if (!xdr_bool(xdrs, &more_data))
    return(FALSE);

  /*
   * If there is no more data, set the pointer to 0 (No effect if we
   * were encoding) and return TRUE
   */
  if (!more_data)
  {
    *objpp = NULL;
    return( TRUE);
  }

  /*
   * Otherwise, call xdr_reference.  The result is that xdr_pointer is
   * the same as xdr_reference, except that xdr_pointer adds a Boolean
   * to the encoded data and will properly handle NULL pointers.
   */
  return(xdr_reference(xdrs, objpp, obj_size, xdr_obj));

} /* end function xdr_pointer() */
```

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_reference

This routine recursively converts a structure that is referenced by a pointer inside the structure.

Format

```
bool_t xdr_reference(XDR *xdrs, u_char **objpp, u_long obj_size, xdrproc_t
xdr_obj);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

objpp
Address of the address of a structure containing the data being converted. If *objpp* is zero, the `xdr_reference` routine allocates the necessary storage when decoding. This argument must be non-zero when encoding.

When `xdr_reference` encodes data, it passes `*`*objpp* to *xdr_obj*. When decoding, `xdr_reference` allocates memory if `*`*objpp* equals zero.

obj_size
Size of the referenced structure.

xdr_obj
XDR routine that describes the object being pointed to. This routine can describe complex data structures, and these structures may contain pointers.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_rejected_reply

Converts the remainder of an RPC reply message after the header indicates that the reply is rejected.

Format

```
bool_t xdr_rejected_reply(XDR *xdrs, struct rejected_reply *rr);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

rr
Address of the structure containing the reply message.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_replymsg

Converts the RPC reply header, then calls the appropriate routine to convert the rest of the message.

Format

`bool_t xdr_replymsg(XDR *xdrs, struct rpc_msg *rmsg);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

rmsg
Address of the structure containing the reply message.

Description

The `xdr_replymsg` routine calls the `xdr_rejected_reply` or `xdr_accepted_reply` routine to convert the body of the RPC reply message from the local data format to XDR format, or the other way around.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_short

Converts a two-byte integer from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_short(XDR *xdrs, short *sp);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

sp
Address of the integer being converted.

Description

This routine provides the same functionality as `xdr_u_short`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_string

Converts a null-terminated string from the local data format to XDR format, or the other way around.

Format

`bool_t xdr_string(XDR *xdrs, char **cpp, u_long maxsize);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

cpp
Address of the address of the first byte in the string.

maxsize
Maximum length of the string. The service protocol determines this value.

Description

The `xdr_string` routine is the same as the `xdr_wrapstring` routine, except `xdr_string` allows you to specify the *`maxsize`*.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_u_char

Converts an unsigned character from local format to XDR format, or the other way around.

Format

```
bool_t xdr_u_char(XDR *xdrs, u_char bp);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

bp
Address of the character being converted.

Description

This routine provides the same functionality as `xdr_char`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_u_hyper

Converts an VAX quad word to an XDR unsigned hyper-integer, or the other way around.

Format

```
bool_t xdr_u_hyper(XDR *xdrs, quad *ptr);
```

Arguments

xdrs

Address of a structure containing XDR encoding and decoding information.

ptr

Address of the structure containing the quad word. The quad word is stored in standard VAX format, with the low-order longword first in memory.

Description

This routine provides the same functionality as the `xdr_hyper` routine.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_u_int

Converts a four-byte unsigned integer from local format to XDR format, or the other way around.

Format

`bool_t xdr_u_int(XDR *xdrs, int *ip);`

Arguments

xdrs
Address of a structure containing XDR encoding and decoding information.

ip
Address of the integer.

Description

This routine provides the same functionality as `xdr_int`, `xdr_long`, and `xdr_u_long`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_u_long

Converts an unsigned longword from local format to XDR format, or the other way around.

Format

`bool_t xdr_u_long(XDR *xdrs, u_long *lp);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

lp
Address of the longword.

Description

This routine provides the same functionality as `xdr_long`, `xdr_int`, and `xdr_u_int`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_u_short

Converts a two-byte unsigned integer from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_u_short(XDR *xdrs, u_short *sp);
```

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

sp

Address of the integer being converted.

Description

This routine provides the same functionality as `xdr_short`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_union

Converts a union from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_union(XDR *xdrs, enum_t *dscmp, u_char *unp, xdr_discrim
*choices, xdrproc_t dfault);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

dscmp
Integer from the *choices* array.

unp
Address of the union.

choices
Address of an array. This array maps integers to XDR routines.

dfault
XDR routine that is called if the *dscmp* integer is not in the *choices* array.

Description

The `xdr_union` routine searches the array choices for the value of *dscmp*. If it finds the value, it calls the corresponding XDR routine to process the remaining data. If `xdr_union` doesn't find the value, it calls the `dfault` routine.

Example

The `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI_XDR_2.C` file contains a sample routine that calls `xdr_union`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_vector

Converts a vector (fixed length array) from the local data format to XDR format, or the other way around.

Format

```
bool_t xdr_vector(XDR *xdrs, u_char *basep, u_long nelem, u_long elmsize,
xdrproc_t xdr_elem);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

basep
Address of the array.

nelem
Number of elements in the array.

elmsize
Size of each element.

xdr_elem
Converts each element from the local data format to XDR format, or the other way around.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdr_void

Converts nothing.

Format

```
bool_t xdr_void(XDR *xdrs, u_char *ptr);
```

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

ptr
Ignored.

Description

Use this routine as a place-holder for a program that passes no data. The server and client expect an XDR routine to be called, even when there is no data to pass.

Diagnostics

This routine always returns `TRUE`.

xdr_wrapstring

Converts a null-terminated string from the local data format to XDR format, or the other way around.

Format

`bool_t xdr_wrapstring(XDR *xdrs, char **cpp);`

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

cpp

Address of the address of the first byte in the string.

Description

The `xdr_wrapstring` routine calls the `xdr_string` routine. The `xdr_wrapstring` routine hides the *`maxsize`* argument from the programmer. Instead, the maximum size of the string is assumed to be 2^{32} - 1.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdrmem_create

Creates a memory buffer XDR stream.

Format

`void xdrmem_create(XDR *xdrs, u_char *addr, u_long size, enum xdr_op op);`

Arguments

xdrs

Address of the structure containing XDR encoding and decoding information.

addr

Address of the buffer containing the encoded data.

size

Size of the *`addr`* buffer.

op

Operations you will perform on the buffer. Valid values are `XDR_ENCODE`, `XDR_DECODE`, and `XDR_FREE`. You may change this value.

Description

The `xdrmem_create` routine initializes a structure so that other XDR routines can write to a buffer. The UDP and UDPA transports use this routine.

xdrrec_create

Creates a record-oriented XDR stream.

Format

```
void xdrrec_create(XDR *xdrs, u_long sendsize, u_long recvsize,
u_char *tcp_handle, int (*readit)(), int (*writeit)();
```

Arguments

xdrs
Address of the structure being created. The `xdrrec_create` routine will write XDR encoding and decoding information to this structure.

sendsize
Size of the send buffer in bytes. The minimum size is 100 bytes. If you specify fewer than 100 bytes, 4000 bytes is used as the default.

recvsize
Size of the receive buffer in bytes. The minimum size is 100 bytes. If you specify fewer than 100 bytes, 4000 bytes is used as the default.

tcp_handle
Address of the client or server handle.

readit
Address of a user-written routine that reads data from the stream transport. This routine must use the following format:

```
int readit(u_char *tcp_handle, u_char *buffer, u_long len)
```

`tcp_handle` is the client or server handle, *`*buffer`* is the buffer to fill, and *`len`* is the number of bytes to read. The *`readit`* routine returns either the number of bytes read, or -1 if an error occurs.

writeit
Address of a user-written routine that writes data to the stream transport. This routine must use the following format:

```
int writeit(u_char *tcp_handle, u_char *buffer, u_long len)
```

- `tcp_handle` is the client or server handle.
- `buffer` is the address of the buffer being written.
- `len` is the number of bytes to write.

The *`writeit`* routine returns either the number of bytes written, or -1 if an error occurs.

Description

The `xdrrec_create` routine requires one of the following:

- The TCP transport
- A stream-oriented interface (such as file I/O) not supported by TCPware. The stream consists of data organized into records. Each record is either an RPC request or reply.

The `clnttcp_create` and `svcfd_create` routines call the `xdrrec_create` routine.

xdrrec_endofrecord

Marks the end of a record.

Format

`bool_t xdrrec_endofrecord(XDR *xdrs, bool_t sendnow);`

Arguments

xdrs
Address of the structure containing XDR encoding and decoding information.

sendnow
Indicates when the calling program will send the record to the *`writeit`* routine.

If *`sendnow`* is `TRUE`, `xdrrec_endofrecord` sends the record now. If *`sendnow`* is `FALSE`, `xdrrec_endofrecord` writes the record to a buffer and sends the buffer when it runs out of buffer space.

Description

A client or server program calls the `xdrrec_endofrecord` routine when it reaches the end of a record it is writing. The program must call the `xdrrec_create` routine before calling `xdrrec_endofrecord`.

Diagnostics

This routine returns `TRUE` if it succeeds and `FALSE` if it fails.

xdrrec_eof

Goes to the end of the current record, then verifies whether any more data can be read.

Format

`bool_t xdrrec_eof(XDR *xdrs);`

Argument

xdrs
Address of the structure containing XDR encoding and decoding information.

Description

The client or server program must call the `xdrrec_create` routine before calling `xdrrec_eof`.

Diagnostics

This routine returns `TRUE` if it reaches the end of the data stream, and `FALSE` if it finds more data to read.

xdrrec_skiprecord

Goes to the end of the current record.

Format

```
bool_t xdrrec_skiprecord(XDR *xdrs);
```

Argument

xdrs

Address of the structure containing XDR encoding and decoding information.

Description

A client or server program calls the `xdrrec_skiprecord` routine before it reads data from a stream. This routine ensures that the program starts reading a record from the beginning.

The `xdrrec_skiprecord` routine is similar to the `xdrrec_eof` routine, except that `xdrrec_skiprecord` does not verify whether any more data can be read.

The client or server program must call the `xdrrec_create` routine before calling `xdrrec_skiprecord`.

Diagnostics

This routine returns `TRUE` if it has skipped to the start of a record. Otherwise, it returns `FALSE`.

xdrstdio_create

Initializes a `stdio` XDR stream.

Format

`void xdrstdio_create(XDR *`*`xdrs`*`, FILE *`*`file`*`, enum xdr_op `*`op`*`);`

Arguments

`xdrs`

Address of the structure containing XDR encoding and decoding information.

`file`

File pointer `FILE *`, which is to be associated with the stream.

`op`

An XDR operation, one of: `XDR_ENCODE`, `XDR_DECODE`, or `XDR_FREE`.

Description

The `xdrstdio_create` routine initializes a `stdio` stream for the specified file.

19. ONC RPC Sample Programs

Introduction

This chapter is for RPC programmers. It explains:

- How to run the sample programs.
- The purpose of each sample program file.

Introducing Sample Programs

The ONC RPC sample programs are divided into three groups:

- `GETSYI`
- `PRINT`
- `SYSINFO`

Each group has a command procedure to facilitate compiling and linking. All command procedures are in the `TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]` directory.

For more information on each program, see the comments in the `GETSYI.COM`, `PRINT.COM`, and `SYSINFO.COM` files.

Running Sample Programs

To run an RPC sample program, follow these steps:

1. Move to the directory where you want the command procedure to place the client and server sample programs. It must be a directory in which you have write privilege.
2. Compile the sample client and server programs by entering one of the following commands at the DCL prompt:

```
$ @TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]PRINT
$ @TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]SYSINFO
$ @TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI XDR1
$ @TCPWARE_ROOT:[TCPWARE.EXAMPLES.RPC]GETSYI XDR2
```

3. Verify whether the Port Mapper is running. Use the `RPCINFO` command or the `NETCU SHOW SERVICES` command. If the Port Mapper is not running, ask the system manager to start it.
4. Log on to a second terminal. Run the server that you compiled in step 2. To stop the server, type **CTRL**+**C**.
5. Define symbols that point to the executable client program. A symbol can point to either a logical or a disk/directory specification, as follows:

   ```
   symbol:==$logical:prog
   symbol:==$disk:[dir]prog
   ```

   - *`symbol`* specifies `GETSYI`, `PRINTF`, or `SYSINFO`.
   - *`logical`* is the logical pointing to the directory that contains the .EXE client program. This logical must translate to a disk and directory specification.
   - *`prog`* is the .EXE program for `GETSYI`, `PRINT`, or `SYSINFO`.
   - *`disk`*`:[`*`dir`*`]` is the disk and directory where the .EXE client program is located.

   These symbols remain valid until you log off.

6. Run the clients. Use the commands given in the following sections.

Running GETSYI Client

To run the `GETSYI` client, enter the following command at the DCL prompt:

```
$ GETSYI [-u | -t][-d#][-nnode][-hhost]code[code…]
```

`GETSYI`	Runs the GETSYI client.
`-u`	UDP transport. Supported only for the GETSYI_CLNT_CALL client. This is the default.
`-t`	TCP transport. Supported only for the GETSYI_CLNT_CALL client.
`-d#`	Debugging value passed to the ONCRPC_SET_CHAR routine. Debugging values are defined in the ONCRPC_CONST.H file. The pound sign (#) represents a hexadecimal number. The default is 0.

`-n`*`node`*	Name of the node about which the server is returning information. Can be used only if the server is part of a VMS cluster. The default is a NULL string (no node).
`-h`*`host`*	Domain name of the host running the remote server. If you omit *`host`*, *`node`* is used as the default. If *`node`* is not specified, the default is the local host.
`Code`	String indicating what information the server needs to return. You can enter up to 64 codes. The codes are • `BOOTTIME  NODE_SWVERS` • `CLUSTER_NODES NODENAME` • `CPU PAGEFILE_FREE` • `NODE_HWTYPE  PAGEFILE_PAGE` • `NODE_HWVERS  SWAPFILE_FREE` • `NODE_NUMBER  SWAPFILE_PAGE` • `NODE_SWTYPE  VERSION`

The `GETSYI_SVC_SUBS.C` file defines all possible codes. Three codes in the file are specific to VMS Version 5.x or OpenVMS. These are commented out. You can remove the comments in order to use them.

The OpenVMS System Services Reference Manual describes each code under the `$GETSYI` system service.

Running PRINT Client

To run the PRINT client, type the following command at the DCL prompt:

```
$ PRINTF [-d#][-hhost]filename
```

`-d#`	Debugging value that is passed to the `ONCRPC_SET_CHAR` routine. Debugging values are defined in the `ONCRPC_CONST.H` file. The pound sign (#) represents a hexadecimal number. The default is 0.
`-h`*`host`*	Domain name of the host running the remote server. The default is the local host.
`filename`	Name of the file to be displayed on the screen. You must have the appropriate privilege to gain access to this file.

Running SYSINFO Client

To run the SYSINFO client, type the following command at the DCL prompt:

```
$ SYSINFO [-d#][limit]
```

-d#	Debugging value that is passed to the ONCRPC_SET_CHAR routine. Debugging values are defined in the ONCRPC_CONST.H file. The pound sign (#) represents a hexadecimal number. The default is 0.
limit	Maximum number of replies the client can receive before it exits. The client processes until it reaches this limit or it times out, whichever comes first.

Miscellaneous Clients and Servers

The sample programs listed in the below table include three client programs using the `client_call`, `callrpc`, and `pmap_rmtcall` routines; a synchronous server; and a server using the `registerrpc` routine.

In this group of programs, a client calls a server to request system information, and the server provides the information.

File	**Description**
GETSYI.COM	Command procedure that compiles and links related RPC sample programs.
GETSYI.H	Header file used by the sample RPC GETSYI programs. Generated by RPCGEN.
GETSYI.X	Sample RPCGEN input file for the TCP and UDP transports.
GETSYI_CLNT.C	Sample client code generated by the RPCGEN compiler.
GETSYI_CLNT_CALL.C	Sample RPC client program using the `clnt_call` routine.

GETSYI_CLNT_CALLRPC.C	Sample RPC client program using the `callrpc` routine.
GETSYI_CLNT_RMTCALL.C	Sample RPC client program using the `pmap_rmtcall` routine.
GETSYI_CLNT_SUBS.C	Miscellaneous client support routines.
GETSYI_DEF.H	Contains various structure definitions used by the RPC sample programs.
GETSYI_PROC_S.C	Sample RPC procedure for a synchronous server.
GETSYI_SVC.C	Sample RPC program for a synchronous server. Generated by RPCGEN.
GETSYI_SVC_REG.C	Sample RPC program and procedure using the `registerrpc` routine.
GETSYI_SVC_SUBS.C	Miscellaneous server support routines for the sample GETSYI programs.
GETSYI_XDR.C	XDR routines generated by RPCGEN, used by sample RPC clients and servers.
GETSYI_XDR_2.C	Alternative XDR routines using `xdr_union`, used by sample RPC clients and servers.

Batch RPC Sample Programs

In the batch programs listed in the below table, a client sends a file to a server one record at a time. After the last record is sent, the client flushes the pipeline and receives the total number of records received by the server.

File	**Description**
PRINT.C	Sample RPC batch client program.
PRINT.COM	Command procedure that compiles and links related RPC sample programs.

`PRINT.H`	Header file for the sample RPC batch programs. Generated by RPCGEN.
`PRINT.X`	RPCGEN input file used by the sample RPC batch programs.
`PRINT_DEF.H`	Contains various structure definitions used by the RPC sample batch programs.
`PRINT_SVC.C`	Sample RPC batch server program.
`PRINT_XDR.C`	XDR routines used by the sample RPC batch programs. Generated by RPCGEN.

Broadcast RPC Sample Programs

In the broadcast RPC programs listed in the below table, the server returns the name of its host and operating system. The `each_result` routine displays the address of the remote host and the values returned.

The `clnt_broadcast` routine waits for replies until it times out or reaches the specified limit. Then the client stops processing.

File	**Description**
`SYSINFO.C`	Sample RPC client program using broadcast RPC.
`SYSINFO.COM`	Command procedure that compiles and links related RPC sample programs.
`SYSINFO.H`	Header file used by the sample RPC broadcast programs. Generated by RPCGEN.
`SYSINFO.X`	RPCGEN input file used by the sample RPC broadcast programs.
`SYSINFO_DEF.H`	Contains various structure definitions used by the sample RPC broadcast programs.
`SYSINFO_SVC.C`	Sample RPC server program using broadcast RPC.
`SYSINFO_XDR.C`	XDR routines used by the sample RPC broadcast programs. Generated by RPCGEN.