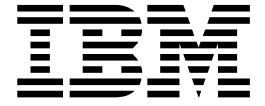


z/VM



TCP/IP Programmer's Reference

Version 6 Release 4

Note:

Before you use this information and the product it supports, read the information in "Notices" on page 427.

This edition applies to version 6, release 4, modification 0 of IBM z/VM (product number 5741-A07) and to all subsequent releases and modifications until otherwise indicated in new editions.

This edition replaces SC24-6239-04.

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About This Document

z/VM: TCP/IP Programmer's Reference describes the routines for application programming in IBM® Transmission Control Protocol/Internet Protocol for z/VM® version 6, release 4, modification 0.

This document contains information about the following application programming interfaces (API):

- C sockets
- Pascal
- Virtual Machine Communication Facility (VMCF)
- Inter-User Communication Vehicle sockets
- Remote Procedure Calls (RPCs)
- X Window System
- Simple Network Management Protocol (SNMP) agent distributed program interface
- Conversational Monitor System (CMS) command interface to the name server
- Simple Mail Transfer Protocol (SMTP)

The descriptive information in the chapters is supplemented with appendixes that contain sample programs and quick references.

For comments and suggestions about this document, use the Reader's Comment Form located at the back of this document. This form gives instructions on submitting your comments by mail, by FAX, or by electronic mail.

Intended Audience

This document is intended for users and programmers who are familiar with z/VM and the Control Program (CP) and the Conversational Monitor System (CMS) components. You should also be familiar with the C or Pascal programming language and the specific application programming interface (API) that you are using.

Before using this document, you should be familiar with z/VM, CP, and CMS. In addition, TCP/IP for z/VM at level 640 should already be installed and customized for your network.

Conventions and Terminology

This topic describes important style conventions and terminology used in this document.

How the Term “internet” Is Used in This Document

In this document, an internet is a logical collection of networks supported by routers, gateways, bridges, hosts, and various layers of protocols, which permit the network to function as a large, virtual network.

Note: The term “internet” is used as a generic term for a TCP/IP network, and should not be confused with the Internet, which consists of large national

backbone networks (such as MILNET, NSFNet, and CREN) and a myriad of regional and local campus networks worldwide.

How Numbers Are Used in This Document

In this document, numbers over four digits are represented in metric style. A space is used rather than a comma to separate groups of three digits. For example, the number sixteen thousand, one hundred forty-seven is written 16 147.

Syntax, Message, and Response Conventions

The following topics provide information on the conventions used in syntax diagrams and in examples of messages and responses.

How to Read Syntax Diagrams

Special diagrams (often called *railroad tracks*) are used to show the syntax of external interfaces.

To read a syntax diagram, follow the path of the line. Read from left to right and top to bottom.

- The \blacktriangleright — symbol indicates the beginning of the syntax diagram.
- The — \blacktriangleright symbol, at the end of a line, indicates that the syntax diagram is continued on the next line.
- The \blacktriangleright — symbol, at the beginning of a line, indicates that the syntax diagram is continued from the previous line.
- The — \blacktriangleleft symbol indicates the end of the syntax diagram.

Within the syntax diagram, items on the line are required, items below the line are optional, and items above the line are defaults. See the examples in Table 1.

Table 1. Examples of Syntax Diagram Conventions



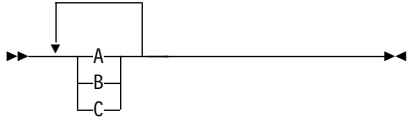
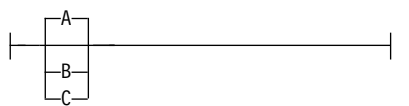
Syntax Diagram Convention	Example
<p>Keywords and Constants</p> <p>A keyword or constant appears in uppercase letters. In this example, you must specify the item KEYWORD as shown.</p> <p>In most cases, you can specify a keyword or constant in uppercase letters, lowercase letters, or any combination. However, some applications may have additional conventions for using all-uppercase or all-lowercase.</p>	
<p>Abbreviations</p> <p>Uppercase letters denote the shortest acceptable abbreviation of an item, and lowercase letters denote the part that can be omitted. If an item appears entirely in uppercase letters, it cannot be abbreviated.</p> <p>In this example, you can specify KEYWO, KEYWOR, or KEYWORD.</p>	

Table 1. Examples of Syntax Diagram Conventions (continued)

Syntax Diagram Convention	Example
<p>Symbols</p> <p>You must specify these symbols exactly as they appear in the syntax diagram.</p>	<p>* Asterisk : Colon , Comma = Equal Sign - Hyphen () Parentheses . Period</p>
<p>Variables</p> <p>A variable appears in highlighted lowercase, usually italics.</p> <p>In this example, <i>var_name</i> represents a variable that you must specify following KEYWORD.</p>	<p>▶—KEYWOrd—<i>var_name</i>—▶</p>
<p>Repetitions</p> <p>An arrow returning to the left means that the item can be repeated.</p> <p>A character within the arrow means that you must separate each repetition of the item with that character.</p> <p>A number (1) by the arrow references a syntax note at the bottom of the diagram. The syntax note tells you how many times the item can be repeated.</p> <p>Syntax notes may also be used to explain other special aspects of the syntax.</p>	<p>▶—repeat—▶</p> <p>▶—repeat—▶</p> <p>▶—repeat—▶ (1)</p> <p>Notes: 1 Specify <i>repeat</i> up to 5 times.</p>
<p>Required Item or Choice</p> <p>When an item is on the line, it is required. In this example, you must specify A.</p> <p>When two or more items are in a stack and one of them is on the line, you must specify one item. In this example, you must choose A, B, or C.</p>	<p>▶—A—▶</p> <p>▶— A B C—▶</p>
<p>Optional Item or Choice</p> <p>When an item is below the line, it is optional. In this example, you can choose A or nothing at all.</p> <p>When two or more items are in a stack below the line, all of them are optional. In this example, you can choose A, B, C, or nothing at all.</p>	<p>▶— A—▶</p> <p>▶— A B C—▶</p>
<p>Defaults</p> <p>When an item is above the line, it is the default. The system will use the default unless you override it. You can override the default by specifying an option from the stack below the line.</p> <p>In this example, A is the default. You can override A by choosing B or C.</p>	<p>▶— A B C—▶</p>

Table 1. Examples of Syntax Diagram Conventions (continued)

Syntax Diagram Convention	Example
<p>Repeatable Choice</p> <p>A stack of items followed by an arrow returning to the left means that you can select more than one item or, in some cases, repeat a single item.</p> <p>In this example, you can choose any combination of A, B, or C.</p>	
<p>Syntax Fragment</p> <p>Some diagrams, because of their length, must fragment the syntax. The fragment name appears between vertical bars in the diagram. The expanded fragment appears in the diagram after a heading with the same fragment name.</p> <p>In this example, the fragment is named "A Fragment."</p>	<p>▶ A Fragment ▶</p> <p>A Fragment:</p> 

Examples of Messages and Responses

Although most examples of messages and responses are shown exactly as they would appear, some content might depend on the specific situation. The following notation is used to show variable, optional, or alternative content:

- xxx Highlighted text (usually italics) indicates a variable that represents the data that will be displayed.
- [] Brackets enclose optional text that might be displayed.
- { } Braces enclose alternative versions of text, one of which will be displayed.
- | The vertical bar separates items within brackets or braces.
- ... The ellipsis indicates that the preceding item might be repeated. A vertical ellipsis indicates that the preceding line, or a variation of that line, might be repeated.

Where to Find More Information

Appendix F, "Abbreviations and Acronyms," on page 423, lists the abbreviations and acronyms that are used throughout this document.

The "Glossary" on page 431, defines terms used throughout this document that are associated with TCP/IP communication in an internet environment.

For more information about related publications, see the documents listed in the "Bibliography" on page 433.

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- Go to IBM Support Portal (www.ibm.com/support/entry/portal/Overview/).

Summary of Changes

This document contains terminology, maintenance, and editorial changes. Technical changes are indicated by a vertical line to the left of the change. Some product changes might be provided through and might be available for some prior releases.

SC24-6239-05, z/VM Version 6 Release 4

This edition includes changes to support the general availability of z/VM V6.4.

Client/Server TLS/SSL Support

New `ioctl()` commands have been added to allow clients/servers that communicate through the TCP/IP stack to have their data flow through the TLS/SSL server. The new `ioctls` are supported for C programs as well as assembler programs which use IUCV.

In addition, support has been added which allows data to flow encrypted over RSCS TCPNJE links. This support encrypts traffic which was previously unencrypted. It accomplishes this through modifications to TCP/IP and RSCS in accordance with existing TCPNJE standards, which will allow the TCPNJE traffic to flow through the TLS/SSL server.

The following tables have been updated:

- IUCV Socket Call Syntax - Table 21 on page 154
- IOCTL - Table 22 on page 170

z/VM LDAP Server and Client Utilities z/OS V2.2 Equivalency

The LDAP server has been upgraded to the current level of the z/OS® product.

Chapter 12, “Remote authorization and auditing through LDAP,” on page 383 has been updated for this support:

Domain Name System (DNS) IPv6 Support

The TCP/IP support for IPv6 Domain Name Servers updates will support IPv6 domain name system (DNS) servers that have an IPv6 address.

The following changes have been made as a result of this support:

- “UDP Communication Procedures” on page 61
 - “Udp6Open” on page 104 - new
 - “Udp6Send” on page 105 - new
- “VMCF TCPIP Communication CALLCODE Requests” on page 120
 - “V6OPENudp” on page 134 - new
 - “V6SENDudp” on page 135 - new

SC24-6239-04, z/VM Version 6 Release 3 (September 2015)

This edition includes changes to support product changes provided or announced after the general availability of z/VM V6.3.

SC24-6239-03, z/VM Version 6 Release 3

This edition includes changes to support the general availability of z/VM V6.3.

Removal of A220, CLAW, DHCP and LPD Support

The removal of unsupported TCP/IP device drivers and servers is part of an ongoing effort to provide only those TCP/IP services that are required by customers to support their enterprise.

The following appendices have been updated.

- Appendix E, “Related Protocol Specifications,” on page 417
- Appendix F, “Abbreviations and Acronyms,” on page 423

SC24-6239-02, z/VM Version 6 Release 2

This edition includes changes to support the general availability of z/VM V6.2.

IPv6 Support for FTP Server and Client

Provide support for IPv6 in the zVM FTP client and server.

The following changes have been made as a result of this support:

- FTP Server Exit (see Chapter 10, “FTP Server Exit,” on page 367).

IPv6 Support for SMTP Server and Client

Provide support for IPv6 in the zVM SMTP client and server.

The following changes have been made as a result of this support:

- HELO command (see “HELO” on page 330)
- EHLO command (see “EHLO” on page 331)
- “Mail Forwarding Exit Parameter Lists” on page 351.
- “Client Verification Exit Parameter Lists” on page 345.
- “REXX Parameter List” on page 357.

Support Withdrawal

The z/VM Kerberos servers (VMKERB and ADMSERV) have been removed from TCP/IP for z/VM, Level 620. The Kerberos protocol is no longer supported.

SC24-6239-01, z/VM Version 6 Release 1 (Updated Edition)

This edition includes changes to support product changes provided or announced after the general availability of z/VM V6.1.

z/VM SSL Server Enhancements

These enhancements improve the SSL server's ability to provide concurrent secure connectivity by increasing its overall performance and decreasing the amount of system resources it requires.

The following return code ZeroResources has been added to procedure calls:

- TcpSClient
- TcpSServer

The following return code SSLcloseINprogress has been added to procedure calls:

- TcpAbort
- TcpClose
- TcpFSend/TcpSend/TcpWaitSend
- TcpSClient
- TcpSClose
- TcpSServer

SC24-6239-00, z/VM Version 6 Release 1

This edition includes changes or additions to support the general availability of z/VM V6.1.

Chapter 1. z/VM C Socket Application Programming Interface

This chapter describes the z/VM C socket application programming interface (API). z/VM C sockets are C Language functions that closely correspond to the sockets used by UNIX applications that use the Berkeley Software Distribution (BSD) 4.4.

z/VM C sockets are intended as replacements for VM TCP/IP C sockets (formerly documented in this chapter). Although TCP/IP C sockets are still supported for compatibility, the z/VM C socket API is preferred.

This chapter describes how to write, compile, and run applications that use z/VM C sockets. Existing applications that use the VM TCP/IP C sockets library may continue to do so without any modification. To use the z/VM C socket functions, existing TCP/IP C socket applications may need to be recompiled, but no source changes are required. Instructions are provided in this chapter.

Note:

1. To run programs that use z/VM C sockets, you must have Language Environment[®] (supplied with z/VM) installed on your system. Language Environment provides header files and the object code and run-time library for the z/VM C socket functions.

To compile programs that use the z/VM C socket API, you also need the IBM C for VM/ESA (C/VM[™]) Compiler, Version 3 (5654-033) Release 1.

For specific program requirements, see the *z/VM: General Information* manual.

2. This chapter provides a guide to using the z/VM C socket API. For complete reference information on the z/VM C socket functions, see the *XL C/C++ for z/VM: Runtime Library Reference*.

This chapter contains the following sections:

- “TCP/IP Network Communication” on page 2 defines some of the basic networking terms.
- “What is a Socket?” on page 3 provides an overview of socket programming concepts.
- “Client/Server Conversation” on page 9 shows how a client and server use sockets to exchange information.
- “Network Application Example” on page 14 shows how sockets are used in a network application program.
- “z/VM C Socket Implementation” on page 20 explains how z/VM has implemented the support for C sockets. This section also explains the incompatibilities between z/VM C sockets and VM TCP/IP C sockets.
- “Compiling and Linking a Sockets Program” on page 29 describes how to compile and link programs to use the z/VM C sockets library.
- “Running a Sockets Program” on page 33 describes how to run programs that use the z/VM C sockets library.
- “C Sockets Quick Reference” on page 37 lists the z/VM C socket calls.
- “TCP Client Program” on page 39 shows an example of a TCP client program using z/VM C sockets.

- “TCP Server Program” on page 40 shows an example of a TCP server program using z/VM C sockets.
- “UDP Client Program” on page 42 shows an example of a UDP client program using z/VM C sockets.
- “UDP Server Program” on page 43 shows an example of a UDP server program using z/VM C sockets.

TCP/IP Network Communication

Network communication, or “internetworking”, defines a set of protocols that allow application programs to talk with each other without regard to the hardware and operating systems where they are run. Internetworking allows application programs to communicate independently of their physical network connections.

TCP/IP is an internetworking technology and is named after its two main protocols: Transmission Control Protocol (TCP), and Internet Protocol (IP). You should also be familiar with the following basic internetworking terms:

client A process that requests services on the network.

server A process that responds to a request for service from a client.

datagram

A basic unit of information, consisting of one or more data packets, which are passed across an internet at the transport level.

packet The unit or block of a data transaction between a computer and its network. A packet usually contains a network header, at least one high-level protocol header, and data blocks. Generally, the format of data blocks does not affect how packets are handled. Packets are the exchange medium used at the Internetwork layer to send data through the network.

Transport Protocols

There are two general types of transport protocols:

- A **connectionless protocol** treats each datagram as independent from all others. Each datagram must contain all the information required for its delivery. An example of such a protocol is **User Datagram Protocol (UDP)**. UDP is a datagram-level protocol built directly on the IP layer and used for application-to-application programs on a TCP/IP host. UDP does not guarantee data delivery, and is therefore considered unreliable. Application programs that require reliable delivery of streams of data should use TCP.
- A **connection-oriented protocol** requires that hosts establish a logical connection with each other before communication can take place. This connection is sometimes called a “virtual circuit”, although the actual data flow uses a packet-switching network. A connection-oriented exchange includes three phases:
 1. Start the connection.
 2. Transfer data.
 3. End the connection.

An example of such a protocol is **Transmission Control Protocol (TCP)**. TCP provides a reliable vehicle for delivering packets between hosts on an internet. TCP breaks a stream of data into datagrams, sends each one individually using IP, and reassembles the datagrams at the destination node. If any datagrams are lost or damaged during transmission, TCP detects this and re-sends the missing or damaged datagrams. The data stream that is received is therefore a reliable copy of the original.

These types of protocols are illustrated in Figure 2 on page 13, and in Figure 3 on page 14.

What is a Socket?

A **socket** can be thought of as an endpoint in a two-way communication channel. Socket routines create the communication channel, and the channel carries data between application programs either locally or over networks. Each socket open by a process — like any open file in a POSIX process — has a unique (within the process) number associated with it called a “file descriptor”, an integer that designates a socket and allows the application program to refer to it when needed.

Using an electrical analogy, you can think of the communication channel as the electrical wire with its plug and the port, or socket, as the electrical socket or outlet, as shown in Figure 1.

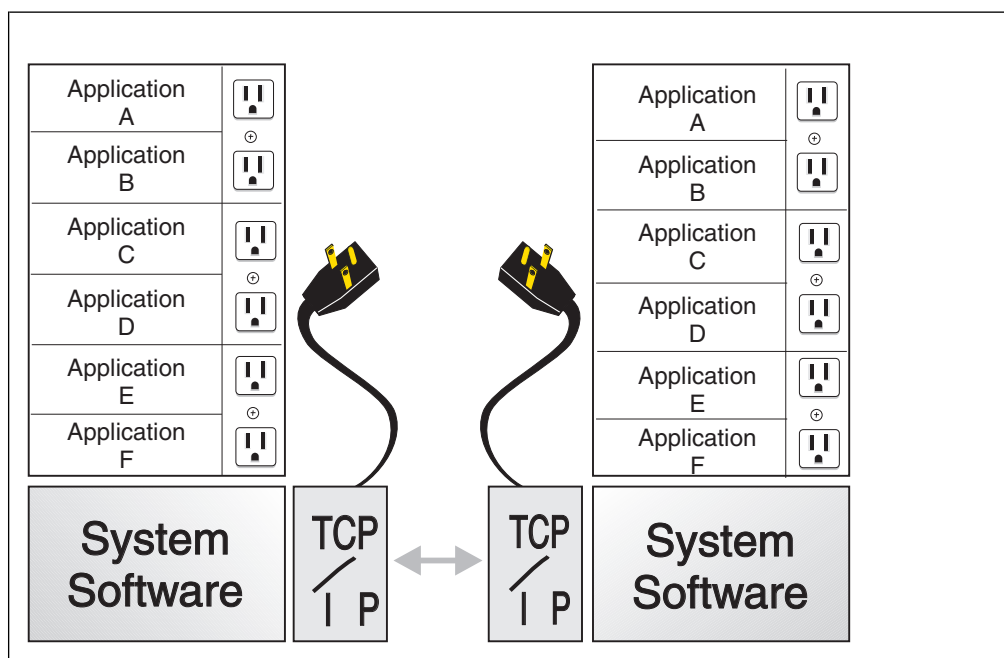


Figure 1. An Electrical Analogy Showing the Socket Concept

Figure 1 shows many application programs running on a client and many application programs on a server. When the client starts a socket call, a socket connection is made between an application on the client and an application on the server.

Another analogy used to describe socket communication is a telephone conversation. Dialing a phone number from your telephone is similar to starting a socket connection. The telephone switching unit knows where to logically make the correct switch to complete the call at the remote location. During your telephone conversation, this connection is present and information is exchanged. After you hang up, the connection is broken and you must start it again. The client uses the `connect()` function call to start the logical switch mechanism to connect to the server.

User processes ask the sockets library to create a socket when one is needed. The sockets library returns an integer, the file descriptor that the application uses every time it wants to refer to that socket.

Sockets perform in many respects like UNIX files or devices, so they can be used with such traditional operations as `read()` or `write()`. For example, after two application programs create sockets and open a connection between them, one program can use `write()` to send a stream of data, and the other can use `read()` to receive it. Because each file or socket has a unique descriptor, the system knows exactly where to send and to receive the data.

Address Families

The z/VM C socket API supports four address families (also called domains):

AF_INET and AF_INET6

`AF_INET` and `AF_INET6` (internet domain) sockets provide a means of communicating between application programs that are on different systems using the TCP and UDP transport protocols provided by a TCP/IP product. These address families support both stream and datagram sockets. TCP/IP for z/VM must be configured for you to be able to use these address families.

AF_IUCV

`AF_IUCV` (VM IUCV) sockets provide communication between processes on a single VM system, or on a group of systems that share IUCV connectivity. VM IUCV sockets allow interprocess communication within VM independent of TCP/IP. The `AF_IUCV` domain supports only stream sockets.

AF_UNIX

`AF_UNIX` sockets (also called local sockets) provide communication between processes on a single VM system, or on a group of systems that share a single Byte File System (BFS) server. UNIX domain sockets allow interprocess communication within VM independent of TCP/IP. On z/VM, the `AF_UNIX` domain supports only stream sockets.

The primary difference between VM IUCV sockets and UNIX sockets is how partners are identified (for example, how they are named).

Socket Types

The z/VM C socket API provides application programs with an interface that hides the details of the physical network. The API supports **stream** sockets, **datagram** sockets, and **raw** sockets, each providing different services for application programs. Stream and datagram sockets interface to the network layer protocols, and raw sockets interface to the network interface layers. You choose the most appropriate interface for an application.

Stream Sockets

The stream sockets interface provides a connection-oriented service. After the partner applications connect, the data sent on stream sockets acts like a stream of information. There are no boundaries between data, so communicating processes must agree on their own mechanism to distinguish information. For example, the process sending information could first send the length of the data, followed by the data itself. The process receiving information reads the length and then loops, reading data until all of it has been transferred. Stream sockets guarantee delivery of the data in the order it was sent and without duplication. The stream socket interface provides a reliable connection-oriented service. Data is sent without errors or duplication and is received in the same order as it is sent. Flow control is built in, to avoid data overruns. No boundaries are imposed on the data; the data is considered to be a stream of bytes.

Stream sockets are the most-commonly used, because the burden of transferring the data reliably is handled by the system rather than by the application.

Datagram Sockets

The datagram socket interface provides a connectionless service. Datagrams are sent as independent packets. The service provides no guarantees; datagrams can be lost, duplicated, and can arrive out of order. The size of a datagram is limited to the size that can be sent in a single transaction.

Raw Sockets

The raw socket interface provides direct access to lower layer protocols, such as the **Internet Protocol (IP)** and **Internet Control Message Protocol (ICMP or ICMPv6)**. You can use raw sockets to test new protocol implementations. You can extend the socket interface; you can define new socket types to provide additional services. Because they isolate you from the communication functions of the different protocol layers, socket interfaces are largely independent of the underlying network. In the AF_INET address family, stream sockets interface to TCP, datagram sockets interface to UDP, and raw sockets interface to ICMP and IP. In the AF_INET6 address family, stream sockets interface to TCP, datagram sockets interface to UDP, and raw sockets interface to ICMPv6 and IP.

Guidelines for Using Socket Types

The following criteria will help you choose the appropriate socket type for an application program.

If you are communicating with an existing application program, you must use the same protocol as the existing application program. For example, if you want to communicate with an application that uses TCP, you must use AF_INET or AF_INET6 stream sockets. For new application programs, you should consider the following factors:

- **Reliability:** Stream sockets provide the most reliable connection. Datagram sockets are unreliable, because datagrams can be discarded, corrupted, or duplicated during transmission. This may be acceptable if the application program does not require reliability, or if the application program implements the reliability on top of the sockets interface. The trade-off is the improved performance available with datagram sockets.
- **Performance:** The overhead associated with reliability, flow control, packet reassembly, and connection maintenance degrade the performance of stream sockets in comparison with datagram sockets.
- **Data transfer:** Datagram sockets impose a limit on the amount of data transferred in a single transaction. If you send less than 2048 bytes at a time, use datagram sockets. As the amount of data in a single transaction increases, use stream sockets.

If you are writing a new protocol on top of IP, or wish to use the ICMP protocol, then you must use raw sockets.

Domain-specific Socket Addresses

The following sections describe the different ways to address processes who communicate with each other using sockets.

Address Families

Each address family defines a different style of addressing. All hosts in the same address family use the same scheme for addressing socket endpoints. The AF_INET and AF_INET6 address families identify processes by IP address and

port number. The AF_UNIX address family identifies processes by file name in the Byte File System. The AF_IUCV address family identifies processes by VM user ID and application name.

Socket Address

A socket address is defined by the *sockaddr* structure in the `sys/socket.h` header file. The structure has three fields, as shown in the following example:

```
struct sockaddr {
    unsigned char sa_len;
    unsigned char sa_family;
    char          sa_data[14];    /* variable length data */
};
```

The *sa_len* field contains the length of the entire *sockaddr* structure, in bytes. The *sa_family* field contains a value identifying the address family. It is AF_INET or AF_INET6 for the internet domain, AF_UNIX for the UNIX domain, and AF_IUCV for the IUCV domain. The *sa_data* field is different for each address family. Each address family defines its own structure, which can be overlaid on the *sockaddr* structure. See “Addressing within the AF_INET and AF_INET6 Domains,” “Addressing within the AF_UNIX Domain” on page 8, and “Addressing within the AF_IUCV Domain” on page 9.

Addressing within the AF_INET and AF_INET6 Domains

Before discussing the contents of the AF_INET and AF_INET6 *sockaddr* structures, the following terms must be introduced:

Internet Addresses: Internet addresses represent a network interface. Every internet address within an administered domain is unique. On the other hand, it is not necessary that every host have a single internet address; in fact, a host has as many internet addresses as it has network interfaces.

Internet addresses can be in one of two formats: IPv4 (IP version 4) or IPv6 (IP version 6). Hosts can support either addressing format or both. IPv4 internet addresses are 32-bit quantities. The AF_INET address family communicates through IPv4 addresses. IPv6 internet addresses are 128-bit quantities. The AF_INET6 address family communicates through IPv6 addresses.

Ports: A port distinguishes between different application programs using the same AF_INET network interface. It is an additional qualifier used by the system software to get data to the correct application program. Physically, a port is a 16-bit integer. Some ports are reserved for particular application programs or protocols and are called **well-known ports**.

Network byte order and host byte order: Ports and addresses are always specified in calls to the socket functions using the network byte order convention. This convention is a method of sorting bytes that is independent of specific machine architectures. Host byte order, on the other hand, sorts bytes in the manner which is most natural to the host software and hardware. There are two common host byte order methods:

- **Little-endian** byte ordering places the least significant byte first. This method is used in Intel microprocessors, for example.
- **Big-endian** byte ordering places the most significant byte first. This method is used in IBM z/Architecture[®] and S/390[®] mainframes and Motorola microprocessors, for example.

The network byte order is defined to always be big-endian, which may differ from the host byte order on a particular machine. Using network byte ordering for data exchanged between hosts allows hosts using different architectures to exchange address information without confusion because of byte ordering. The following C functions allow the application program to switch numbers easily back and forth between the host byte order and network byte order without having to first know what method is used for the host byte order:

- `htonl()` translates an unsigned long integer into network byte order.
- `htons()` translates an unsigned short integer into network byte order.
- `ntohl()` translates an unsigned long integer into host byte order.
- `ntohs()` translates an unsigned short integer into host byte order.

See Figure 5 on page 15, Figure 7 on page 16, and Figure 8 on page 16 for examples of using the `htons()` call to put port numbers into network byte order.

The C functions `inet_ntop()` and `inet_pton()` are used to manipulate IPv6 addresses. For more information on these functions, see *XL C/C++ for z/VM: Runtime Library Reference*.

AF_INET addresses: A socket address in the AF_INET address family is defined by the `sockaddr_in` structure, which is defined in the `netinet/in.h` header file:

```
typedef unsigned long in_addr_t;
struct in_addr {
    in_addr_t s_addr;
};
struct sockaddr_in {
    unsigned char sin_len; /* length of sockaddr struct */
    unsigned char sin_family; /* addressing family */
    unsigned short sin_port; /* port number */
    struct in_addr sin_addr; /* IP address */
    unsigned char sin_zero[8]; /* unassigned */
};
```

The `sin_len` field is set to either 0 or `sizeof(struct sockaddr_in)` when providing a `sockaddr_in` structure to the sockets library. Both values are treated the same. When the sockets library provides a `sockaddr_in` structure to the application, the `sin_len` field is set to `sizeof(struct sockaddr_in)`.

The `sin_family` field is set to AF_INET.

The `sin_port` field is set to the port to which the process is bound, in network byte order.

The `sin_addr` field is set to the internet address (IP address) of the interface to which the process is bound, in network byte order.

The `sin_zero` field is not used and must be set to all zeros.

AF_INET6 addresses: If the socket descriptor `socket` was created in the AF_INET6 domain, the format of the name buffer is expected to be `sockaddr_in6`, as defined in the `netinet/in.h`:

```
struct sockaddr_in6 {
    uint8_t sin6_len; /* length of sockaddr structure */
    sa_family_t sin6_family; /* addressing family */
    in_port_t sin6_port; /* port number */
};
```

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```
    uint32_t      sin6_flowinfo; /* ignored */
    struct in6_addr sin6_addr;    /* IP address */
    uint32_t      sin6_scope_id; /* scope ID */
};
```

The *sin6_len* field must be set to either 0 or `sizeof(struct sockaddr_in6)`. Both values are treated the same.

The *sin6_family* must be set to `AF_INET6`.

The *sin6_port* field is set to the port to which the socket is bound. It must be specified in network byte order.

The *sin6_flowinfo* field is currently unsupported so its contents are ignored.

The *sin6_addr.s6_addr* field is set to the internet address of the interface to which the socket is bound. It must be specified in network byte order.

The *sin6_scope_id* field identifies a set of interfaces as appropriate for the scope of the address carried in the *sin6_addr* field. For link local addresses, the *sin6_scope_id* can be used to specify the outgoing interface index. The z/VM stack supports *sin6_scope_id* for link local addresses only

Addressing within the AF_UNIX Domain

A socket address in the `AF_UNIX` address family is defined by the *sockaddr_un* structure, which is defined in the `sys/un.h` header file:

```
struct sockaddr_un {
    unsigned char sun_len; /* length of sockaddr struct */
    unsigned char sun_family; /* addressing family */
    char sun_path[108]; /* file name */
};
```

When the application provides a *sockaddr_un* structure to the sockets library, the *sun_len* field should be set to either 0 or a value greater than or equal to `SUN_LEN(&sa)`, where *sa* is the name of the *sockaddr_un* variable, but less than or equal to `sizeof(struct sockaddr_un)`. The `SUN_LEN()` macro, which is defined in `sys/un.h`, evaluates to an expression which returns the total length of the used portion of the *sockaddr_un* structure, when *sun_path* has been filled in with a null-terminated file name. The length returned by `SUN_LEN()` does not include the terminating null character. If a 0 is specified for *sun_len*, the *sockaddr* length provided on the specific socket function call determines how long the path name is. If *sun_len* is nonzero, the lesser of *sun_len* and the provided length is used. In either case, if a null character appears in the string before the given length, the path name is considered to end there. When the sockets library provides a *sockaddr_un* structure to the application, the *sun_len* field is set to `SUN_LEN(&sa)+1`, where *sa* is the name of the *sockaddr_un* variable. This length thus includes the null byte which terminates the file name.

The *sun_family* field is set to `AF_UNIX`.

The *sun_path* field contains the name of the file which represents the open socket. It need not be null delimited, although it is recommended that it is, so that the `SUN_LEN()` macro can be used. A file by this name will be created in the Byte File System by the `bind()` function call, and must exist there for the `connect()` function call to succeed. Because the Byte File System contains the file, the form of the path name should follow the POSIX conventions. Generally, an absolute path name (one that begins with a slash) should be specified, so that the client and the server can

both use the same path name to identify the file. If an AF_UNIX socket is not yet bound when a client calls the connect() function, it will be bound to the null path name string (for example, the string ""). In this case, no file is created in the Byte File System.

For more information about the Byte File System, see the *z/VM: OpenExtensions User's Guide*.

Addressing within the AF_IUCV Domain

A socket address in the AF_IUCV address family is defined by the *sockaddr_iucv* structure, which is defined in the *saiucv.h* header file:

```
struct sockaddr_iucv {
    unsigned char  siucv_len;          /* length of sockaddr struct */
    unsigned char  siucv_family;      /* addressing family */
    unsigned short siucv_port;        /* port number */
    unsigned long  siucv_addr;        /* address */
    unsigned char  siucv_nodeid[8];   /* nodeid to connect to */
    unsigned char  siucv_userid[8];   /* userid to connect to */
    unsigned char  siucv_name[8];     /* iucvname for connect */
};
```

The *siucv_len* field is set to either 0 or sizeof(struct sockaddr_iucv) when providing a *sockaddr_iucv* structure to the sockets library. Both values are treated the same. When the sockets library provides a *sockaddr_iucv* structure to the application, the *siucv_len* field is set to sizeof(struct sockaddr_iucv).

The *siucv_family* field is set to AF_IUCV.

The *siucv_port*, *siucv_addr*, and *siucv_nodeid* fields are reserved for future use. The *siucv_port* and *siucv_addr* fields must be zeroed. The *siucv_nodeid* field must be set to exactly eight blank characters.

The *siucv_userid* field is set to the VM user ID of the application which owns the address. This field must be eight characters long, padded with blanks on the right. It cannot contain the null character.

The *siucv_name* field is set to the application name by which the socket is known. A server advertises a particular application name, and this is the name used by the client to connect to the server. The recommended form of the name contains eight characters, padded with blanks to the right.

For more information about IUCV, see the *z/VM: CMS Application Development Guide for Assembler*.

Client/Server Conversation

The client and server exchange data using a number of socket functions. They can send data using send(), sendto(), sendmsg(), write(), or writev(). They can receive data using recv(), recvfrom(), recvmsg(), read(), or readv(). The following is an example of the send() and recv() calls:

```
send(s, addr_of_data, len_of_data, 0);
recv(s, addr_of_buffer, len_of_buffer, 0);
```

The send() and recv() functions specify the socket *s* on which to communicate, the address in memory of the buffer that contains, or will contain, the data (*addr_of_data*, *addr_of_buffer*), the size of this buffer (*len_of_data*, *len_of_buffer*), and a flag that tells how the data is to be sent. Using the flag 0 tells TCP/IP to transfer

the data normally. The server uses the socket that is returned from the `accept()` call. The client uses the socket that is returned from the `socket()` call.

These functions return the amount of data that was either sent or received. Because stream sockets send and receive information in streams of data, it can take more than one call to `send()` or `recv()` to transfer all the data. It is up to the client and server to agree on some mechanism of signaling that all the data has been transferred.

When the conversation is over, both the client and server call the `close()` function to end the connection. The `close()` function deallocates the socket, freeing its space in the table of connections. To end a connection with a specific client, the server closes the socket returned by `accept()`. If the server closes its original socket, the “listening” socket, it can no longer accept new connections, but it can still converse with the clients it is connected to. The following is an example of the `close()` call:

```
close(s);
```

Server Perspective for AF_INET

Before the server can accept any connections with clients, it must register itself with TCP/IP and “listen” for client requests on a specific port.

socket()

The server must first allocate a socket. This socket provides an endpoint that clients connect to.

Opened sockets are identified by file descriptors, like any open files in a POSIX environment. The programmer calls the `socket()` function to allocate a new socket, as shown in the following example:

```
socket(AF_INET, SOCK_STREAM, 0);
```

The `socket()` function requires the address family (`AF_INET`), the type of socket (`SOCK_STREAM`), and the particular networking protocol to use (when `0` is specified, the system automatically uses the appropriate protocol for the specified socket type). A new socket is allocated and its file descriptor is returned.

bind()

At this point, an entry in the table of communications has been reserved for your application program. However, the socket has no port or IP address associated with it until you use the `bind()` function, which requires three parameters:

- The socket the server was just given
- The number of the port on which the server wishes to provide its service
- The IP address of the network connection on which the server is listening (to understand what is meant by “listening”, see “listen()”).

The server puts the port number and IP address into a `sockaddr_in` structure, passing it and the socket file descriptor to the `bind()` function. For example:

```
struct sockaddr_in sa;  
:  
:  
bind(s, (struct sockaddr *) &sa, sizeof sa);
```

listen()

After the `bind`, the server has specified a particular IP address and port. Now it must notify the system that it intends to listen for connections on this socket. The

listen() function puts the socket into passive open mode and allocates a backlog queue of pending connections. In passive open mode, the socket is open for clients to contact. For example:

```
listen(s, backlog_number);
```

The server gives the file descriptor of the socket on which it will be listening and the number of requests that can be queued (the *backlog_number*). If a connection request arrives before the server can process it, the request is queued until the server is ready.

The SOMAXCONN statement in the TCP/IP configuration file (PROFILE TCPIP) determines the maximum length that *backlog_number* can be. For more information on the SOMAXCONN statement, see *z/VM: TCP/IP Planning and Customization*.

accept()

Up to this point, the server has allocated a socket, bound the socket to an IP address and port, and issued a passive open. The next step is for the server to actually establish a connection with a client. The accept() call blocks the server until a connection request arrives, or, if there are connection requests in the backlog queue, until a connection is established with the first client in the queue. The following is an example of the accept() call:

```
struct sockaddr_in sa;
int addrlen;
:
:
client_sock = accept(s, (struct sockaddr *) &sa, &addrlen);
```

The server passes the file descriptor of its socket to the accept() call. When the connection is established, the accept() call creates a new socket representing the connection with the client, and returns its file descriptor. When the server wishes to communicate with the client or end the connection, it uses the file descriptor of this new socket, *client_sock*. The original socket *s* is now ready to accept connections with other clients. The original socket is still allocated, bound, and opened passively. To accept another connection, the server calls accept() again. By repeatedly calling accept(), the server can establish many connections simultaneously.

select()

The server is now ready to start handling requests on this port from any client with the server's IP address and port number. If the server handles just one client at a time, it can just start sending or receiving data. A server is not limited to one active socket, though. Often a server processes requests from several clients at the same time, and additionally listens for new clients wanting to establish connections. For maximum performance, such a server should either create a new thread to handle each client request, or set all of its sockets to “nonblocking” mode, so that a delay in handling one client request does not affect other client requests. Using nonblocking mode allows a single-threaded server to operate only on those sockets that are ready for communication. The select() call allows an application program to test for activity on a group of sockets.

Note: The select() function can also be used with other descriptors, such as file descriptors, pipes, or character special files such as the tty.

To allow you to test any number of sockets with just a single call to select(), place the file descriptors of the sockets to test into a “bit set”, passing the bit set to the select() call. A bit set is a string of bits where each possible member of the set is on or off. If the member's bit is off, the member is not in the set. If the member's bit is

on, the member is in the set. If the socket with file descriptor 3 is a member of a bit set, then the bit that represents it is on.

The following macros are provided to manipulate the bit sets:

Macro	Description
-------	-------------

FD_ZERO	
----------------	--

	Clears the whole bit set
--	--------------------------

FD_SET	
---------------	--

	Sets the bit corresponding to a particular file descriptor
--	------------------------------------------------------------

FD_CLR	
---------------	--

	Clears the bit corresponding to a particular file descriptor
--	--------------------------------------------------------------

FD_ISSET	
-----------------	--

	Tests whether the bit corresponding to a particular file descriptor is set or cleared
--	---------------------------------------------------------------------------------------

To be active, a socket must be ready for reading data or for writing data, or an exceptional condition must have occurred. Therefore, the server specifies three bit sets of file descriptors in its call to the `select()` function: one bit set for file descriptors on which to receive data, another for file descriptors on which to write data, and one for sockets with exception conditions. The `select()` call tests each file descriptor in each bit set for activity and returns only those file descriptors that are active.

A server that processes many clients simultaneously can be written so that it processes only those clients that are ready for activity.

Client Perspective for AF_INET

The client first issues the `socket()` function call to allocate a socket on which to communicate:

```
socket(AF_INET, SOCK_STREAM, 0);
```

To connect to the server, the client places the port number and the IP address of the server into a `sockaddr_in` structure, like the one used by the server of its `bind()` call. If the client does not know the server's IP address, but does know the server's host name, the `gethostbyname()` function may be called to translate the host name into its IP address. The client then calls `connect()`:

```
struct sockaddr_in sa;  
:  
:  
connect(s, (struct sockaddr_in *) &sa, sizeof sa);
```

When the connection is established, the client uses its socket to communicate with the server.

Typical TCP Socket Session

You can use TCP sockets for both passive (server) and active (client) processes. Whereas some functions are necessary for both types, some are role-specific. After you make a connection, it exists until you close the socket. During the connection, data is either delivered or an error code is returned by TCP/IP.

See Figure 2 on page 13 for the general sequence of calls to be followed for most socket routines using TCP, or stream sockets.

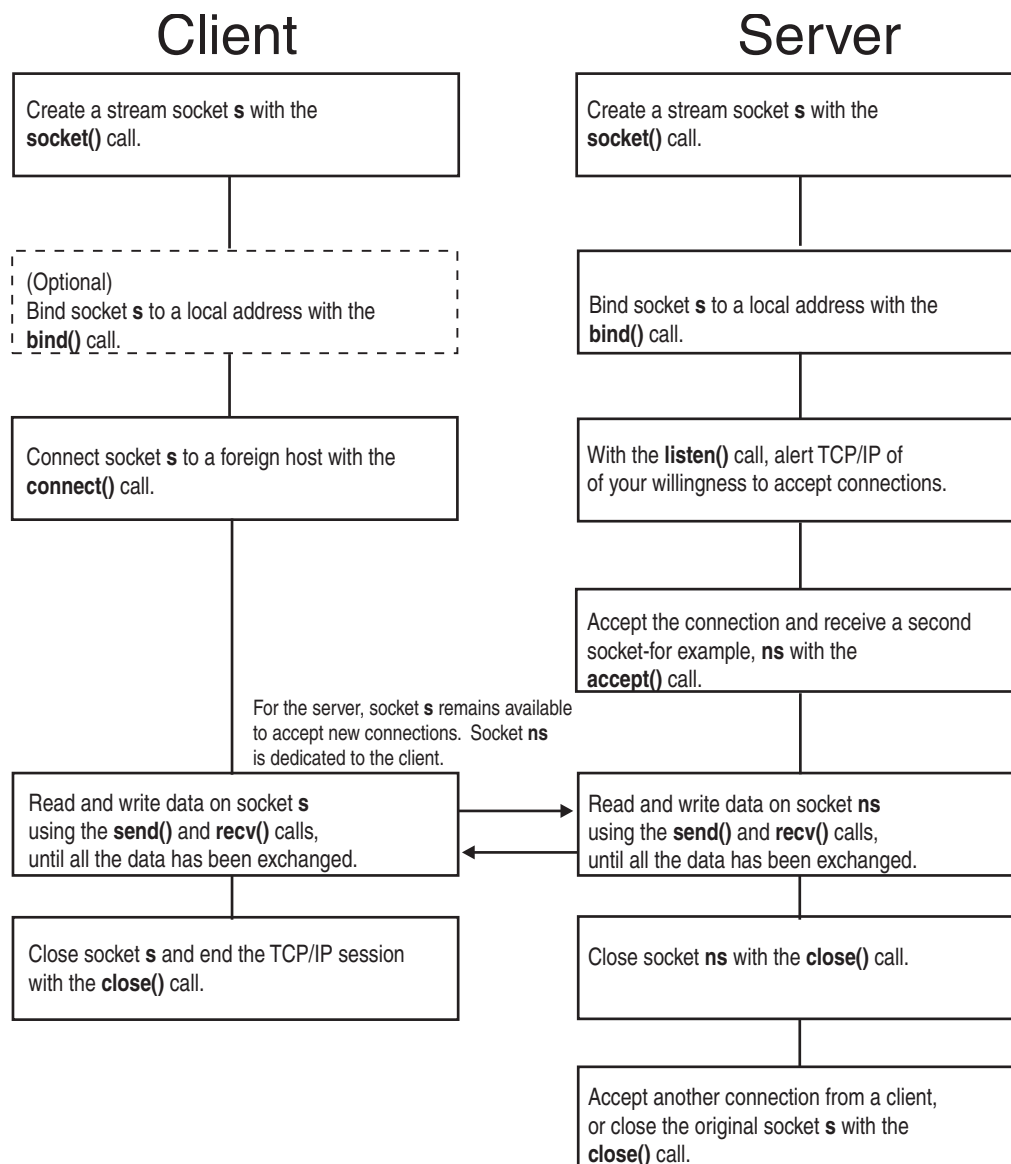


Figure 2. A Typical Stream Socket Session

Typical UDP Socket Session

UDP socket processes, unlike TCP socket processes, are not clearly distinguished by server and client roles. The distinction is between connected and unconnected sockets. An unconnected socket can be used to communicate with any host; but a connected socket, because it has a dedicated destination, can send data to, and receive data from, only one host.

Both connected and unconnected sockets send their data over the network without verification. Consequently, after a packet has been accepted by the UDP interface, the arrival and integrity of the packet cannot be guaranteed.

See Figure 3 on page 14 for the general sequence of calls to be followed for most socket routines using UDP, or datagram, sockets.

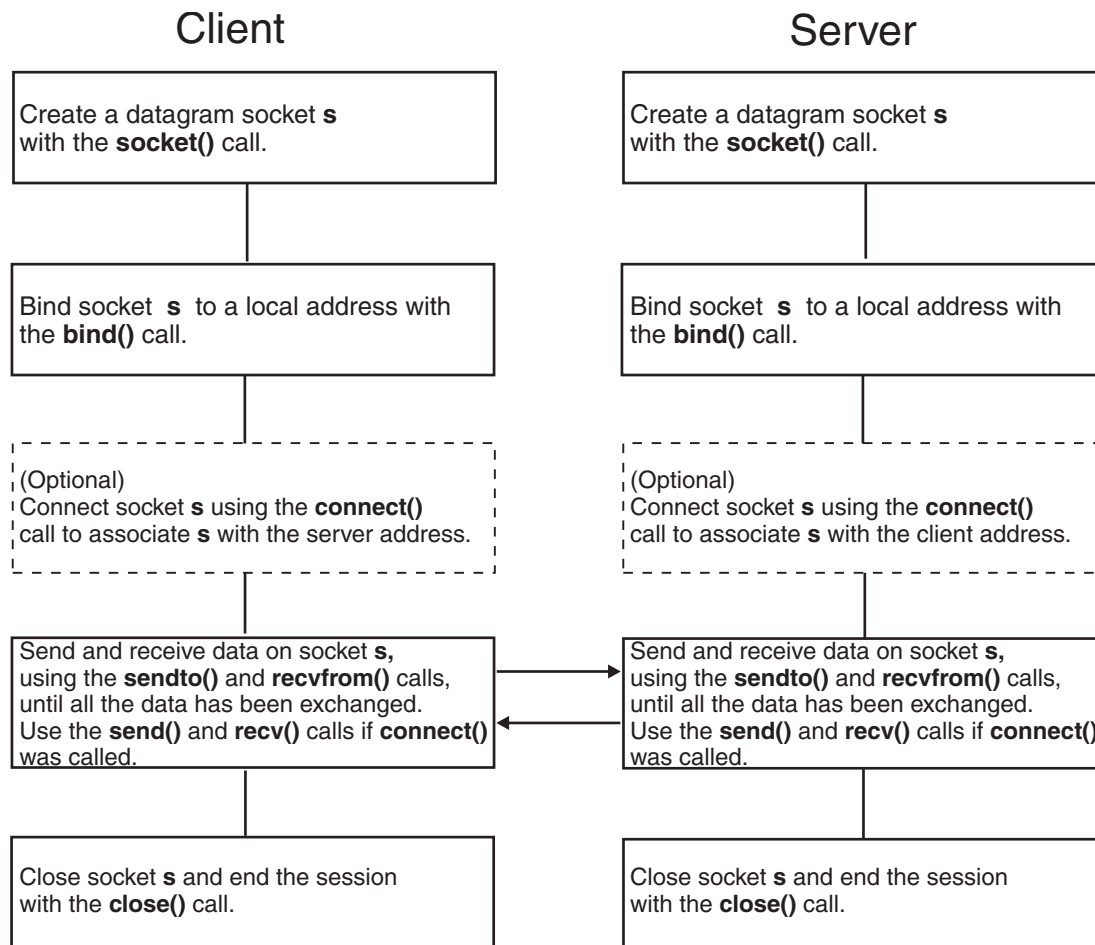


Figure 3. A Typical Datagram Socket Session

Locating the Server's Port

In the client/server model, the server provides a resource by listening for clients on a particular port. Such application programs as FTP, SMTP, and Telnet listen on a **well-known port**, a port reserved for use by a specific application program or protocol. However, for your own client/server application programs, you need a method of assigning port numbers to represent the services you intend to provide. One general method of defining services and their ports is to enter them into the ETC SERVICES file. The programmer uses the getservbyname() function to determine the port for a particular service. If the port number for a particular service changes, only the ETC SERVICES file must be modified.

Note: TCP/IP for z/VM is shipped with an ETC SERVICES file containing such well-known services as FTP, SMTP, and Telnet.

Network Application Example

The following steps illustrates using socket functions in an AF_INET network application program.

Note: Error checking has been omitted from the examples. Error checking is very important, and has been omitted only to avoid complicating the examples.

1. First, an application program must open a socket using the `socket()` call, as shown in Figure 4.

```
int s;
:
:
s = socket(AF_INET, SOCK_STREAM, 0);
```

Figure 4. An Application Using `socket()`

This example allocates a socket `s` in the `AF_INET` address family, with socket type `SOCK_STREAM` and protocol `0`. Passing `0` for the protocol chooses the default, which for the `AF_INET` domain and `SOCK_STREAM` type is `IPPROTO_TCP`. The supported values for the socket domain, type, and protocol are defined in the `netinet/in.h` header file.

If successful, the `socket()` call returns a positive integer called a file descriptor that is used in subsequent function calls to identify the socket.

2. After an application program creates a socket, it can explicitly bind a unique address to the socket, as shown in Figure 5.

```
int rc;
int s;
struct sockaddr_in myname;

/* Clear the structure to be sure that the sin_len and */
/* sin_zero fields are clear */
memset(&myname, 0, sizeof myname);
myname.sin_family = AF_INET;
myname.sin_addr.s_addr = INADDR_ANY; /* any interface */
myname.sin_port = htons(5001);
:
:
rc = bind(s, (struct sockaddr *) &myname, sizeof myname);
```

Figure 5. An Application Using `bind()`

This example binds the socket with file descriptor `s` to port 5001, allowing it to accept connections from any interface available to the host in the internet domain. Servers must bind to an address and port to become accessible to the network. Also shown in this example is a handy utility routine called `htons()`, which takes a short integer (like a port number) in host byte order and returns it in network byte order.

3. After binding to a socket, a server that uses stream sockets must indicate its readiness to accept connections from clients. The server does this with the `listen()` call, as shown in Figure 6.

```
int s;
int rc;
:
:
rc = listen(s, 5);
```

Figure 6. An Application Using `listen()`

This example tells TCP/IP that the server is ready to begin accepting connections, and that a maximum of five connection requests can be queued for the server. Additional requests are ignored.

4. Clients using stream sockets begin a connection request by calling `connect()`, as shown in Figure 7.

```
int s;
struct sockaddr_in servername;
int rc;
:
:
memset(&servername, 0, sizeof servername);
servername.sin_family = AF_INET;
servername.sin_addr.s_addr = inet_addr("129.5.24.1");
servername.sin_port = htons(5001);
:
:
rc = connect(s, (struct sockaddr *) &servername, sizeof servername);
```

Figure 7. An Application Using `connect()`

This example attempts to connect the socket with file descriptor `s` to the server with an address specified in the `servername` variable. This could be the server that was used in Figure 5 on page 15. After a successful return, the socket with file descriptor `s` is associated with the connection to the server. This example also uses another handy utility routine, `inet_addr()`, which takes an internet address in dotted-decimal form and returns it as a long integer in network byte order.

Figure 8 shows another example of the `connect()` call. It uses the utility routine `gethostbyname()` to find the internet address of the host rather than using `inet_addr()` with a specific address.

```
int rc;
int s;
char *hostname = "jphost.ibm.com";
struct sockaddr_in servername;
struct hostent *hp;

hp = gethostbyname(hostname);
:
:

/* Clear the structure to be sure that the sin_len and */
/* sin_zero fields are clear.                               */
memset(&servername, 0, sizeof servername);
servername.sin_family = AF_INET;
servername.sin_addr.s_addr = *(in_addr_t *) hp->h_addr;
servername.sin_port = htons(5001);
:
:
rc = connect(s, (struct sockaddr *) &servername, sizeof servername);
```

Figure 8. A `connect()` Function Using `gethostbyname()`

5. Servers using stream sockets accept a connection request with the `accept()` call, as shown in Figure 9 on page 17.

```

int clientsocket;
int s;
struct sockaddr_in clientaddress;
int addrlen;
:
:
addrlen = sizeof clientaddress;
clientsocket = accept(s, (struct sockaddr *) &clientaddress, &addrlen);

```

Figure 9. An Application Using `accept()`

If connection requests are not pending on the socket with file descriptor `s`, the `accept()` call blocks the server (unless `s` is in nonblocking mode). When a connection request is accepted, the socket, the name of the client, and length of the client name are returned, along with a file descriptor representing a new socket. The new socket is associated with the client that began the connection, and `s` is again available to accept new connections.

6. Clients and servers have many calls from which to choose for data transfer. The `send()` and `recv()`, `readv()` and `writew()`, and `read()` and `write()` calls can be used only on sockets that are in the connected state. The `sendto()` and `recvfrom()`, and `sendmsg()` and `recvmsg()` calls can be used at any time on datagram sockets. Figure 10 illustrates the use of `send()` and `recv()`.

```

int bytes_sent;
int bytes_received;
char data_sent[256];
char data_received[256];
int s;
:
:
bytes_sent = send(s, data_sent, sizeof data_sent, 0);
:
:
bytes_received = recv(s, data_received, sizeof data_received, 0);

```

Figure 10. An Application Using `send()` and `recv()`

This example shows an application program sending data on a connected socket and receiving data in response. The flags field can be used to specify additional options to `send()` or `recv()`, such as sending out-of-band data. (In this case no flags are being used, so 0 is passed.)

7. If the socket is not in a connected state, additional address information must be passed to `sendto()` and can be optionally returned from `recvfrom()`. An example is shown in Figure 11 on page 18.

```
int bytes_sent;
int bytes_received;
char data_sent[256];
char data_received[256];
struct sockaddr_in to;
struct sockaddr_in from;
int addrlen;
int s;
:
:
memset(&to, 0, sizeof to);
to.sin_family = AF_INET;
to.sin_addr.s_addr = inet_addr("129.5.24.1");
to.sin_port = htons(5001);
bytes_sent = sendto(s, data_sent, sizeof data_sent, 0,
                   (struct sockaddr *) &to, sizeof to);
:
:
addrlen = sizeof from; /* must be initialized */
bytes_received = recvfrom(s, data_received,
                          sizeof data_received, 0, (struct sockaddr *) &from, &addrlen);
```

Figure 11. An Application Using `sendto()` and `recvfrom()`

The `sendto()`, `recvfrom()`, `sendmsg()`, and `recvmsg()` calls take additional parameters that allow the caller to specify the recipient of the data or to be notified of the sender of the data. Usually, `sendto()`, `recvfrom()`, `sendmsg()`, and `recvmsg()` are used for datagram sockets, and `send()` and `recv()` are used for stream sockets.

8. The `writv()`, `readv()`, `sendmsg()`, and `recvmsg()` calls provide the additional features of “scatter” and “gather” buffers, two related operations where data is received and stored in multiple buffers (scatter data), and then taken from multiple buffers and transmitted (gather data). The `writv()` and `sendmsg()` calls gather the data and send it. The `readv()` and `recvmsg()` calls receive data and scatter it into multiple buffers.
9. Applications can handle multiple file descriptors. In such situations, use the `select()` call to determine the file descriptors that have data to be read, those that are ready for data to be written, and those that have pending exceptional conditions. Figure 12 on page 19 is an example of how the `select()` call is used.

```

fd_set readsocks;
fd_set writesocks;
fd_set exceptsocks;
struct timeval timeout;
int number_found;
:
:
/* set bits in read, write, and except bit masks */
FD_ZERO(&readsocks);
FD_ZERO(&writesocks);
FD_ZERO(&exceptsocks);

FD_SET(s, &readsocks);
FD_SET(s, &writesocks);
FD_SET(s, &exceptsocks);

timeout.tv_sec=5;      /* Wait up to 5 seconds for activity */
timeout.tv_usec=0;    /* No additional microseconds */

/* First argument is number of bits in masks to check */
number_found = select(s+1,
                    &readsocks, &writesocks, &exceptsocks, &timeout);

```

Figure 12. An Application Using `select()`

In this example, the application program uses bit sets to indicate that the sockets are being tested for certain conditions and also indicates a timeout. If the timeout parameter is a null pointer, the `select()` call blocks until a socket becomes ready. If the timeout parameter is nonnull, `select()` waits up to this amount of time for at least one socket to become ready on the indicated conditions. This is useful for application programs servicing multiple connections that cannot afford to block, waiting for data on one connection.

10. In addition to `select()`, application programs can use the `fcntl()` or `ioctl()` calls to help perform asynchronous (nonblocking) socket operations. An example of the use of the `ioctl()` call is shown in Figure 13.

```

int s;
int dontblock;
char buf[256];
int rc;
:
:
dontblock = 1;
:
:
rc = ioctl(s, FIONBIO, &dontblock);
:
:
if (recv(s, buf, sizeof buf, 0) == -1 && errno == EWOULDBLOCK)
    /* no data available */
else
    /* either got data or some other error occurred */

```

Figure 13. An Application Using `ioctl()`

In this example, the socket with file descriptor `s` is placed into nonblocking mode. When this file descriptor is passed as a parameter to calls that would block, such as `recv()` when data is not present, it causes the call to return with an error code, and the global `errno` value is set to `EWOULDBLOCK` or `EAGAIN`. Setting the mode of the socket to be nonblocking allows an application program to continue processing without becoming blocked.

11. A socket with file descriptor *s* is deallocated with the `close()` call, as shown in Figure 14.

```
int rc;  
int s;  
rc = close(s);
```

Figure 14. An Application Using `close()`

z/VM C Socket Implementation

The following sections describe some important implementation details of the z/VM C socket API.

Header Files

Most of the socket header files used by the z/VM C sockets library are shipped with Language Environment. The only header file that is unique to the z/VM library is `saiucv.h`, which contains the `sockaddr` structure definition for AF_IUCV sockets.

`_OE_SOCKETS` Preprocessor Symbol

In general, the Language Environment header files are sensitive to whether the `_OE_SOCKETS` preprocessor symbol has been defined. In order to use the Language Environment header files for sockets programming, you must define the `_OE_SOCKETS` preprocessor symbol before you include any Language Environment header files. You can do this in your program by placing a statement similar to the following at the top of each source file:

```
#define _OE_SOCKETS
```

Alternatively, you can cause the `_OE_SOCKETS` preprocessor symbol to be defined by the compiler, by using the `-D` option on the `c89` command line. See “Compiling and Linking a Sockets Program” on page 29 for more information on compiling sockets programs.

For IPv6 sockets programming (AF_INET6 sockets), the symbol `_OPEN_SYS SOCK_IPV6` must also be defined.

Function Prototypes

Although they contain function prototypes for all of the POSIX.1 functions, the Language Environment header files do not contain prototypes for all of the socket functions. Specifically, when `_OE_SOCKETS` is defined, the following socket functions are available, but have no prototypes provided:

Header File

Functions

`sys/socket.h`

`accept()`, `bind()`, `connect()`, `getpeername()`, `getsockname()`, `getsockopt()`,
`listen()`, `recv()`, `recvfrom()`, `recvmsg()`, `send()`, `sendmsg()`, `sendto()`,
`setsockopt()`, `shutdown()`, `socket()`

`netdb.h`

`endhostent()`, `endnetent()`, `endprotoent()`, `endservent()`, `sethostent()`,
`setnetent()`, `setprotoent()`, `setservent()`

`arpa/inet.h`

`inet_lnaof()`, `inet_netof()`

sys/uio.h

readv(), writev()

Because the socket functions were designed to be useful for any networking interface, the types of the parameters declared for the functions do not always exactly match the types of the arguments provided. In one sense, therefore, it is convenient that prototypes are not always provided, as it reduces the number of possible compiler warning messages because of type mismatches. On the other hand, socket programs may contain subtle bugs because of misunderstandings about the type definitions of the function parameters, so care should be taken when coding a function call. One way to ensure care is to use prototypes and to explicitly cast function arguments when necessary (and only when necessary). For example, the `connect()` function call accepts a pointer to a `sockaddr` structure, but the `sockaddr` structure is a generic structure not associated with any particular address family. A program using `AF_INET` sockets might provide a pointer to a `sockaddr_in` structure for this `connect()` parameter. Because these two pointer types are not compatible, an explicit cast should be used on the function call to convert the `sockaddr_in` pointer into a generic `sockaddr` pointer.

Suppressing Function Prototypes

If you are porting a large program that you know is coded correctly, you may at first receive a lot of type-mismatch compiler errors if the program is not coded to explicitly cast function arguments to their proper types. This is common when porting code from other systems, because not all systems provide function prototypes for the socket functions. To avoid correcting the function calls to perform the explicit cast operations, you can define the `_NO_PROTO` preprocessor symbol before including any header files. If the `_NO_PROTO` preprocessor symbol is defined before including any Language Environment or z/VM header file, function prototypes will be suppressed, or at least modified to omit type declarations for the function arguments. Use of this preprocessor symbol will avoid the compiler warning messages and make porting easier, but be aware that it may also obscure coding errors in the program.

If you wish to define the `_NO_PROTO` preprocessor symbol, you can do so by placing a statement similar to the following at the top of each source file of your program:

```
#define _NO_PROTO
```

Alternatively, you can cause the `_NO_PROTO` preprocessor symbol to be defined by the compiler, by using the `-D` option on the `c89` command line. See “Compiling and Linking a Sockets Program” on page 29 for more information on compiling sockets programs.

Multithreading

The z/VM C sockets library is a multithreading sockets library. This means that you can write programs to exploit the z/VM multithreading capabilities provided for POSIX programs, and still use socket functions without worrying about socket calls by one thread interfering with calls by another thread, or about the entire process being blocked just because one thread is blocked.

The z/VM C sockets library protects its internal data structures with mutexes, and uses thread-local data areas, where necessary, to ensure that socket calls by different threads can occur “concurrently”. The z/VM C sockets library is careful

to never hold one of these internal mutexes when it might block for a substantial period of time, so multiple threads can use socket functions with as much concurrency as possible.

Some function calls in the z/VM C sockets library are not “primitive” socket function calls, however. For example, the `gethostbyname()` function call is really a procedure which tries to resolve a host name by reading data from local files and by communicating with Domain Name Servers in the network.

Multithreading versus Nonblocking Sockets

In a single-threaded program, a server that wants to handle concurrent requests from multiple clients usually sets all of its sockets to nonblocking mode, so that if a socket call on behalf of one client can not be processed immediately, other client requests are not delayed. In a multithreaded server, another approach is available. Instead of setting the sockets to be nonblocking, the server can create a separate thread to handle each client request. If a call to a socket function by one thread blocks, only that client request is affected; other threads are free to continue processing requests from other clients. Using multiple threads can therefore simplify the programming model, because each thread can concentrate on a single client without worrying about any other client. Either approach is available with the z/VM C sockets library.

Conflicts Between Socket Calls

When one thread of a multithreaded program is issuing a socket function call for a given socket, other threads are restricted from issuing certain socket function calls against that same socket. These restrictions are enforced by the TCP/IP service virtual machine. The following list describes the restrictions for each type of socket call:

- Multiple read-type calls (`read()`, `readv()`, `recv()`, `recvfrom()`, or `recvmsg()`) and multiple write-type calls (`write()`, `writv()`, `send()`, `sendto()`, or `sendmsg()`) for the same socket can be in progress simultaneously. The read-type calls are satisfied in the order they are issued, independently of the write-type calls. Similarly, the write-type calls are satisfied in the order they are issued, independently of the read-type calls.
- Multiple `accept()` calls for the same listening stream socket can be in progress simultaneously. They are satisfied in the order they are issued.
- Multiple `select()` calls referring to any combination of sockets (or other file descriptors) may be in progress simultaneously. When the state of a socket or other file descriptor changes, all active `select()` calls are checked; any that are then satisfied will return.
- Calls other than the read-type, write-type, `accept()`, and `select()` calls may not be in progress simultaneously for the same socket. For example, your program must wait for a write-type call to complete (or interrupt it) before issuing a `close()` call for the same socket.

If your program violates one of these restrictions, the function call that violates it will fail with an `ECONFLICT` error, except a `close()` call, which will fail with an `EAGAIN` error.

POSIX Signals and Thread Cancellation

The POSIX.1 standard greatly enhances the ANSI C Language definition by defining and guaranteeing certain aspects of signal processing. For example, many POSIX.1 function calls are defined to unblock, returning the `EINTR` error code, if a signal is delivered to a thread while it is blocked in a function call. POSIX.1 also defines what function calls a program may safely make while in a signal handler.

Similarly, the (draft) POSIX.1c threading standard defines the conditions under which a thread may be “cancelled” by a call to the `pthread_cancel()` function, and what function calls are considered to be “cancellation points”. The intent of this section is to define these attributes for the z/VM C sockets library.

Any socket function call which blocks may return `EINTR` if interrupted by a signal. That is, if a signal is caught by a thread which is blocked in a call to a socket function, that socket function will unblock and return the `EINTR` error code when the signal handler returns. The z/VM C sockets library blocks signal delivery in places when it is holding any internal mutexes, so signal delivery will occur only when the z/VM C sockets library can tolerate it. However, the following strict restriction does exist: **It is not supported for a signal handler to use `longjmp()` or `siglongjmp()` to exit from a signal handler.** In order for the z/VM C sockets library to properly recover from being interrupted, the signal handler *must* return, allowing the interrupted function call to resume from the point of interruption. This restriction only exists for signal handlers which might run because the thread was interrupted in the middle of a call to a socket function.

All z/VM C socket functions are async signal safe, and may thus be called without restriction from signal handlers.

All z/VM C socket functions are defined to *possibly* be thread cancellation points, as defined in the (draft) POSIX.1c threading standard, and *no* socket functions are defined to be async cancel safe. Any socket function which blocks will be a cancellation point. Although it is not supported by POSIX, it is safe for a cancellation cleanup handler to use `longjmp()` or `siglongjmp()` to exit, even if a function in the z/VM C sockets library was interrupted by the thread cancellation request.

Note: The difference between using `longjmp()` from a cancellation cleanup handler and using `longjmp()` from a signal handler is that in the case of cancellation, the z/VM C sockets library uses a cancellation cleanup handler of its own (which gets invoked before the application's cleanup handler) to clean up outstanding socket activity.

Sockets and Their Relationship to Other POSIX Functions

The z/VM C sockets library allocates file descriptors for sockets from the same pool of numbers that CMS uses for other open files in the POSIX environment. Among other things, this means that non-socket-specific POSIX functions can be called for file descriptors allocated to sockets. For example, the `fstat()` function can be called to retrieve information about an open socket. In the case of a socket, the `st_mode` field of the `stat` structure returned will indicate that the file descriptor is a socket. The `S_ISSOCK()` macro, defined in `sys/stat.h`, can be used to test the `st_mode` field. The `S_ISSOCK()` macro is analogous to the `S_ISREG()`, `S_ISFIFO()`, and other related macros provided in `sys/stat.h` to test for other file types.

Examples of other POSIX functions which can be called for socket file descriptors are `fchmod()`, `fchown()`, `dup()`, and `dup2()`. Note that using `fcntl()`, `dup()`, or `dup2()`, it is possible to open several file descriptors for the same socket. When this is done, all of the file descriptors are considered to be equivalent, in the sense that none of them has any special status over the rest. A socket is closed when the last file descriptor which refers to a socket is closed.

When using `AF_UNIX` sockets, files are created by the `bind()` function call in the Byte File System, CMS's implementation of a POSIX-compliant file system. These

files cannot be opened with the `open()` function, and are used only by the `connect()` function in the z/VM C sockets library. If `stat()` or `lstat()` is used on one of these files, the `st_mode` field in the return `stat` structure indicates that the file is a socket. The `S_ISSOCK()` macro can be used to test for this file type.

Note: Certain other function calls in the BPX layer of interfaces may report these files to be “external links”.

Secure Connection Considerations

Applications can set up connections to be secure using the secure `ioctl` commands and data structures defined in Table 21 on page 154 and Table 22 on page 170. Secure connections flow through a TLS/SSL server. Once a connection is secure, any data that the application sends is encrypted by the TLS/SSL server before it is sent over the TCP connection. Any data that the application receives is decrypted by the TLS/SSL server before it is returned to the application.

Starting a Secure Connection

Use the `SIOCSECSERVER` `ioctl` command to indicate to the TLS/SSL server that a connection is to be secure and that the TLS/SSL server needs to wait for an incoming handshake. Use the `SIOCSECCLIENT` `ioctl` command to indicate to the TLS/SSL server that a connection is to be secure and that the TLS/SSL server needs to initiate an outbound handshake. The `SecureDetail` structure must be provided on these `ioctl` calls. Refer to Table 21 on page 154 for details.

If using non-blocking sockets, the application can wait for the handshake to complete by waiting for the socket to become writable. In this case, the `ioctl` request will complete with a return code of -1 and an `ErrNo` of `EINPROGRESS`. If the handshake fails for any reason, an exception will be raised on the socket. A read can then be issued to get the error. If using blocking sockets, the `ioctl` will block until the handshake completes.

Stopping a Secure Connection

Use the `SIOCSECCLOSE` `ioctl` command, passing in the `CloseReq` structure, to stop encrypted data from flowing on a TCP connection. The peer is notified that the connection is returning to clear text with an `ErrNo` of `EIBMCLRTEXT` on the next read or write of the socket. The peer side must issue an `SIOCSECCLOSE` `ioctl` command to return the TCP connection to clear text. Any undelivered data at the time the `SIOCSECCLOSE` `ioctl` command is issued is thrown away.

Applications that negotiate security can use this option to stop the secure connection. For example, an application negotiates, using clear text, that a secure connection needs to be established. Later, the application performs a separate negotiation to stop the secure connection. After both sides agree to stop secure data from flowing on a connection, the application issues the `SIOCSECCLOSE` `ioctl` command. If non-blocking sockets are used, the application can wait for the request to complete by waiting for the socket to become writable. In this case, the `ioctl` request will complete with a return code of -1 and an `ErrNo` of `EINPROGRESS`. If blocking sockets are used, the `ioctl` blocks until the request is complete. After the request completes, the connection is no longer secure and any data that flows over the connection is in clear text.

Note: It is the applications responsibility to process all data prior to issuing the `SIOCSECCLOSE` `ioctl`. Any unprocessed data will be thrown away by the TLS/SSL server.

Requesting Details for a Secure Connection

Use the SIOCSECSTATUS ioctl command to request details about a session such as whether or not it is secure and the encryption suite being used. The SecStatus structure is returned. This structure provides the security level and cipher details.

Determine if an TLS/SSL Server is Available

Use the SIOCTLSQUERY ioctl command, passing in the QueryTls structure, to determine if a TLS/SSL server is available, and if a label is specified, is it known to the TLS/SSL server. If using non-blocking sockets, the application can wait for the Query to complete by waiting for the socket to become writable. In this case, the ioctl request will complete with a return code of -1 and an ErrNo of EINPROGRESS. If the Query fails for any reason, an exception will be raised on the socket. A read can then be issued to get the error. If using blocking sockets, the ioctl will block until the Query completes.

Miscellaneous Implementation Notes

The following are some miscellaneous points to consider when writing socket programs for the z/VM C sockets library:

1. Most of the socket functions are defined to return an EFAULT error if an address is passed which cannot be used by the sockets library. In certain cases, your program may receive a signal such as SIGSEGV instead. A multithreading library such as the z/VM C sockets library has difficulty prechecking for all of the conditions that could cause an EFAULT error, so invalid addresses may sometimes be used instead of causing EFAULT. In the worst case, if using AF_INET sockets, the library's IUCV connection with the TCP/IP service virtual machine may be severed by TCP/IP when it receives an IUCV error because of an invalid address or length.
2. If you receive an error from a sockets function call, you may call the perror() or strerror() functions to translate the errno into an error message. These routines can decode socket error codes as well as error codes from non-socket functions. For compatibility with the VM TCP/IP C sockets library, the z/VM C sockets library defines a tcperror() function which invokes perror(). A small difference between tcperror() and perror() is that if the sockets library encountered an error during its most recent IUCV communication on the invoking thread, the tcperror() function will report that error as well as the one represented in the errno variable. It is not necessary to use tcperror() unless this additional information concerning IUCV errors is needed.
3. If you wish to use the AF_UNIX or AF_IUCV addressing domains, the virtual machines that connect to each other need authorization in their user directory entries to allow the connection to be established. This is usually handled by placing a statement in the user directory entry of the server virtual machine like the following:

```
IUCV ALLOW
```

This statement tells CP to allow any virtual machine to establish an IUCV connection to the server.

Another possibility is to place a statement like the following in the user directory entry for each client virtual machine:

```
IUCV ANY
```

This statement tells CP to allow the client virtual machine to establish an IUCV connection with any other virtual machine.

The requirement that virtual machines need authorization to connect through IUCV is true for the AF_INET and AF_INET6 connections, but this is usually not a problem. AF_INET and AF_INET6 connections connect through the

TCP/IP server virtual machine, and that virtual machine is expected to have an IUCV ALLOW statement in its directory entry, which permits any client virtual machine to establish a connection with it.

Incompatibilities with the VM TCP/IP C Sockets Library

The goal of the z/VM C sockets library is to allow easier porting of UNIX programs that use sockets, and to provide a sockets API which can coexist with, and is more compatible with, the POSIX.1 API. To achieve this goal, it was often necessary to introduce incompatibilities with the TCP/IP C sockets library, because it has many incompatibilities with typical UNIX implementations. The following are some of the incompatibilities between the VM TCP/IP C sockets library and the z/VM C sockets library:

1. The names of the socket header files differ a great deal between the two libraries. For example, the z/VM C sockets library does not have a **manifest.h** header file, and you should not attempt to include one in your program. Another example is that the old **bsdtypes.h** header file has been replaced with a **sys/types.h** header file. The **time.h** header file has been replaced with two header files, **time.h** and **sys/time.h**. It is necessary for you to include the correct one (or both, if necessary) in your program. Be sure to use the header file names required by the functions as documented in this reference guide.

Do not omit the path name prefixes which are documented. For example, do not include **time.h** when you really should be including **sys/time.h**. The path name prefixes are significant.

2. Most of the header files to be used with the z/VM C sockets library are provided with Language Environment. Because those header files support several levels of socket functionality (on z/OS), it is necessary for all z/VM C socket programs to declare the level of functionality they want by defining the **_OE_SOCKETS** preprocessor symbol *before* including any Language Environment header files. Failure to do so will usually cause several confusing compilation error messages. One way to define this preprocessor symbol is to place a statement similar to the following at the top of each source file of your program:

```
#define _OE_SOCKETS
```

Alternatively, you can cause the **_OE_SOCKETS** preprocessor symbol to be defined by the compiler, by using the **-D** option on the **c89** command line. See “Compiling and Linking a Sockets Program” on page 29 for more information on compiling sockets programs.

3. The BSD 4.4 UNIX system introduced a new field into the *sockaddr* structures used by many socket functions. For each socket address family, there is a *sockaddr_xx* structure which contains fields that define the address. For example, in the AF_INET address family, the structure is called *sockaddr_in* and primarily contains an IP address and port number. In the AF_UNIX address family, the structure is called *sockaddr_un* and primarily contains a file name. There is also a generic structure called *sockaddr*.

In the TCP/IP C sockets library definitions, such structures do not contain self-defining length fields. Each socket function that accepts a *sockaddr* structure also accepts a length, so there is really no need for them to contain lengths within the structure. In the 4.4 BSD UNIX implementation, however, there is now a length field in the *sockaddr* structure, so the Language Environment header files have them too. The z/VM C sockets library uses them, therefore, when processing those functions. When a *sockaddr* structure is given to the z/VM C sockets library, the length fields are handled as follows:

- For AF_INET and AF_INET6 sockets, the library verifies that the length field is either 0 or `sizeof(struct sockaddr_in)`. If the library sees a zero

length, it assumes that the application does not know about length fields, and uses `sizeof(struct sockaddr_in)` instead. If it sees any other length value, it rejects the socket request with `EINVAL`.

- For `AF_UNIX` sockets, if the length field is nonzero, the library uses it to limit how much of the file name is examined; a zero length field is ignored.
- For `AF_IUCV` sockets, if the length field is nonzero, the library checks to make sure it is equal to `sizeof(struct sockaddr_iucv)`.

If you do not explicitly initialize the `sockaddr` length field, then, depending on how the storage is allocated, you might have an unintended value there, and get unexpected `EINVAL` errors. This is more of a problem for `AF_UNIX` sockets than for `AF_INET` and `AF_INET6` sockets. The reason is that an `AF_INET` or `AF_INET6` `sockaddr` structure already contains a field which must be zeros, so most robust applications use `memset()` to zero the entire `sockaddr` structure before filling it in. Because the z/VM C sockets library treats a zero `sockaddr_in` length field the same as if `sizeof(struct sockaddr_in)` were specified, robust `AF_INET` and `AF_INET6` applications need no changes to deal with `sockaddr` length fields. `AF_UNIX` `sockaddr` structures have no fields which must be zero, however, so it is less likely that the structure will be cleared before filling it in, especially since the full size is so much bigger. Having un-initialized data in that length field might cause the socket library to use less of the file name than you intend.

A simple method to check code you are porting for proper length-field handling is to search for places that initialize the “family” field, which is called `sin_family` for `AF_INET`, `sin6_family` for `AF_INET6` sockets, and `sun_family` for `AF_UNIX` sockets. If there is a call to `memset()` just before this code to clear the entire structure, you are probably safe. If not, you should fill in the length field. For `AF_INET` sockets, either fill it in with 0 or `sizeof(struct sockaddr_in)`. For `AF_INET6` sockets, either fill it in with 0 or `sizeof(struct sockaddr_in6)`. For `AF_UNIX` sockets, either fill it in with 0 or a value greater than or equal to `SUN_LEN(&sa)`, where `sa` is the name of the `sockaddr_un` variable, but less than or equal to `sizeof(struct sockaddr_un)`. For more information and examples of how to initialize the `sockaddr` length fields, see the `bind()` and `connect()` functions in *XL C/C++ for z/VM: Runtime Library Reference*.

4. The z/VM C sockets library supports the `selectex()` function call. No `WAITECBs` are done, because the CMS OS `WAIT` and `POST` are not multitasking-aware and are not interruptable. Instead, the `ECB` post bits are checked directly during a polling loop that processes socket and file descriptors. If a set post bit is found, then `selectex()` stops processing and returns to its caller.

Consider replacing the usage of `ECBs` with POSIX constructs such as condition variables. You can then create a thread that waits on the condition variable, and when the condition being waited for has really occurred, it could signal a thread blocked in a `select()` call, if necessary, to cause it to exit the `select()`. In many cases, the signal is not even necessary; the thread that waited on the condition variable could process the event itself without disturbing the other threads.

5. If your program calls `tcperror()` instead of `perror()`, you must define the constant `_OPEN_SOURCE` as follows:

```
#define _OPEN_SYS SOCK_EXT
```

This will cause `tcperror()` to be mapped to `perror()`.

6. If you used the TCP/IP C sockets library, and did not call the `maxdesc()` function to increase the number of sockets you could open, your program was guaranteed that no socket descriptor would be greater than 49. This guarantee

may have been exploited by programs, allowing them to set the `FD_SETSIZE` preprocessor symbol to a very small value. The `FD_SETSIZE` preprocessor symbol is used by the `sys/time.h` header file to control how much storage it takes to hold an `fd_set`, as used by the `select()` function call. When using the z/VM C sockets library, there is no relationship between file descriptor numbers as allocated by CMS and the value of the `FD_SETSIZE` preprocessor symbol. Another change to keep in mind is that the default `FD_SETSIZE` in the Language Environment `sys/time.h` header file is 2048, much larger than the default of 256 in the TCP/IP `bsdtypes.h` header file.

7. Programs compiled with the TCP/IP C sockets library header files must be recompiled before they can be link edited to the z/VM C sockets library. The two sets of header files do not produce object-compatible code. For example, the external symbol names associated with socket functions have changed, and the `errno` mapping is quite different.
8. If your program includes BSD header files (`bsdtypes.h`, `bsdtime.h`, `bsdtoems.h`), you must remove those includes. The z/VM C sockets library covers BSD functions, but it does not provide those header files.
9. In the TCP/IP C sockets library, `getdtablesize()` returns the maximum number of socket descriptors. In the z/VM C sockets library, `getdtablesize()` functions as it really should, returning the maximum number of file descriptors. The z/VM C sockets library provides `getstablesize()` for determining the maximum number of socket descriptors. If an existing TCP/IP application that uses `getdtablesize()` is being rebuilt with the z/VM C sockets library, to get the same results as before you must either use the `APPTYPE` environment variable or change the `getdtablesize()` call to `getstablesize()`.
10. The TCP/IP remote procedure calls library (RPCLIB) cannot be used with the z/VM C sockets library. Use the VMRPC library instead. For more information about RPC, see Chapter 5, "Remote Procedure Calls," on page 187.

Incompatibilities with z/OS and OS/390 C Sockets

The z/VM C socket API is equivalent to the OS/390® Language Environment 2.5 sockets subset, except the following functions have not been implemented in z/VM:

- `accept_and_recv()`
- `aio_read()`
- `aio_write()`
- `poll()`
- `send_file()`
- `socketpair()`
- `srx_np()`

Incompatibilities with the Berkeley Socket Implementation

The following list summarizes some of the differences between the z/VM C socket implementation and the Berkeley socket implementation:

1. The z/VM `ioctl()` implementation may be different from the current Berkeley `ioctl()` implementation.
2. The z/VM `getsockopt()` and `setsockopt()` calls support only a subset of the options available, and only for the `AF_IUCV`, `AF_INET`, and `AF_INET6` address families.
3. z/VM C sockets do *not* work with the X-windows library for TCP/IP. If your application program uses this X-windows library, you *must* use the TCP/IP C socket API instead of the z/VM C socket API.

4. In the z/VM C socket API, the AF_UNIX address family does not support datagram sockets or nonblocking mode.
5. In the z/VM socket API, select() is used to determine when an asynchronous secure ioctl call completes.

Compiling and Linking a Sockets Program

This section describes how to compile and link-edit C Language programs that use the z/VM C sockets library.

Note: An existing application that currently uses the VM TCP/IP C sockets library (COMMTXT) may continue to do so in exactly the same way it did before, without any modification. Also, the application may also continue to use the RPCLIB TXTLIB without modification. See “Running a Sockets Program” on page 33. However, to use the z/VM C socket functions, the application may need to be recompiled. See “Compiling and Linking a TCP/IP C Sockets Program” on page 31.

Compiling and Linking a z/VM C Sockets Program

To compile z/VM C socket programs, you must have the IBM C for VM/ESA Compiler, Version 3 (5654-033) Release 1, and IBM Language Environment (supplied with z/VM) installed on your z/VM system. In order to use AF_INET sockets, you must have TCP/IP installed and running.

To compile and link-edit a z/VM C sockets application program, use the **c89** utility. You must make sure that **c89** has access to the files it needs to compile and link-edit. The VM-unique header files reside on the CMS S-disk. The Language Environment object code and header files reside on the Y-disk.

Another aspect to ensuring that **c89** has all required files available is to make sure that you have a Byte File System mounted and available. The files and directories in this Byte File System must be arranged in the manner done by the BFS installation procedures. Specifically, the **/usr/include/sys/time.h** file is assumed to be an external link of type CMSDATA to the SYS_TIME H file.

The **c89** program can be run from the CMS command line (or equivalent) or from within a POSIX command shell, if you are running with a command shell. The syntax is the same in both cases. For example, if you wish to compile the testprog.c file in your current Byte File System (BFS) directory and bind the socket function stubs to it, use a command like the following:

```
c89 -o testprog -D_OE_SOCKETS testprog.c
```

Depending on the TCP/IP functions your application uses, additional libraries (listed in Table 2) may be required. For example, if testprog.c uses RPC functions, the command would be:

```
c89 -o testprog -D_OE_SOCKETS testprog.c -l//VMRPC
```

Table 2. TCP/IP TXTLIB Files and Applications

TXTLIB File	Application
VMRPC	Remote procedure calls
SCEELKED	C APIs
SCEE OBJ	C writable static variables

C Sockets API

The previous examples assume that `testprog.c` is the only source file in the program, and that the `_OE_SOCKETS` preprocessor symbol is not defined in the source file itself. If it is, then do not specify the `-D` option. To avoid having to type the `-D` option all the time, or including it in your **make** file, put the following statement in the beginning of every source file of your program, before it includes its first header file:

```
#define _OE_SOCKETS
```

If you want to use the Language Environment extended socket and bulkmode support, define the feature test macro `_OPEN_SYS SOCK_EXT` using a preprocessor directive, either on the **c89** compile command line:

```
c89 filename -D_OPEN_SYS SOCK_EXT
```

or in the source code before including any header files:

```
#define _OPEN_SYS SOCK_EXT
```

For more information about this macro, see the *XL C/C++ for z/VM: Runtime Library Reference*.

Sometimes defining `_OE_SOCKETS` in the source program itself is inconvenient because, for example, you are porting many source files from another system, and you would rather not change them all. In this case, define `_OE_SOCKETS` on the **c89** command line with the `-D` option, either by hand or in your **make** file, if you are using the **make** utility. For more information about the **make** utility, see *z/VM: OpenExtensions Advanced Application Programming Tools*.

The `-o` option in the example above tells **c89** to store the final executable file with the name `testprog`. This overrides the default name of `a.out`.

When you compile, be very careful *not* to have the disk containing the header files for TCP/IP accessed ahead of the disk containing the Language Environment header files. Because both TCP/IP and Language Environment ship socket header files with the same names, it is important to use the correct Language Environment header files, and not the TCP/IP files. No TCP/IP header files are needed to compile z/VM C socket programs. However, if you are using RPC functions, then header files on the TCP/IP disk are required.

If you would rather have **c89** produce a MODULE file on a CMS minidisk or accessed SFS directory, then specify something like the following on your **c89** command:

```
c89 -o //testprog -D_OE_SOCKETS testprog.c
```

This will cause **c89** to create a CMS file called TESTPROG MODULE A instead of an executable file in the BFS.

If the source file itself is on a CMS minidisk or accessed SFS directory, then use a **c89** command like the following:

```
c89 -D_OE_SOCKETS //testprog.c
```

This example adds `//` to the front of the name of the source file, and removes the `-o` option. It adds the `//` because the source file resides on a CMS minidisk. The `-o` option is removed because when the `testprog.c` source file is on a minidisk, the **c89** default name for the executable file is `//testprog.module.a`, so there is no need to specify it explicitly.

Note: It is not necessary to use uppercase letters in the name, type, or mode of a CMS file when the file ID is preceded with `//`. The file ID is converted to uppercase automatically.

If your program is composed of several source files, for example `progfile1.c` and `progfile2.c`, you can use either of the two following sequences to produce an executable file.

```
c89 -c -D_OE_SOCKETS progfile1.c
c89 -c -D_OE_SOCKETS progfile2.c
c89 -o testprog progfile1.o progfile2.o
```

or

```
c89 -o testprog -D_OE_SOCKETS progfile1.c progfile2.c
```

In the first sequence, the source files are first compiled (the `-c` option prevents `c89` from trying to link edit them) and then link-edited in a separate `c89` command. In the second sequence, the source files are compiled and link-edited in one command. The point being demonstrated in this example is that the `-D` option is needed only for the compilation step.

Many other variations of the `c89` command are possible. See the *z/VM: OpenExtensions Commands Reference* for a complete description of the `c89` command.

After you have created an executable program, you can use the OPENVM GET and OPENVM PUT commands to move it back and forth between a CMS minidisk or accessed SFS directory and the Byte File System. See the *z/VM: OpenExtensions Commands Reference* for information on those commands.

Compiling and Linking a TCP/IP C Sockets Program

If you want to recompile and relink an existing application that was built with VM TCP/IP C sockets, you have three choices:

- Convert the program to use the z/VM C sockets library
- Recompile and relink using the z/VM C sockets library with minimal changes to the program source
- Recompile using the TCP/IP C sockets library

Converting Your Program to Use z/VM C Sockets

To convert a TCP/IP C sockets program to use z/VM C sockets:

1. Go to “Incompatibilities with the VM TCP/IP C Sockets Library” on page 26. Make the necessary changes to your program to resolve the incompatibilities.
2. Go to “Compiling and Linking a z/VM C Sockets Program” on page 29 and follow the instructions.

Using the z/VM C Sockets Library with Minimal Changes to Program Source

You can recompile and relink your VM TCP/IP C sockets program to use the z/VM C sockets library (SCEELKED) with little or no source code modification:

- If your program uses remote procedure calls, you must use the VMRPC library instead of RPCLIB.
- If your program includes BSD header files (`bsdtypes.h`, `bsdtime.h`, `bsdtoCMS.h`), you must remove those includes. Language Environment covers BSD functions, but it does not provide those header files.

- Define the feature test macro `_TCPVM_SOCKETS` using a preprocessor directive, either on the `c89` command line:

```
c89 filename -D_TCPVM_SOCKETS
```

or in the source code before including any header files:

```
#define _TCPVM_SOCKETS
```

Recompiling with the TCP/IP C Sockets Library

To recompile with the TCP/IP C sockets library:

1. Access the TCP/IP Client-code minidisk (usually TCPMAINT 592) *ahead* of the disk that contains the Language Environment header files (usually the Y-disk) to avoid conflicts.
2. Establish the C development environment:
 - a. Access the C compiler.
 - b. Issue `GLOBAL LOADLIB SCEERUN`.
3. Compile your program. Make sure that the preprocessor symbol `VM` is defined; if it is not already defined in your program, you can specify it on the compile command:

```
CC myprog (DEF(VM))
```

With OpenExtensions, you can also use the `c89` command or the `make` utility.

4. Select the link libraries your application needs and put them on a `GLOBAL TXTLIB` command. `COMMTXT` and `SCEELKED` are the minimum required:

```
GLOBAL TXTLIB COMMTXT SCEELKED
```

Additional libraries (listed in Table 3) may be required, depending on the functions your application uses. For example, programs that use RPC must issue:

```
GLOBAL TXTLIB COMMTXT RPCLIB SCEELKED
```

Note that the Language Environment text library, `SCEELKED`, should always be listed last.

Table 3. TCP/IP TXTLIB Files and Applications

TXTLIB File	Application
COMMTXT	TCP/IP C sockets and Pascal API
RPCLIB	Remote procedure calls
X11LIB	Xlib, Xmu, Xext, and Xau routines
OLDXLIB	X Release 10 compatibility routines
XTLIB	X Intrinsic
XAWLIB	Athena widget set
XMLIB	OSF/Motif-based widget set
DPILIB	SNMP DPI
SCEELKED	C APIs
SCEE OBJ	C writable static variables

5. Link-edit your programs into an executable module. The sample applications in this book are built using the `TCpload` utility. Your own applications should be built using the `CMOD` command. For example,

```
TCpload sample@c c
```

or

```
CMOD myprog1 myprog2 (AUTO
```

Complete information on compiling and link-editing C programs can be found in the *z/OS: Language Environment Programming Guide*. For information about TCPLOAD, see Appendix A, "TCPLOAD EXEC," on page 403.

Running a Sockets Program

After building your executable sockets program, the next step is to run the program. Before you do, however, some preparation may be necessary. In addition, you may want to consider using environment variables to affect certain aspects of the execution. There are also differences between running a program from the BFS and running it from an accessed minidisk or SFS directory.

Preparing to Run a Sockets Program

If your program uses AF_INET sockets, then you should access the TCP/IP "client" minidisk or SFS directory that contains the TCP/IP configuration files. Usually you can LINK to TCPIP 592 to access the disk. Your installation may have assigned a VMLINK nickname to this minidisk (for example, TCPIP). Issue a VMLINK command (with no arguments) to see if one has been assigned. In the compilation step, it was noted that this disk contains some header files with the same names as Language Environment and VM-unique header files. If you might compile your program again after running it, be sure to access the TCP/IP client disk at a mode *after* the disk that contains the Language Environment header files.

To run your POSIX program, it should reside on an accessed minidisk or SFS directory, or in a mounted BFS file system. As described below, if it resides on an accessed minidisk or SFS directory, you can run it by either typing the name of the executable module on the CMS command line, or by using the OPENVM RUN command. If it resides in the BFS, you can run it by either typing the name of the executable file on a POSIX shell command line, or by using the OPENVM RUN command. Before running a module that resides on an accessed minidisk or SFS directory, either by using the OPENVM RUN command or by simply typing the name of the module on the CMS command line, you must establish the proper run-time Language Environment load library with the following CMS command:

```
GLOBAL LOADLIB SCEERUN
```

Note: If you have a TCP/IP C sockets application that you have recompiled and relinked with the z/VM C sockets library, with no source changes, but you want the maxdesc() and getdtablesize() functions to operate the same way they did in the TCP/IP C socket API, you must set the APPTYPE environment variable (to the value OLDAPP) before running your program. For example:

```
GLOBALV SELECT CENV SETLP APPTYPE OLDAPP
```

This will cause the maxdesc() default to be 50 and getdtablesize() to return a maximum of 50.

Using Environment Variables

Environment variables can be used to affect certain aspects of the execution of a z/VM C sockets program. If the z/VM C sockets program is executed from the OpenExtensions shell, the shell controls the contents of the program's environment. For example, the following shell command could be used to set the APPTYPE environment variable:

```
export APPTYPE=OLDAPP
```

C Sockets API

If the z/VM C sockets program is being run from the CMS command line (or equivalent), then the global variables existing in the CENV group managed by the GLOBALV command are used as the environment variables for the process. In this case, a CMS command like the following could be used to temporarily set the APPTYPE environment variable:

```
GLOBALV SELECT CENV SET APPTYPE OLDAPP
```

Note: Be aware, however, that some of the environment variables described below accept values which are case sensitive, and which will often be set to lowercase values. It can be difficult, using the GLOBALV command, to set lowercase values, because commands typed in from the CMS command line are automatically uppercased by CMS before processing. One way to set the variable to a mixed-case value is to issue the GLOBALV command from a REXX exec with “Address Command” in effect.

Some of the environment variables described below are set to values which represent file names. For these environment variables, the given file names are interpreted as POSIX-style file names, which means that case is significant, and that the file name is interpreted as residing in the Byte File System unless you precede the file name with two slashes. To specify the name of a file which resides on a minidisk or accessed SFS directory instead of in the BFS, precede the name of the file with two slashes, and separate the CMS file name and type (and mode, if specified) with a period.

The following environment variables can be used to affect the execution of the Language Environment sockets library:

Variable

Description

APPTYPE

This environment variable forces the z/VM C socket functions maxdesc() and getdtablesize() to return the same values that those functions returned in the TCP/IP C socket API.

HOSTALIASES

This environment variable tells the socket library resolver code to use the named file when searching for aliases for AF_INET host names. For example, setting the variable to the string /etc/aliases tells the resolver to use the /etc/aliases file when needed. By default, no aliases file is used by the resolver. If you intend to transfer an aliases file into the BFS using the OPENVM PUTBFS command, be sure to specify the BFSLINE NL option, or let it default.

X_ADDR

This environment variable tells the socket library resolver code to use the named file in place of the HOSTS ADDRINFO file, which contains information about AF_INET networks known to this host. For example, setting the variable to the string /etc/addr tells the resolver to use the /etc/addr file in place of the default file, which is //HOSTS.ADDRINFO. If you intend to transfer the HOSTS ADDRINFO file into the BFS using the OPENVM PUTBFS command, be sure to specify the BFSLINE NONE option. This environment variable is used by the gethostbyaddr() function call, the getnetent() function call, and several others.

Note: When using the TCP/IP C sockets library, the format of this environment variable is **X-ADDR**.

X_SITE

This environment variable tells the socket library resolver code to use the named file in place of the HOSTS SITEINFO file, which contains information about AF_INET hosts known to this host. For example, setting the variable to the string /etc/hosts tells the resolver to use the /etc/hosts file in place of the default file, which is //HOSTS.SITEINFO. If you intend to transfer the HOSTS SITEINFO file into the BFS using the OPENVM PUTBFS command, be sure to specify the BFSLINE NONE option. This environment variable is used by the gethostbyname() function call, the gethostent() function call, and several others.

Note: When using the TCP/IP C sockets library, the format of this environment variable is **X-SITE**.

X_XLATE

This environment variable tells the socket library resolver code to use the named file in place of the STANDARD TCPXLBIN file, which contains ASCII to EBCDIC and EBCDIC to ASCII translation tables for use by the resolver when sending or receiving information from an AF_INET network. For example, setting the variable to the string /etc/xlate tells the resolver to use the /etc/xlate file in place of the default file, which is //STANDARD.TCPXLBIN. If you intend to transfer the STANDARD TCPXLBIN file into the BFS using the OPENVM PUTBFS command, be sure to specify the BFSLINE NONE option. This environment variable is used by the gethostbyname() and gethostbyaddr() function calls.

Note: When using the TCP/IP C sockets library, the format of this environment variable is **X-XLATE**.

Running a Program Residing in the BFS

If you are using a POSIX command shell, and the executable file is in your path, then simply type the name of the program to run it:

```
testprog
```

or

```
/dirname/dirname/.../testprog
```

In this scenario, the shell will spawn a process to run your program. Any program which is spawned is automatically considered by CMS to be a POSIX program, and will have access to OpenExtensions services.

If you are not using a POSIX command shell, then use the OPENVM RUN command to execute the program. For example:

```
OPENVM RUN /dirname/dirname/.../testprog
```

In this scenario, the OPENVM RUN command will spawn a process to run your program. As before, your program will automatically have access to OpenExtensions services. Be aware that path name arguments to the OPENVM RUN command are case sensitive.

Running a Program Residing on an Accessed Minidisk or SFS Directory

If the executable file is on an accessed minidisk or SFS directory, then there are several ways to execute it.

The OPENVM RUN command, which was mentioned earlier to run a program residing in the BFS, can also run a MODULE file. To do so, uppercase the file name on the command line, as follows:

```
OPENVM RUN TESTPROG
```

If the executable file is on an accessed minidisk or SFS directory, you can type the name of the module on the CMS command line to run it, but you must also tell CMS that the program is a POSIX program and should be given access to the OpenExtensions services.

The following are the two techniques for establishing your program as a POSIX program when you run it:

1. Specify the Language Environment POSIX(ON) run-time option on the CMS command line. In order to be able to pass run-time options to a program, the EXECOPS compiler option must be in effect when the program is compiled. Because it is the default setting, EXECOPS is in effect unless overridden with the NOEXECOPS option. Specify the run-time options by separating them from the program arguments with a slash (/) as you run your program:

```
testprog runopt1 runopt2 ... / arg1 arg2 arg3 ...
```

To specify the POSIX(ON) run-time option, use a command like the following:

```
testprog posix(on)/arg1 arg2 arg3 ...
```

2. Specify the Language Environment POSIX(ON) run-time option by putting it in the source file containing the main function. If you plan to run the program often by simply typing its name on the CMS command line, the most convenient way to get the program recognized as a POSIX program is to place a pragma like the following in the source file which contains the main function:

```
#pragma runopts(posix(on))
```

With this pragma, you never need to type the POSIX(ON) run-time option.

When you run a program by typing its name on the CMS command line, and the EXECOPS compiler option was in effect when you compiled your program (it is by default), then everything before the first slash, if there is a slash on the command line, will be interpreted as a run-time option. Because POSIX path names often contain slashes, this can cause program arguments to be misinterpreted as run-time options if your program accepts a POSIX path name as an argument. To avoid this, consider placing a pragma like the following in the source file containing the main function:

```
#pragma runopts(noexecops, posix(on))
```

This will prevent POSIX path names from accidentally being interpreted as run-time options, and cause the POSIX(ON) run-time option to always be in effect.

Using pragma statements such as the ones discussed above is necessary only when you intend to run your program from the CMS command line by typing its name. If you use OPENVM RUN to run the program, or run it from a POSIX command shell, all operands are interpreted as program arguments, and the program is automatically treated as a POSIX program.

C Sockets Quick Reference

This section provides brief descriptions of the z/VM C socket calls. For additional information about these socket functions, see the *XL C/C++ for z/VM: Runtime Library Reference*.

Table 4. C Sockets Quick Reference

Socket() Call	Description
accept()	Accepts a connection request from a foreign host.
bind()	Assigns a local address to a socket.
close()	Closes a socket.
connect()	Requests a connection to a foreign host.
endhostent()	Closes the HOSTS SITEINFO file.
endnetent()	Closes the HOSTS ADDRINFO file.
endprotoent()	Closes the ETC PROTO file.
endservent()	Closes the ETC SERVICES file.
fcntl()	Controls socket operating characteristics.
freeaddrinfo()	Frees one or more addrinfo structures returned by getaddrinfo()
gai_strerror()	Returns information on errors returned by getaddrinfo() and getnameinfo()
getaddrinfo()	Resolves IP addresses (IPv4 or IPv6)
getclientid()	Returns the identifier by which the calling application is known to the TCPIP virtual machine.
gethostbyaddr()	Returns information about a host specified by an address.
gethostbyname()	Returns information about a host specified by a name.
gethostent()	Returns the next entry in the HOSTS SITEINFO file.
gethostid()	Returns the unique identifier of the current host.
gethostname()	Returns the standard name of the current host.
getnameinfo()	Translates a socket address to a node name and service location
getnetbyaddr()	Returns the network entry specified by address.
getnetbyname()	Returns the network entry specified by name.
getnetent()	Returns the next entry in the HOSTS ADDRINFO file.
getpeername()	Returns the name of the peer connected to a socket.
getprotobyname()	Returns a protocol entry specified by name.
getprotobynumber()	Searches the ETC PROTO file for a specified protocol number.
getprotoent()	Returns the next entry in the ETC PROTO file.
getservbyname()	Returns a service entry specified by name.
getservbyport()	Returns a service entry specified by port number.
getservent()	Returns the next entry in the SERVICES file.
getsockname()	Obtains the local socket name.
getsockopt()	Gets options associated with sockets in the AF_IUCV, AF_INET, and AF_INET6 domains.
givesocket()	Tells TCPIP to make the specified socket available to a takesocket() call issued by another application.

Table 4. C Sockets Quick Reference (continued)

Socket() Call	Description
htonl()	Translates host byte order to network byte order for a long integer.
htons()	Translates host byte order to network byte order for a short integer.
if_freenameindex()	Frees storage allocated by if_nameindex()
if_indextoname()	Maps a network interface index to its corresponding name
if_nameindex()	Returns all network interface names and indexes
if_nametoindex()	Maps a network interface name to its corresponding index
inet_addr()	Constructs an internet address from character strings set in standard dotted-decimal notation.
inet_lnaof()	Returns the local network portion of an internet address.
inet_makeaddr()	Constructs an internet address from a network number and a local address.
inet_netof()	Returns the network portion of the internet address in network byte order.
inet_network()	Constructs a network number from character strings set in standard dotted-decimal notation.
inet_ntoa()	Returns a pointer to a string in dotted-decimal notation.
inet_ntop()	Converts a binary IP address (IPv4 or IPv6) into string format
inet_pton()	Converts an IP address (IPv4 or IPv6) in string format to binary format
ioctl()	Performs special operations on a socket.
listen()	Indicates that a stream socket is ready for a connection request from a foreign host.
maxdesc()	Allows socket numbers to extend beyond default range of 0 - 49.
ntohl()	Translates network byte order to host byte order for a long integer.
ntohs()	Translates network byte order to host byte order for a short integer.
read()	Reads a set number of bytes into a buffer.
readv()	Obtains data from a socket and reads this data into specified buffers.
recv()	Receives messages from a connected socket.
recvfrom()	Receives messages from a datagram socket, regardless of its connection status.
recvmsg()	Receives messages on a socket into an array of buffers.
select()	Monitors activity on a set of sockets.
selectex()	Monitors activity on a set of different sockets.
send()	Transmits messages to a connected socket.
sendmsg()	Sends messages on a socket from an array of buffers.
sendto()	Transmits messages to a datagram socket, regardless of its connection status.
sethostent()	Opens the HOSTS SITEINFO file at the beginning.
setnetent()	Opens the HOSTS ADDRINFO file at the beginning.

Table 4. C Sockets Quick Reference (continued)

Socket() Call	Description
setprotoent()	Opens the ETC PROTO file at the beginning.
setservent()	Opens the ETC SERVICES file at the beginning.
setsockopt()	Sets options associated with a socket in the AF_IUCV, AF_INET, and AF_INET6 domains.
shutdown()	Shuts down all or part of a full-duplex connection.
socket()	Requests that a socket be created.
takesocket()	Acquires a socket from another application.
write()	Writes a set number of bytes from a buffer to a socket.
writev()	Writes data in the buffers specified by an array of iovec structures.

TCP Client Program

The following is an example of a C socket TCP client program.

```

/*
 * Include Files.
 */
#define VM
#define _XOPEN_SOURCE_EXTENDED 1
#include <arpa/inet.h>
#include <in.h>
#include <socket.h>
#include <netdb.h>
#include <stdio.h>

/*
 * Client Main.
 */
main(argc, argv)
int argc;
char **argv;
{
    unsigned short port;      /* port client will connect to      */
    char buf[12];             /*data buffer for sending and receiving */
    struct hostent *hostnm;    /*server host name information        */
    struct sockaddr_in server; /*server address                      */
    int s;                    /* client socket                      */

    /*
     * Check Arguments Passed. Should be hostname and port.
     */
    if (argc != 3)
    {
        fprintf(stderr, "Usage: %s hostname port\n", argv[0]);
        exit(-1);
    }

    /*
     * The host name is the first argument. Get the server address.
     */
    hostnm = gethostbyname(argv[1]);
    if (hostnm == (struct hostent *) 0)
    {
        fprintf(stderr, "Gethostbyname failed\n");
        exit(-1);
    }
}

```

C Sockets API

```
/*
 * The port is the second argument.
 */
port = (unsigned short) atoi(argv[2]);

/*
 * Put a message into the buffer.
 */
strcpy(buf, "the message");

/*
 * Put the server information into the server structure.
 * The port must be put into network byte order.
 */
server.sin_family = AF_INET;
server.sin_port = htons(port);
server.sin_addr.s_addr = *((unsigned long *)hostnm->h_addr);

/*
 * Get a stream socket.
 */
if ((s = socket(AF_INET,SOCK_STREAM, 0)) < 0)
{
    perror("Socket()");
    exit(-1);
}

/*
 * Connect to the server.
 */
if (connect(s, &server, sizeof(server)) < 0)
{
    perror("Connect()");
    exit(-1);
}

if (send(s, buf, sizeof(buf), 0) < 0)
{
    perror("Send()");
    exit(-1);
}

/*
 * The server sends back the same message. Receive it into the buffer.
 */
if (recv(s, buf, sizeof(buf), 0) < 0)
{
    perror("Recv()");
    exit(-1);
}

/*
 * Close the socket.
 */
close(s);

printf("Client Ended Successfully\n");
exit(0);
}
```

TCP Server Program

The following is an example of a C socket TCP server program.

```

/*
 * Include Files.
 */
#define VM
#define _XOPEN_SOURCE_EXTENDED 1
#include <arpa/inet.h>
#include <in.h>
#include <socket.h>
#include <stdio.h>

/*
 * Server Main.
 */
main(argc, argv)
int argc;
char **argv;
{
    unsigned short port;          /*port server binds to          */
    char buf[12];                 /*buffer for sending and receiving data */
    struct sockaddr_in client;    /*client address information      */
    struct sockaddr_in server;   /*server address information      */
    int s;                        /*socket for accepting connections */
    int ns;                       /*socket connected to client     */
    int namelen;                 /*length of client name          */

    /*
     * Check arguments. Should be only one: the port number to bind to.
     */

    if (argc != 2)
    {
        fprintf(stderr, "Usage:%s port\n", argv[0]);
        exit(-1);
    }
    /*
     * First argument should be the port.
     */
    port = (unsigned short)atoi(argv[1]);

    /*
     * Get a socket for accepting connections.
     */
    if ((s = socket(AF_INET,SOCK_STREAM, 0)) < 0)
    {
        perror("Socket()");
        exit(-1);
    }

    /*
     * Bind the socket to the server address.
     */
    server.sin_family = AF_INET;
    server.sin_port = htons(port);
    server.sin_addr.s_addr = INADDR_ANY;

    if (bind(s, &server, sizeof(server)) < 0)
    {
        perror("Bind()");
        exit(-1);
    }

    /*
     * Listen for connections. Specify the backlog as 1.
     */
    if (listen(s, 1) != 0)
    {

```

C Sockets API

```
        perror("Listen()");
        exit(-1);
    }

    /*
     * Accept a connection.
     */
    namelen = sizeof(client);
    if ((ns = accept(s, &client,&namelen)) == -1)
    {
        perror("Accept()");
        exit(-1);
    }

    /*
     * Receive the message on the newly connected socket.
     */
    if (recv(ns, buf, sizeof(buf),0) == -1)
    {
        perror("Recv()");
        exit(-1);
    }

    /*
     * Send the message back to the client.
     */
    if (send(ns, buf, sizeof(buf),0) < 0)
    {
        perror("Send()");
        exit(-1);
    }

    close(ns);
    close(s);

    printf("Server ended successfully\n");
    exit(0);
}
```

UDP Client Program

The following is an example of a C socket UDP client program.

```
#define _XOPEN_SOURCE_EXTENDED 1
#include <arpa/inet.h>
#include <in.h>
#include <socket.h>
#include <netdb.h>
#include <stdio.h>

main(argc, argv)
int argc;
char **argv;
{

    int s;
    unsigned short port;
    struct sockaddr_in server;
    char buf[32];

    /* argv[1] is internet address of server argv[2] is port of server.
     * Convert the port from ascii to integer and then from host byte
     * order to network byte order.
     */
    if(argc != 3)
    {
```

```

    printf("Usage: %s <host address> <port> \n",argv[0]);
    exit(1);
}
port = htons(atoi(argv[2]));

/* Create a datagram socket in the internet domain and use the
 * default protocol (UDP).
 */
if ((s = socket(AF_INET, SOCK_DGRAM, 0)) < 0)
{
    perror("socket()");
    exit(1);
}

/* Set up the server name */
server.sin_family      = AF_INET;          /* Internet Domain */
server.sin_port        = port;             /* Server Port */
server.sin_addr.s_addr = inet_addr(argv[1]); /* Server's Address */

strcpy(buf, "Hello");

/* Send the message in buf to the server */
if (sendto(s, buf, (strlen(buf)+1), 0, &server, sizeof(server)) < 0)
{
    perror("sendto()");
    exit(2);
}

/* Deallocate the socket */
close(s);
}

```

UDP Server Program

The following is an example of a C socket UDP server program.

```

#define _XOPEN_SOURCE_EXTENDED 1
#include <arpa/inet.h>
#include <in.h>
#include <socket.h>
#include <netdb.h>
#include <stdio.h>

main()
{
    int s, namelen, client_address_size;
    struct sockaddr_in client, server;
    char buf[32];

    /*
     * Create a datagram socket in the internet domain and use the
     * default protocol (UDP).
     */
    if ((s = socket(AF_INET, SOCK_DGRAM, 0)) < 0)
    {
        perror("socket()");
        exit(1);
    }

    /*
     * Bind my name to this socket so that clients on the network can
     * send me messages. (This allows the operating system to demultiplex
     * messages and get them to the correct server)
     *
     * Set up the server name. The internet address is specified as the
     * wildcard INADDR_ANY so that the server can get messages from any

```

C Sockets API

```

    * of the physical internet connections on this host. (Otherwise we
    * would limit the server to messages from only one network
    * interface.)
    */
server.sin_family      = AF_INET; /* Server is in Internet Domain */
server.sin_port        = 0;       /* Use any available port */
server.sin_addr.s_addr = INADDR_ANY; /* Server's Internet Address */

if (bind(s, &server, sizeof(server)) < 0)
{
    perror("bind()");
    exit(2);
}

/* Find out what port was really assigned and print it */
namelen = sizeof(server);
if (getsockname(s, (struct sockaddr *) &server, &namelen) < 0)
{
    perror("getsockname()");
    exit(3);
}

printf("Port assigned is %d\n", ntohs(server.sin_port));

/*
 * Receive a message on socket s in buf of maximum size 32
 * from a client. Because the last two parameters
 * are not null, the name of the client will be placed into the
 * client data structure and the size of the client address will
 * be placed into client_address_size.
 */
client_address_size = sizeof(client);

if(recvfrom(s, buf, sizeof(buf), 0, (struct sockaddr *) &client,
            &client_address_size) < 0)
{
    perror("recvfrom()");
    exit(4);
}

/*
 * Print the message and the name of the client.
 * The domain should be the internet domain (AF_INET).
 * The port is received in network byte order, so we translate it to
 * host byte order before printing it.
 * The internet address is received as 32 bits in network byte order
 * so we use a utility that converts it to a string printed in
 * dotted decimal format for readability.
 */
printf("Received message %s from domain %s port %d internet"
"address %s\n",
    buf,
    (client.sin_family == AF_INET?"AF_INET":"UNKNOWN"),
    ntohs(client.sin_port),
    inet_ntoa(client.sin_addr));

/*
 * Deallocate the socket.
 */
close(s);
}

```

Chapter 2. TCP/UDP/IP API (Pascal Language)

This chapter describes the Pascal language application program interface (API) provided with TCP/IP for z/VM. This interface allows programmers to write application programs that use the TCP, UDP, and IP layers of the TCP/IP protocol suite.

You should have experience in Pascal language programming and be familiar with the principles of internetwork communication to use the Pascal language API.

Your program uses procedure calls to initiate communication with the TCPIP virtual machine. Most of these procedure calls return with a code that indicates success, or the type of failure incurred by the call. The TCPIP virtual machine starts asynchronous communication by sending you notifications.

The general sequence of operations is:

1. Start TCP/UDP/IP service (BeginTcpIp, StartTcpNotice).
2. Specify the set of notifications that TCP/UDP/IP may send you (Handle).
3. Establish a connection (TcpOpen, UdpOpen, RawIpOpen, TcpWaitOpen).
If using TcpOpen, you must wait for the appropriate notification that a connection has been established.
4. Transfer data buffer to or from the TCPIP virtual machine (TcpSend, TcpFSend, TcpWaitSend, TcpReceive, TcpFReceive, TcpWaitReceive, UdpSend, UdpNReceive, RawIpSend, RawIpReceive).

Note: TcpWaitReceive and TcpWaitSend are synchronous calls.

5. Check the status returned from the TCPIP virtual machine in the form of notifications (GetNextNote).
6. Repeat the data transfer operations (steps 4 and 5) until the data is exhausted.
7. Terminate the connection (TcpClose, UdpClose, RawIpClose).
If using TcpClose, you must wait for the connection to terminate.
8. Terminate the communication service (EndTcpIp).

Control is returned to you, in most instances, after the initiation of your request. When appropriate, some procedures have alternative wait versions that return only after completion of the request. The bodies of the Pascal procedures are in the TCPIP ATCPPSRC file.

A sample program is supplied with the TCP/IP program, see "Sample Pascal Program" on page 111.

Software Requirements

To develop programs in Pascal that interface directly to the TCP, UDP, and IP protocol boundaries, you require the IBM VS Pascal Compiler & Library (5668-767).

Data Structures

Programs containing Pascal language API calls must include the appropriate data structures. The data structures are declared in the CMCOMM COPY and CMCLIEN COPY. The CMCOMM and CMCLIEN are included in the ALLMACRO MACLIB shipped with TCP/IP. To include these files in your program source, enter:

```
%include CMCOMM
%include CMCLIEN
```

Additional include statements are required in programs that use certain calls. The following list shows the members of the ALLMACRO MACLIB that need to be included for the various calls.

- CMRESGLB for GetHostResol
- CMINTER for GetHostNumber, GetHostString, IsLocalAddress, and IsLocalHost.

The load modules are in the TCPIP COMMTXT file. Include this file in your GLOBAL TXTLIB command when you are creating a load module to link an application program.

Connection State

ConnectionState is the current state of the connection. For the Pascal declaration of the ConnectionStateType data type, see Figure 15. ConnectionStateType is used in StatusInfoType and NotificationInfoType. It defines the client program's view of the state of a TCP connection, in a form more readily usable than the formal TCP connection state defined by RFC 793. For the mapping between TCP states and ConnectionStateType, see Table 5 on page 47.

```
ConnectionStateType =
(
    CONNECTIONclosing,
    LISTENING,
    NONEXISTENT,
    OPEN,
    RECEIVINGonly,
    SENDINGonly,
    TRYINGtoOPEN
);
```

Figure 15. Pascal Declaration of Connection State Type

CONNECTIONclosing

Indicates that no more data can be transmitted on this connection, because it is going through the TCP connection closing sequence.

LISTENING

Indicates that you are waiting for a foreign site to open a connection.

NONEXISTENT

Indicates that a connection no longer exists.

OPEN

Indicates that data can go either way on the connection.

RECEIVINGonly

Indicates that data can be received, but cannot be sent on this connection, because the client has done a `TcpClose`.

SENDINGonly

Indicates that data can be sent out, but cannot be received on this connection, because the foreign application has done a `TcpClose` or equivalent.

TRYINGtoOPEN

Indicates that you are trying to contact a foreign site to establish a connection.

Table 5. TCP Connection States

TCP State	ConnectionStateType
CLOSED	NONEXISTENT
LAST-ACK, CLOSING, TIME-WAIT	If there is incoming data that the client program has not received, then <code>RECEIVINGonly</code> , else <code>CONNECTIONclosing</code> .
CLOSE-WAIT	If there is incoming data that the client program has not received, then <code>OPEN</code> , else <code>SENDINGonly</code> .
ESTABLISHED	OPEN
FIN-WAIT-1, FIN-WAIT-2	<code>RECEIVINGonly</code>
LISTEN	LISTENING
SYN-SENT, SYN-RECEIVED	TRYINGtoOPEN

Connection Information Record

The connection information record is used as a parameter in several of the procedure calls. It enables you and the TCP/IP program to exchange information about the connection. There are two types of records, one used for IPv4 calls and one used for IPv6. The IPv4 Pascal declaration is shown in Figure 16. For more information about the use of each field, see “`TcpOpen` and `TcpWaitOpen`” on page 94 and “`TcpStatus`” on page 102. The IPv6 declaration is shown in Figure Figure 17 on page 48. For more information about the use of each field, see “`Tcp6Open` and `Tcp6WaitOpen`” on page 83 and “`Tcp6Status`” on page 86.

```

StatusInfoType =
  record
    Connection: ConnectionType;
    OpenAttemptTimeout: integer;
    Security: SecurityType;
    Compartment: CompartmentType;
    Precedence: PrecedenceType;
    BytesToRead: integer;
    UnackedBytes: integer;
    ConnectionState: ConnectionStateType;
    LocalSocket: SocketType;
    ForeignSocket: SocketType;
  end;

```

Figure 16. Pascal Declaration of Connection Information Record

Connection

Specifies a number identifying the connection that is described. This connection number is different from the connection number displayed by

the NETSTAT command. For more information about the NETSTAT command, see *z/VM: TCP/IP User's Guide*.

OpenAttemptTimeout

Specifies the number of seconds that TCP continues to attempt to open a connection. You specify this number. If the limit is exceeded, TCP stops trying to open the connection and shuts down any partially open connection.

Security, Compartment, Precedence

Specifies entries used only when working within a multilevel secure environment.

BytesToRead

Specifies the number of data bytes received from the foreign host by TCP, but not yet delivered to the client. TCP maintains this value.

UnackedBytes

Specifies the number of bytes sent by your program, but not yet sent to the foreign TCP, or the number of bytes sent to the foreign TCP, but not yet acknowledged.

LocalSocket

Specifies the local internet address and local port. Together, these form one end of a connection. The foreign socket forms the other end. For the Pascal declaration of the SocketType record, see Figure 18 on page 49.

ForeignSocket

Specifies the foreign, or remote, internet address and its associated port. These form one end of a connection. The local socket forms the other end.

```
Status6InfoType =  
  record  
    Connection: ConnectionType;  
    OpenAttemptTimeout: integer;  
    Security: SecurityType;  
    Compartment: CompartmentType;  
    Precedence: PrecedenceType;  
    BytesToRead: integer;  
    UnackedBytes: integer;  
    ConnectionState: ConnectionStateType;  
    LocalSocket: Socket6Type;  
    ForeignSocket: Socket6Type;  
  end;
```

Figure 17. IPv6 Pascal Declaration of Connection Information Record

Connection

Specifies a number identifying the connection that is described. This connection number is different from the connection number displayed by the NETSTAT command. For more information about the NETSTAT command, see *z/VM: TCP/IP User's Guide*.

OpenAttemptTimeout

Specifies the number of seconds that TCP continues to attempt to open a connection. You specify this number. If the limit is exceeded, TCP stops trying to open the connection and shuts down any partially open connection.

Security, Compartment, Precedence

Specifies entries used only when working within a multilevel secure

environment. These fields only have meaning when returned on a `Tcp6Status` call for an IPv4 connection. When specified for IPv6 connection requests, they will be ignored.

BytesToRead

Specifies the number of data bytes received from the foreign host by TCP, but not yet delivered to the client. TCP maintains this value.

UnackedBytes

Specifies the number of bytes sent by your program, but not yet sent to the foreign TCP, or the number of bytes sent to the foreign TCP, but not yet acknowledged.

LocalSocket

Specifies the local internet address, in IPv6 format, and local port. Together, these form one end of a connection. The foreign socket forms the other end. For the Pascal declaration of the `Socket6Type` record, see Figure 19.

ForeignSocket

Specifies the foreign, or remote, internet address, in IPv6 format, and its associated port. These form one end of a connection. The local socket forms the other end.

Socket Record

```

InternetAddressType = UnsignedIntegerType;
PortType = UnsignedHalfWordType;
SocketType =
  record
    Address: InternetAddressType;
    Port: PortType;
  end;

```

Figure 18. Pascal Declaration of Socket Type

Field	Description
Address	Specifies the internet address.
Port	Specifies the port.

```

IPv6AddressType = packed array (.1..16.) of char;
Socket6Type =
  record
    Address6: IPv6AddressType;
    Port: PortType;
    Flow: UnsignedIntegerType;
    Scope: UnsignedIntegerType;
  end; { Socket6Type }

```

Figure 19. IPv6 Pascal Declaration of Socket Type

Field	Description
Address6	Specifies the internet address. This can be specified as an IPv6 address or an IPv6 mapped IPv4 address (refer to RFC 4291).
Port	Specifies the port.
Flow	This field is ignored.
Scope	The scope field identifies a set of interfaces as appropriate for the scope of

the address carried in the Socket6Type record address field. For link local address, the scope can be used to specify the outgoing interface index. The z/VM stack supports scope for link local addresses only.

Notification Record

The notification record is used to provide event information. You receive this information by using the GetNextNote call. For more information, see “GetNextNote” on page 67. It is a variant record; the number of fields is dependent on the type of notification. For the Pascal declaration of this record. see Figure 20.

```
NotificationInfoType =
  record
    Connection: ConnectionType;
    Protocol: ProtocolType;
    case NotificationTag: NotificationEnumType of
      BUFFERspaceAVAILABLE:
        (
          AmountOfSpaceInBytes: integer
        );
      CLEARtextRESUMED
        (
          Connection: ConnectionType;
        );
      CONNECTIONstateCHANGED:
        (
          NewState: ConnectionStateType;
          Reason: CallReturnCodeType
        );
      DATAdelivered:
        (
          BytesDelivered: integer;
          LastUrgentByte: integer;
          PushFlag: Boolean
        );
      EXTERNALinterrupt:
        (
          RuptCode: integer
        );
      FRECEIVEerror:
        (
          ReceiveTurnCode: CallReturnCodeType;
          ReceiveRequestErr: Boolean;
        );
      FSENDresponse:
        (
          SendTurnCode: CallReturnCodeType;
          SendRequestErr: Boolean;
        );
      IOinterrupt:
        (
          DeviceAddress: integer;
          UnitStatus: UnsignedByteType;
          ChannelStatus: UnsignedByteType
        );
      IUCVinterrupt:
        (
          IUCVResponseBuf: IUCVBufferType
        );
      PINGresponse:
        (
          PingTurnCode: CallReturnCodeType;
          ElapsedTime: TimeStampType
        );
```

Figure 20. Notification Record (Part 1 of 2)

```

QueryTLSComplete:
(
  QTLSTurnCode: CallReturnCodeType;
);
RAWIPpacketsDELIVERED:
(
  RawIpDataLength: integer;
  RawIpFullLength: integer;
);
RAWIPspaceAVAILABLE:
(
  RawIpSpaceInBytes: integer;
);
READYforHANDSHAKE:
(
  HSTurnCode: CallReturnCodeType;
);
RESOURCESavailable: ();
SecureHandshakeComplete:
(
  SecHSCompleteDetail: SecureHSCompleteDetailType;
);
SMSGreceived: ();
TIMERexpired:
(
  Datum: integer;
  AssociatedTimer: TimerPointerType
);
UDPdatagramDELIVERED:
(
  DataLength: integer;
  ForeignSocket: SocketType;
  FullLength: integer
);
UDPdatagramSPACEavailable: ();
UDPresourcesAVAILABLE: ();
URGENTpending:
(
  BytesToRead: integer;
  UrgentSpan: integer
);
USERdefinedNOTIFICATION:
(
  UserData: UserNotificationDataType
);
end;

```

Figure 21. Notification Record (Part 2 of 2)

Connection

Indicates the client's connection number to which the notification applies. In the case of USERdefinedNOTIFICATION, this field is as supplied by the user in the AddUserNote call.

Protocol

In the case of USERdefinedNOTIFICATION, this field is as supplied by the user in the AddUserNote call. For all other notifications, this field is reserved.

NotificationTag

Is the type of notification being sent, and a set of fields dependent on the value of the tag. Possible tag values relevant to the TCP/UDP/IP interface and the corresponding fields are:

BUFFERspaceAVAILABLE

Notification given when space becomes available on a connection

for which `TcpSend` previously returned `NObufferSPACE`. For more information about these procedures, see “`TcpFSend`, `TcpSend`, and `TcpWaitSend`” on page 91.

AmountOfSpaceInBytes

Indicates the minimum number of bytes that the TCP/IP service has available for buffer space for this connection. The actual amount of buffer space might be more than this number.

CLEARtextRESUMED

Notification given when a `Close_Notify` command is received on the connection.

Connection

Indicates the connection number which received the `Close_notify` command.

CONNECTIONstateCHANGED

Indicates that a TCP connection has changed state.

NewState

Indicates the new state for this connection.

Reason

Indicates the reason for the state change. This field is meaningful only if the `NewState` field has a value of `NONEXISTENT`.

Note:

1. The following is the sequence of state notifications for a connection.
 - For active open:
 - `OPEN`
 - `RECEIVINGonly` or `SENDINGonly`
 - `CONNECTIONclosing`
 - `NONEXISTENT`.
 - For passive open:
 - `TRYINGtoOPEN`
 - `OPEN`
 - `RECEIVINGonly` or `SENDINGonly`
 - `CONNECTIONclosing`
 - `NONEXISTENT`.

Your program should be prepared for any intermediate step or steps to be skipped.
2. The normal TCP connection closing sequence can lead to a connection staying in `CONNECTIONclosing` state for up to two minutes, corresponding to the TCP state `TIME-WAIT`.
3. Possible Reason codes giving the reason for a connection changing to `NONEXISTENT` are:
 - `OK` (means normal closing)
 - `UNREACHABLEnetwork`
 - `TIMEOUTopen`
 - `OPENrejected`
 - `REMOTEReset`
 - `WRONGsecORprc`
 - `UNEXPECTEDsyn`

- FATALerror
- KILLEDbyCLIENT
- TIMEOUTconnection
- TCPipSHUTDOWN
- DROPPEDbyOPERATOR.

DATAdelivered

Notification given when your buffer (named in an earlier TcpReceive or TcpFReceive request) contains data.

Note: The data delivered should be treated as part of a byte-stream, not as a message. There is no guarantee that the data sent in one TcpSend (or equivalent) call on the foreign host is delivered in a single DATAdelivered notification, even if the PushFlag is set.

BytesDelivered

Indicates the number of bytes of data delivered to you.

LastUrgentByte

Indicates the number of bytes of urgent data remaining, including data just delivered.

PushFlag

TRUE if the last byte of data was received with the push bit set.

EXTERNALinterrupt

Notification given when a simulated external interrupt occurs in your virtual machine. The Connection and Protocol fields are not applicable.

RuptCode

The interrupt type.

FRECEIVEerror

Notification given in place of DATAdelivered when a TcpFReceive that initially returned OK has terminated without delivering data.

ReceiveTurnCode

Specifies the reason the TcpFReceive has failed or was canceled. If ReceiveRequestErr is set to FALSE, ReceiveTurnCode contains the same reason as the Reason field in the CONNECTIONstateCHANGED with NewState set to NONEXISTENT notification for this connection (see 2 on page 52). ReceiveTurnCode could be OK, if the connection closed normally.

ReceiveRequestErr

If TRUE, the TcpFReceive was rejected during initial processing. If FALSE, the TcpFReceive was initially accepted, but was terminated because of connection closing.

Note: Normally, you do not need to take any action upon receipt of this notification with ReceiveRequestErr set to FALSE, because your program receives a CONNECTIONstateCHANGED notification informing it that the connection has been terminated.

FSENDresponse

Notification given when a TcpFSend request is completed, successfully or unsuccessfully.

SendTurnCode

Indicates the status of the send operation.

SendRequestErr

If TRUE, the TcpFSend was rejected during initial processing or during retry after buffer space became available. If FALSE, the TcpFSend was canceled because of connection closing.

IOinterrupt

Notification given when a simulated I/O interrupt occurs in your virtual machine. The Connection and Protocol fields are not applicable.

DeviceAddress

This address corresponds to the DEVICE statement.

UnitStatus

Specifies the status returned by the device.

ChannelStatus

Specifies the status returned by the channel.

IUCVinterrupt

Notification given when a simulated IUCV interrupt occurs in your virtual machine. The Connection and Protocol fields are not applicable.

IUCVResponseBuf

Contains the information returned from the application.

PINGresponse

Notification given when a PINGresponse is received.

PingTurnCode

Specifies the status of the ping operation.

ElapsedTime

Indicates the time elapsed between the sending of a request and the reception of a response. This time does not include the time spent in the simulated Virtual Machine Communication Facility (VMCF) communication between your program and the TCPIP virtual machine. This field is valid only if PingTurnCode has a value of OK.

QUERYtlsCOMPLETE

Notification given when the SSL server has completed verification of the label passed on the QueryTLS command.

ReturnCode

Indicates the status of the QUERYtlsCOMPLETE operation. READYforHANDSHAKE to read: 'Any other return code indicates a handshake failure.'

RAWIPpacketsDELIVERED

Notification given when your buffer (indicated in an earlier RawIpReceive request) contains a datagram. Only one datagram is delivered on each notification. Your buffer contains the entire IP header, plus as much of the datagram as fits in your buffer.

RawIpDataLength

Specifies the actual data length delivered to your buffer. If this is less than RawIpFullLength, the datagram was truncated.

RawIpFullLength

Specifies the length of the packet, from the TotalLength field of the IP header.

RAWIPspaceAVAILABLE

When space becomes available after a client does a RawIpSend and receives a NObufferSPACE return code, the client receives this notification to indicate that space is now available.

RawIpSpaceInBytes

Specifies the amount of space available always equals the maximum size IP datagram.

READYforHANDSHAKE

Notification given when a TcpSServer command is issued with a null data buffer. It indicates that the connection is now waiting for a handshake.

ReturnCode

Indicates status of the handshake. A return code of OK indicates that the connection is waiting for a handshake. Any other return code indicates that there was a problem and the handshake cannot be done.

RESOURCESavailable

Notice given when resources needed for a TcpOpen or TcpWaitOpen are available. This notification is sent only if a previous TcpOpen or TcpWaitOpen returned ZEROresources.

SECUREhandshakeCOMPLETE

Notification given when SSL has completed the handshake (either inbound or outbound).

```
SecureHSCompleteDetailType =
record
  ReturnCode: SecureTurnCodeType;
  AlertLevel: SecureAlertLevelType;
  AlertDescription: SignedHalfwordType;
end
```

ReturnCode

Indicates the status of the handshake.

```
SecureTurnCodeType = (NOALERT, ALERT, TIMEOUT)
```

NOALERT

Indicates that the handshake completed successfully.

ALERT

Problems were encountered during the handshake.

TIMEOUT

The handshake did not complete within the time allotted.

AlertLevel

When the ReturnCode is ALERT, this classifies the level of the alert.

SecureAlertLevelType = (AlertOK, Warning, Fatal)

AlertDescription

When the ReturnCode is ALERT, this field contains the details of the failure.

SMSGreceived

Notification given when one or more Special Messages (Smsgs) arrive. The GetSmsg call is used to retrieve queued Smsgs. For information on the SMSG command, see *z/VM: TCP/IP User's Guide*.

TIMERexpired

Notification given when a timer set through SetTimer expires.

Datum

Indicates the data specified when SetTimer was called.

AssociatedTimer

Specifies the address of the timer that expired.

UDPdatagramDELIVERED

Notification given when your buffer, indicated in an earlier UdpNReceive or UdpReceive request, contains a datagram. Your buffer contains the datagram excluding the UDP header.

Note: If UdpReceive was used, your buffer contains the entire datagram excluding the header, with the length indicated by DataLength. If UdpNReceive was used, and DataLength is less than FullLength, your buffer contains a truncated datagram. The reason is that the length of your buffer was too small to contain the entire datagram.

DataLength

Specifies the length of the data delivered to your buffer.

ForeignSocket

Specifies the source of the datagram.

FullLength

Specifies the length of the entire datagram, excluding the UDP header. This field is set only if UdpNReceive was used.

UDPdatagramSPACEavailable

Notification given when buffer space becomes available for a datagram for which UdpSend previously returned NObufferSPACE because of insufficient resources.

UDPresourcesAVAILABLE

Notice given when resources needed for a UdpOpen are available. This notification is sent only if a previous UdpOpen returned UDPzeroRESOURCES.

URGENTpending

Notification given when there is urgent data pending on a TCP connection.

BytesToRead

Indicates the number of incoming bytes not yet delivered to the client.

UrgentSpan

Indicates the number of undelivered bytes to the last known urgent pointer. No urgent data is pending if this is negative.

USERdefinedNOTIFICATION

Notice generated from data passed to AddUserNote by your program.

UserData

A 40-byte field supplied by your program through AddUserNote. The Connection and Protocol fields are also set from the values supplied to AddUserNote.

File Specification Record

The file specification record is used to fully specify a file. The Pascal declaration is shown in Figure 22.

```

SpecOfFileType =
  record
    Owner: DirectoryNameType;
    Case SpecOfSystemType of
      VM:
        (
          VirtualAddress:VirtualAddressType;
          NewVirtualAddress:VirtualAddressType;
          DiskPassword: DirectoryNameType;
          Filename: DirectoryNameType;
          Filetype: DirectoryNameType;
          Filemode: FilemodeType
        );
      MVS:
        (
          (* The MVS declaration is listed here. *)
        );
    end;
  end;

```

Figure 22. Pascal Declaration of File Specification Record

Using Procedure Calls

Your program uses procedure calls to initiate communication with the TCPIP virtual machine. Most of these procedure calls return with a code, which indicates success or the type of failure incurred by the call. For an explanation of the return codes, see Table 97 on page 405.

Before invoking any of the other interface procedures, use BeginTcpIp or StartTcpNotice to start up the TCP/UDP/IP service. Once the TCP/UDP/IP service has begun, use the Handle procedure to specify a set of notifications that the TCP/UDP/IP service can send you. To terminate the TCP/UDP/IP service, use the EndTcpIp procedure.

Notifications

The TCPIP virtual machine sends you notifications to inform you of asynchronous events. Also, some notifications are generated in your virtual machine by the TCP interface. Notifications can be received only after BeginTcp or StartTcpNotice.

The notifications are received by the TCP interface and kept in a queue. Use GetNextNote to get the next notification. The notifications are in Pascal variant record form. For more information (see Figure 20 on page 50).

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The following table provides a short description of the Notification procedure calls and gives the page number where each call's detailed description is located.

Table 6. Pascal Language Interface Summary—Notifications

Procedure Call	Description	Location
GetNextNote	Retrieves the next notification.	"GetNextNote" on page 67
Handle	Specifies the types of notifications that your program can process.	"Handle" on page 68
NotifyIo	Requests that an IOinterrupt notification be sent to you when an I/O interrupt occurs on a given virtual address.	"NotifyIo" on page 72
Unhandle	Specifies notification types that your program can no longer process.	"Unhandle" on page 110
UnNotifyIo	Indicates that you no longer wish to be sent a notification when an I/O interrupt occurs on a given virtual address.	"UnNotifyIo" on page 111

TCP/UDP Initialization Procedures

The UDP initialization procedures affect all present and future connections. Use these procedures to initialize the TCP/IP environment for your program.

The following table provides a short description of the TCP/UDP Initialization procedure calls and gives the page number where each call's detailed description is located.

Table 7. Pascal Language Interface Summary—TCP/UDP Initialization

Procedure Call	Description	Location
TcpNameChange	Identifies the name of the virtual machine running the TCP/IP program when the virtual machine has a name other than TCPIP.	"TcpNameChange" on page 94
BeginTcpIp	Establishes communication with the TCP/IP services.	"BeginTcpIp" on page 63
StartTcpIpNotice	Establishes communication with the TCP/IP services.	"StartTcpIpNotice" on page 82

TCP/UDP Termination Procedure

The Pascal API has one termination procedure call. You should use the EndTcpIp call when you have finished with the TCP/IP services.

The following table provides a short description of the TCP/UDP Termination procedure call and gives the page number where the call's detailed description is located.

Table 8. Pascal Language Interface Summary—TCP/UDP Termination

Procedure Call	Description	Location
EndTcpIp	Terminates communication with the TCP/IP services.	"EndTcpIp" on page 65

Handling External Interrupts

The handling external interrupts procedures allow you to pass simulated external interrupts to the TCP interface. You must call the StartTcpNotice initialization routine before you can begin using the external interrupt calls.

The following table provides a short description of the Handling External Interrupts and gives the page number where each call's detailed description is located.

Table 9. Pascal Language Interface Summary—Handling External Interrupts

Procedure Call	Description	Location
TcpExtRupt	Notifies the TCP interface of the arrival of a simulated external interrupt.	"TcpExtRupt" on page 88
RTcpExtRupt	A version of TcpExtRupt.	"RTcpExtRupt" on page 78
TcpVmcfRupt	Notifies the TCP interface of the arrival of a simulated external VMCF interrupt.	"TcpVmcfRupt" on page 104
RTcpVmcfRupt	A version of TcpVmcfRupt.	"RTcpVmcfRupt" on page 79

TCP Communication Procedures

The TCP communication procedures apply to a particular client connection. Use these procedures to establish a connection and to communicate. You must call either the `BeginTcpIp` or the `StartTcpNotice` initialization routine before you can begin using TCP communication procedures.

The following table provides a short description of the TCP communication procedures and gives the page number where each call's detailed description is located.

Table 10. Pascal Language Interface Summary—TCP Communication Procedures

Procedure Call	Description	Location
Tcp6Open	Initiates a TCP IPv6 connection.	"Tcp6Open and Tcp6WaitOpen" on page 83
Tcp6Status	Obtains the current status of a TCP IPv6 connection.	"Tcp6Status" on page 86
Tcp6WaitOpen	Initiates a TCP IPv6 connection and waits for the establishment of the connection.	"Tcp6Open and Tcp6WaitOpen" on page 83
TcpNameChange	Is used if the virtual machine running the TCP/IP program is not using the default name, TCPIP, and is not the same as specified in the TCPIPUSERID statement of the TCPIP DATA file.	"TcpNameChange" on page 94
TcpOpen	Initiates a TCP IPv4 connection.	"TcpOpen and TcpWaitOpen" on page 94
TcpOption	Sets an option for a TCP connection.	"TcpOption" on page 97
TcpSClient	Indicates to the SSL server that the connection is to be secure and that the SSL server needs to initiate an outbound handshake.	"TcpSClient" on page 98
TcpSClose	Performs <code>Close_Notify</code> on a TLS connection but leave the TCP session up.	"TcpSClose" on page 100
TcpSServer	Indicates to the SSL server that the connection is to be secure and that the SSL server needs to wait for an incoming handshake.	"TcpSServer" on page 100
TcpSStatus	Returns details about a session, such as whether or not it is secure and the encryption suite.	"TcpSStatus" on page 101.
TcpWaitOpen	Initiates a TCP IPv4 connection and waits for the establishment of the connection.	"TcpOpen and TcpWaitOpen" on page 94

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Table 10. Pascal Language Interface Summary—TCP Communication Procedures (continued)

Procedure Call	Description	Location
TcpFSend	Sends TCP data.	“TcpFSend, TcpSend, and TcpWaitSend” on page 91
TcpSend	Sends TCP data.	“TcpFSend, TcpSend, and TcpWaitSend” on page 91
TcpWaitSend	Sends TCP data and waits until TCPIP accepts it.	“TcpFSend, TcpSend, and TcpWaitSend” on page 91
TcpFReceive	Establishes a buffer to receive TCP data.	“TcpFReceive, TcpReceive, and TcpWaitReceive” on page 89
TcpReceive	Establishes a buffer to receive TCP data.	“TcpFReceive, TcpReceive, and TcpWaitReceive” on page 89
TcpWaitReceive	Establishes a buffer to receive TCP data and waits for the reception of the data.	“TcpFReceive, TcpReceive, and TcpWaitReceive” on page 89
TcpClose	Begins the TCP one-way closing sequence.	“TcpClose” on page 87
TcpAbort	Shuts down a TCP connection immediately.	“TcpAbort” on page 87
TcpStatus	Obtains the current status of a TCP IPv4 connection.	“TcpStatus” on page 102

Ping Interface

The Ping interface lets a client send an ICMP echo request to a foreign host. You must call either the `BeginTcpIp` or the `StartTcpNotice` initialization routine before you can begin using the Ping Interface.

The following table provides a short description of the Ping interface procedures and gives the page number where each call’s detailed description is located.

Table 11. Pascal Language Interface Summary—Ping Interface

Procedure Call	Description	Location
PingRequest	Sends an Internet Control Message Protocol (ICMP) echo request.	“PingRequest” on page 73

Monitor Procedures

Two monitor procedures, `MonCommand` and `MonQuery`, provide a mechanism for querying and controlling the TCPIP virtual machine.

The following table provides a short description of the Monitor procedures and gives the page number where each call’s detailed description is located.

Table 12. Pascal Language Interface Summary—Monitor Procedures

Procedure Call	Description	Location
MonCommand	Instructs TCP to read a specific file and execute the commands that it contains.	“MonCommand” on page 70
MonQuery	Performs control functions and retrieves internal TCPIP control blocks.	“MonQuery” on page 71

UDP Communication Procedures

The UDP communication procedures describe the programming interface for the User Datagram Protocol (UDP) provided in the TCP/IP product.

The following table provides a short description of the UDP communication procedures and gives the page number where each call's detailed description is located.

Table 13. Pascal Language Interface Summary—UDP Communication Procedures

Procedure Call	Description	Location
Udp6Open	Requests communication with UDP on a specified socket using IPv4 or IPv6 protocols.	"Udp6Open" on page 104
Udp6Send	Sends a UDP datagram to a specified foreign socket.	"Udp6Send" on page 105
UdpOpen	Requests communication with UDP on a specified socket using IPv4 protocols.	"UdpOpen" on page 107
UdpSend	Sends a UDP datagram to a specified foreign socket.	"UdpSend" on page 109
UdpNReceive	Notifies the TCPIP virtual machine that you are willing to receive UDP datagram data.	"UdpNReceive" on page 106
UdpReceive	Notifies the TCPIP virtual machine that you are willing to receive UDP datagram data.	"UdpReceive" on page 108
UdpClose	Terminates use of a UDP socket.	"UdpClose" on page 106

Raw IP Interface

The Raw IP interface lets a client program send and receive arbitrary IP packets on any IP protocol except TCP and UDP. Only one client can use any given protocol at one time. Only clients in the obey list can use the Raw IP interface. For further information about the obey list, see *z/VM: TCP/IP Planning and Customization*.

The following table provides a short description of the Raw IP interface procedures and gives the page number where each call's detailed description is located.

Table 14. Pascal Language Interface Summary—Raw IP Interface

Procedure Call	Description	Location
RawIpOpen	Informs the TCPIP virtual machine that the client wants to send and receive IP packets of a specified protocol.	"RawIpOpen" on page 75
RawIpReceive	Specifies a buffer to receive raw IP packets of a specified protocol.	"RawIpReceive" on page 75
RawIpSend	Sends raw IP packets of a specified protocol.	"RawIpSend" on page 76
RawIpClose	Informs the TCPIP virtual machine that the client no longer handles the protocol.	"RawIpClose" on page 74

Timer Routines

The timer routines are used with the TCP/UDP/IP interface. You must call either the `BeginTcpIp` or the `StartTcpNotice` initialization routine before you can begin using the timer routines.

The following table provides a short description of the Timer routines and gives the page number where each call's detailed description is located.

Pascal Language

Table 15. Pascal Language Interface Summary—Timer Routines

Procedure Call	Description	Location
CreateTimer	Allocates a timer.	“CreateTimer” on page 64
ClearTimer	Resets a timer.	“ClearTimer” on page 64
SetTimer	Sets a timer to expire after a specified interval.	“SetTimer” on page 82
DestroyTimer	Deallocates a timer.	“DestroyTimer” on page 64

Host Lookup Routines

The host lookup routines (with the exception of `GetHostResol`) are declared in the `CMINTER` member of the `ALLMACRO MACLIB`. The host lookup routine `GetHostResol` is declared in the `CMRESGLB` member of the `ALLMACRO MACLIB`. Any program using these procedures must include `CMINTER` or `CMRESGLB` after the include statements for `CMCOMM` and `CMCLIEN`.

The following table provides a short description of the host lookup routines and gives the page number where each call’s detailed description is located.

Table 16. Pascal Language Interface Summary—Host Lookup Routines

Procedure Call	Description	Location
GetHostNumber	Converts a host name to an internet address using static tables.	“GetHostNumber” on page 65
GetHostResol	Converts a host name to an internet address using a domain name resolver.	“GetHostNumber” on page 65
GetHostString	Converts an internet address to a host name using static tables.	“GetHostString” on page 66
GetIdentity	Returns environment information.	“GetIdentity” on page 66
IsLocalAddress	Determines if an internet address is local.	“IsLocalAddress” on page 69
IsLocalHost	Determines if a host name is local, remote, loopback, or unknown.	“IsLocalHost” on page 69

Other Routines

The following table provides a short description of these procedure calls and gives the page number where the detailed description is located.

Table 17. Pascal Language Interface Summary—Other Routines

Procedure Call	Description	Location
GetSmsg	Retrieves one queued special message (<code>Smsg</code>).	“GetSmsg” on page 68
QueryTLS	Determines if the security server is available, and if the label is specified, is it known to the security server.	“QueryTLS” on page 73.
ReadXlateTable	Reads a binary translation table file.	“ReadXlateTable” on page 77
SayCalRe	Converts a return code into a descriptive message.	“SayCalRe” on page 79
SayConSt	Converts a connection state into a descriptive message.	“SayConSt” on page 80
SayIntAd	Converts an internet address into a name or dotted-decimal form.	“SayIntAd” on page 80
SayIntNum	Converts an internet address into its dotted-decimal form.	“SayIntNum” on page 81

Table 17. Pascal Language Interface Summary—Other Routines (continued)

Procedure Call	Description	Location
SayNotEn	Converts a notification enumeration type into a descriptive message.	“SayNotEn” on page 81
SayPorTy	Converts a port number into a descriptive message or into EBCDIC.	“SayPorTy” on page 81
SayProTy	Converts the protocol type into a descriptive message or into EBCDIC.	“SayProTy” on page 82
SaySslRe	Returns a printable string describing the AlertDescription returned when a handshake completes. The AlertDescription is passed in CallReturn.	“SaySslRe” on page 80.
AddUserNote	Adds a USERdefinedNOTIFICATION notification to the note queue.	“AddUserNote”

Procedure Calls

This section provides the syntax, operands, and other appropriate information for each Pascal procedure call supported by TCP/IP for VM.

AddUserNote

The AddUserNote procedure can be called to add a USERdefinedNOTIFICATION notification to the note queue and wake up GetNextNote if it is waiting for a notification. For more information, see “RTcpExtRupt” on page 78 and “RTcpVmcfRupt” on page 79.

BeginTcpIp

The BeginTcpIp procedures inform the TCPIP virtual machine that you want to start using its services. If your program handles simulated external interrupts itself, use StartTcpNotice rather than BeginTcpIp. For information about simulated external interrupt support, see Chapter 3, “Virtual Machine Communication Facility Interface,” on page 117.

```

procedure BeginTcpIp
(
  var   ReturnCode: integer
);
external;

```

Operand Description

ReturnCode

Indicates success or failure of call. Possible return values are:

- OK
- ABNORMALcondition
- fatalerror
- NOtcpIPservice
- TCPIPALREADYstarted
- TCPIPshutdown
- VIRTUALmemoryTOOsmall

BeginTcplp

If ReturnCode is OK, you must call EndTcpIp when you have finished with the TCP/IP services.

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

ClearTimer

The ClearTimer procedure resets the timer to prevent it from timing out.

```
procedure ClearTimer
(
    T: TimerPointerType
);
external;
```

Operand	Description
---------	-------------

T	Specifies a timer pointer, as returned by a previous CreateTimer call.
---	------------------------------------------------------------------------

CreateTimer

The CreateTimer procedure allocates a timer. The timer is not set in any way. For the procedure to activate the timer, see "SetTimer" on page 82.

```
procedure CreateTimer
(
    var T: TimerPointerType
);
external;
```

Operand	Description
---------	-------------

T	Sets to a timer pointer that can be used in subsequent SetTimer, ClearTimer, and DestroyTimer calls.
---	------------------------------------------------------------------------------------------------------

DestroyTimer

The DestroyTimer procedure deallocates or *fre*es a timer that you created.

```
procedure DestroyTimer
(
    var T: TimerPointerType
);
external;
```

Operand	Description
---------	-------------

T	Specifies a timer pointer, as returned by a previous CreateTimer call.
---	------------------------------------------------------------------------

EndTcpIp

The EndTcpIp procedure releases ports and protocols in use that are not permanently reserved. It causes TCP to clean up any data structures it has associated with you. Use EndTcpIp when you have finished with the TCP/IP services.

It is safe to call EndTcpIp even if BeginTcpIp or StartTcpNotice did not previously succeed.

```
procedure EndTcpIp;
external;
```

The EndTcpIp procedure has no operands.

GetHostNumber

The GetHostNumber procedure resolves a host name into an internet address.

GetHostNumber uses a table lookup to convert the name of a host to an internet address, and returns this address to the HostNumber field. When the name is a dotted-decimal number, GetHostNumber returns the integer represented by that dotted-decimal. The dotted-decimal representation of a 32-bit number has one decimal integer for each of the 4 bytes, separated by dots. For example, 14.0.0.7 for X'0E000007'. For information about how to create host lookup tables, see *z/VM: TCP/IP Planning and Customization*.

The HostNumber field is set to NOhost if the host is not found.

```
procedure GetHostNumber
(
  const   Name: string;
  var     HostNumber: InternetAddressType
);
external;
```

Operand

Description

Name Specifies the name or dotted-decimal number to be converted.

HostNumber

Set to the converted address, or NOhost if conversion fails.

GetHostResol

The GetHostResol procedure resolves a host name into an internet address by using a name server.

GetHostResol passes the query to the remote name server through the resolver. The name server converts the name of a host to an internet address, and returns this address in the HostNumber field. If the name server does not respond or does not find the name, the host name is converted to a host number by table lookup. When the name is a dotted-decimal number, the integer represented by that

GetHostResol

dotted-decimal is returned. The dotted-decimal representation of a 32-bit number has one decimal integer for each of the 4 bytes, separated by dots. For example, 14.0.0.7 for X'0E000007'.

The HostNumber field is set to NOhost if the host is not found.

```
procedure GetHostResol
(
  const   Name: string;
  var     HostNumber: InternetAddressType
);
external;
```

Operand

Description

Name Specifies the name or dotted-decimal number to be converted.

HostNumber

Set to the converted address, or NOhost if conversion fails.

GetHostString

The GetHostString procedure uses a table lookup to convert an internet address to a host name, and returns this string in the Name field. The first host name found in the lookup is returned. If no host name is found, a gateway or network name is returned. If no gateway or network name is found, a null string is returned.

```
procedure GetHostString
(
  Address: InternetAddressType;
  var     Name: SiteNameType
);
external;
```

Operand

Description

Address

Specifies the address to be converted.

Name Set to the corresponding host, gateway, or network name, or to null string if no match found.

GetIdentity

The GetIdentity procedure returns the following information:

- The user ID of the VM user
- The host machine name
- The network domain name
- The user ID of the TCPIP virtual machine.

The host machine name and domain name are extracted from the HOSTNAME and DOMAINORIGIN statements, respectively, in the *user_id* DATA file. If the *user_id* DATA file does not exist, the TCPIP DATA file is used. If a HOSTNAME statement is not specified, then the default host machine name is the name specified by the TCP/IP installer during installation. See *z/VM: TCP/IP Planning*

and Customization. The TCPIP virtual machine user ID is extracted from the TCPIPUSERID statement in the *user_id* DATA file; if the statement is not specified, the default is TCPIP.

```

procedure GetIdentity
(
  var   UserId: DirectoryNameType;
  var   HostName, DomainName: String;
  var   TcpIpServiceName: DirectoryNameType;
  var   Result: integer
);
external;

```

Operand Description

UserId

Specifies the user ID of the VM user or the job name of a batch job that has invoked GetIdentity.

HostName

Specifies the host machine name.

DomainName

Specifies the network domain name.

TcpIpServiceName

Specifies the user ID of the TCPIP virtual machine.

GetNextNote

The GetNextNote procedure retrieves notifications from the queue. This procedure returns the next notification queued for you.

```

procedure GetNextNote
(
  var   Note: NotificationInfoType;
        ShouldWait: Boolean;
  var   ReturnCode: integer
);
external;

```

Operand Description

Note Indicates that the next notification is stored here when ReturnCode is OK.

ShouldWait

Sets ShouldWait to TRUE if you want GetNextNote to wait until a notification becomes available. Set ShouldWait to FALSE if you want GetNextNote to return immediately. When ShouldWait is set to FALSE, ReturnCode is set to NOoutstandingNOTIFICATIONS if no notification is currently queued.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOoutstandingNOTIFICATIONS
- NOTyetBEGUN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

GetSmsg

The GetSmsg procedure is called by your program after receiving an SMSGreceived notification. Each call to GetSmsg retrieves one queued Smsg. Your program should exhaust all queued Smsgs, by calling GetSmsg repeatedly until the Success field returns with a value of FALSE. After a value of FALSE is returned, do not call GetSmsg again until you receive another SMSGreceived notification.

For information about the SMSG command, see *z/VM: TCP/IP User's Guide*

```
procedure GetSMsg
(
  var   Smsg: SmsgType;
  var   Success: Boolean;
);
external;
```

Operand

Description

Smsg Set to the returned Smsg if Success is set to TRUE.

Success

TRUE if Smsg returned, otherwise FALSE.

Handle

The Handle procedure specifies that you want to receive notifications in the given set. You must always use it after calling the BeginTcpIp procedure and before accessing the TCP/IP services. This Pascal set can contain any of the NotificationEnumType values shown in Figure 20 on page 50.

```
procedure Handle
(
  Notifications: NotificationSetType;
  var   ReturnCode: integer
);
external;
```

Operand

Description

Notifications

Specifies the set of notification types to be handled.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOTyetBEGUN
- TCPipSHUTDOWN
- ABNORMALcondition
- FATALerror

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

IsLocalAddress

The IsLocalAddress procedure queries the TCPIP virtual machine to determine whether the HostAddress is one of the addresses recognized for this host. If the address is local, it returns OK. If the address is not local, it returns NONlocalADDRESS.

```

procedure IsLocalAddress
(
    HostAddress: InternetAddressType;
var   ReturnCode: integer
);
external;

```

Operand	Description
----------------	--------------------

HostAddress	Specifies the host address to be tested.
--------------------	------------------------------------------

ReturnCode	Indicates whether the host address is local, or may indicate an error. Possible return values are:
-------------------	----------------------------------------------------------------------------------------------------

- OK
- NONlocalADDRESS
- TCPIPshutdown
- ABNORMALcondition
- FATALerror

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

IsLocalHost

The IsLocalHost procedure returns the correct host class for Name, which may be a host name or a dotted-decimal address.

The host classes are:

Host Class	Description
-------------------	--------------------

HOSTlocal	Specifies an internet address for the local host.
------------------	---------------------------------------------------

HOSTloopback	Specifies one of the dummy internet addresses used to designate various levels of loopback testing.
---------------------	-----------------------------------------------------------------------------------------------------

HOSTremote	Specifies a known host name for some remote host.
-------------------	---------------------------------------------------

HOSTunknown	Specifies an unknown host name (or other error).
--------------------	--------------------------------------------------

IsLocalHost

```
procedure IsLocalHost
(
  const   Name: string;
  var     Class: HostClassType
);
external;
```

Operand

Description

Name Specifies the host name.

Class Specifies the host class.

MonCommand

The MonCommand procedure instructs the TCPIP virtual machine to read a specific file and execute the commands found there. This procedure updates TCPIP internal tables and parameters while the TCPIP virtual machine is running. For example, the type and destination of run-time tracing can be modified dynamically using MonCommand. This procedure is used by the OBEYFILE command. For more information about the OBEYFILE command, see *z/VM: TCP/IP Planning and Customization*. You must be in the TCPIP obey list to use the MonCommand procedure.

```
procedure MonCommand
(
  const   FileSpec: SpecOfFileType;
  var     ReturnCode: integer
);
external;
```

Operand

Description

FileSpec

Specifies a file in a manner that allows access to that file. The TCPIP virtual machine must be authorized to access the file.

The SpecOfFileType record is listed in Figure 22 on page 57.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- ERRORinPROFILE
- HASnoPASSWORD
- INCORRECTpassword
- INVALIDuserID
- INVALIDvirtualADDRESS
- MINIDISKinUSE
- MINIDISKnotAVAILABLE
- NOTyetBEGUN
- PROFILEnotFOUND
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDuser
- UNIMPLEMENTEDrequest

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

MonQuery

The MonQuery procedure obtains status information, or requests TCPIP to perform certain actions. This procedure is used by the NETSTAT command. For more information about the NETSTAT command, see *z/VM: TCP/IP User's Guide*.

```

procedure MonQuery
(
    QueryRecord: MonQueryRecordType;
    Buffer: integer;
    BufSize: integer;
var   ReturnCode: integer;
var   Length: integer
);
external;

```

Operand

Description

Buffer Specifies the address of the buffer to receive data.

BufSize

Specifies the size of the buffer.

ReturnCode

Indicates the success or failure of the call.

Length

Specifies the length of the data returned in the buffer.

QueryRecord

Sets up a QueryRecord to specify the type of status information to be retrieved. The MonQueryRecordType is shown in Figure 23.

```

MonQueryRecordType =
record
case QueryType: MonQueryType of
QUERYhome, QUERYgateways, QUERYcontrolBLOCKS,
QUERYstartTIME, QUERYtelnetSTATUS,
QUERYdevicesANDlinks,
QUERYhomeONLY: ();
QUERYudpPORTowner:
(
    QueryPort: PortType
);
COMMANDcpCMD:
(
    CpCmd: WordType
);
COMMANDdropCONNECTION:
(
    Connection: ConnectionType
);
end; { MonQueryRecordType }

```

Figure 23. Monitor Query Record

The only QueryType values available for your use are:

QUERYhomeONLY

Used to obtain a list of the home internet addresses recognized by your TCPIP virtual machine. Your program sets the Buffer to the address of a variable of type HomeOnlyListType, and the BufSize to its length. When MonQuery returns, Length is set to the length of the Buffer that was used, if ReturnCode is OK. Divide the Length by size of (InternetAddressType) to get the number of the home addresses that are returned.

COMMANDdropCONNECTION

Used to instruct the TCPIP virtual machine to drop a TCP connection. The connection is reset, and the client process owning the connection is sent a NONEXISTENT notification with the Reason field set to DROPPEDbyOPERATOR. Your program sets the Connection field to the number of the connection to be dropped. The connection number is the number displayed by the NETSTAT CONN or the NETSTAT TELNET command, and is not the same number used to refer to the connection by the client program that owns the connection. For information about the NETSTAT command, see *z/VM: TCP/IP User's Guide*. The virtual machine running your program that uses COMMANDdropCONNECTION must be in the TCPIP virtual machine.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- NOTyetBEGUN
- TCPipSHUTDOWN
- UNAUTHORIZEDuser
- UNIMPLEMENTEDrequest

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

NotifyIo

The NotifyIo procedure is used to request that an IOinterrupt notification be sent to you when an I/O interrupt occurs on a given virtual address. You can specify that you wish notifications on up to 10 different virtual device addresses (by means of individual NotifyIo calls). This notification is intended for unsolicited interrupts, not for interrupts showing the completion of a channel program.

```
procedure NotifyIo
(
    DeviceAddress: integer;
var    ReturnCode: integer;
);
external;
```

Operand

Description

DeviceAddress

Specifies the address of the device for which IOinterrupt notifications are to be generated.

ReturnCode

Indicates success or failure of the call. Possible return values are:

- OK
- TOOManyOPENS
- SOFTWAREerror

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

PingRequest

The PingRequest procedure sends an ICMP echo request to a foreign host. When a response is received or the time-out limit is reached, you receive a PingResponse notification.

The PingRequest procedure is used by the PING user command. For more information about the PING command, see *z/VM: TCP/IP Planning and Customization*.

```

procedure PingRequest
(
  ForeignAddress: InternetAddressType;
  Length: integer;
  Timeout: integer;
  var ReturnCode: integer
);
external;

```

Operand

Description

ForeignAddress

Specifies the address of the foreign host to be pinged.

Length

Specifies the length of the ping packet, excluding the IP header. The range of values for this field are 8 to 512 bytes.

Timeout

Specifies how long to wait for a response, in seconds.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- BADlengthARGUMENT
- CONNECTIONalreadyEXISTS
- NObufferSPACE
- NOTyetBEGUN

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note: CONNECTIONalreadyEXISTS, in this context, means a ping request is already outstanding.

QueryTLS

The QueryTLS with an optional label determines if the security server is available, and if the label is specified, is it known to the security server.

```
Procedure QueryTLS
(
    TLSLabel: DirectoryNameType;
    TLSKeyring: KeyringType;
    var ReturnCode: CallReturnCodeType
);
KeyringType = packed array(. 1..KEYRINGlength .) of char;
KEYRINGlength = 50;
```

Operand Description

TLSLabel

The certificate label passed along to the security server for verification.

TLSKeyring

Specifies the group that the label resides in; this capability is not yet available and must be specified as null.

ReturnCode

Indicates success or failure of the call. Possible return code values are:

- OK
- BACKlevelSSL
- KEYRINGnotPERMITTED
- KEYRINGnotRECOGNIZED
- LABELnotPERMITTED
- LABELnotRECOGNIZED
- NOTyetBEGUN
- SOFTWAREError
- SSLnotAVAILABLE
- SSLnotRESPONDING
- TCPipSHUTDOWN
- TLSnotAVAILABLE
- UNAUTHORIZEDuser

RawIpClose

The RawIpClose procedure tells the TCPIP virtual machine that the client does not handle the protocol any longer. Any queued incoming packets are discarded.

When the client is not handling the protocol, a return code of NOSuchCONNECTION is received.

```
procedure RawIpClose
(
    ProtocolNo: integer;
    var ReturnCode: integer
);
external;
```

Operand Description

ProtocolNo

Specifies the number of the IP protocol.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDuser

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

RawIpOpen

The RawIpOpen procedure tells the TCPIP virtual machine that the client wants to send and receive packets of the specified protocol.

You cannot use protocols 6 and 17. They specify the TCP (6) and UDP (17) protocols. When you specify 6, 17, or a protocol that has been opened by another virtual machine, you receive the LOCALportNOTavailable return code.

```

procedure RawIpOpen
(
    ProtocolNo: integer;
var   ReturnCode: integer
);
external;

```

Operand Description

ProtocolNo

Specifies the number of the IP protocol.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- LOCALportNOTavailable
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDuser

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note: You can open the ICMP protocol, but your program receives only those ICMP packets that are not interpreted by the TCPIP virtual machine.

RawIpReceive

The RawIpReceive procedure specifies a buffer to receive Raw IP packets of the specified protocol. You get the notification RAWIPpacketsDELIVERED when a packet is put in the buffer.

RawIpReceive

```
procedure RawIpReceive
(
    ProtocolNo: integer;
    Buffer: Address31Type;
    BufferLength: integer;
var    ReturnCode: integer
);
external;
```

Operand Description

ProtocolNo

Specifies the number of the IP protocol.

Buffer Specifies the address of your buffer.

BufferLength

Specifies the length of your buffer. If you specify a length greater than 8492 bytes, only the first 8492 bytes are used.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDuser

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

RawIpSend

The RawIpSend procedure sends IP packets of the given protocol number. The entire packet, including the IP header, must be in the buffer. The TCPIP virtual machine uses the total length field of the IP header to determine where each packet ends. Subsequent packets begin at the next doubleword (8-byte) boundary within the buffer.

The packets in your buffer are transmitted as is with the following exceptions.

- They can be fragmented. The fragment offset and flag fields in the header are filled.
- The version field in the header is filled.
- The checksum field in the header is filled.
- The source address field in the header is filled.

You get the return code NOsuchCONNECTION if the client is not handling the protocol, or if a packet in the buffer has another protocol. The return code BADlengthARGUMENT is received when:

- The DataLength is less than 40 bytes or more than 8K bytes.
- NumPackets is 0.
- A packet is greater than 2048 bytes.
- All packets do not fit into DataLength.

A ReturnCode value of NObufferSPACE indicates that the data is rejected because TCPIP is out of buffers. When buffer space is available, the notification RAWIPspaceAVAILABLE is sent to the client.

```

procedure RawIpSend
(
    ProtocolNo: integer;
    Buffer: Address31Type;
    DataLength: integer;
    NumPackets: integers;
var
    ReturnCode: integer
);
external;

```

Operand	Description
---------	-------------

ProtocolNo

Specifies the number of the IP protocol.

Buffer Specifies the address of your buffer containing packets to send.

DataLength

Specifies the total length of data in your buffer.

NumPackets

Specifies the number of packets in your buffer.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- BADlengthARGUMENT
- NObufferSPACE
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDuser

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

Note: If your buffer contains multiple packets to send, some of the packets may have been sent even if ReturnCode is not OK.

ReadXlateTable

The ReadXlateTable procedure reads the binary translation table file specified by TableName, and fills in the AtoETable and EtoATable translation tables.

ReadXlateTable

```
procedure ReadXlateTable
(
  var   TableName: DirectoryNameType;
  var   AtoETable: AtoEType;
  var   EtoATable: EtoAType;
  var   TranslateTableSpec: SpecOfFileType;
  var   ReturnCode: integer
);
external;
```

Operand	Description
---------	-------------

TableName	Specifies the name of the translate table. ReadXlateTable tries to read TableName TCPXLBIN. If that file exists but it has a bad format, ReadXlateTable returns with a ReturnCode FILEformatINVALID. If <i>user_id</i> TCPXLBIN does not exist, ReadXlateTable tries to read TCPIP TCPXLBIN. ReturnCode reflects the status of reading that file.
------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

AtoETable	Contains an ASCII-to-EBCDIC table if the return code is OK.
------------------	-------------------------------------------------------------

EtoATable	Contains an EBCDIC-to-ASCII table if the return code is OK.
------------------	-------------------------------------------------------------

TranslateTableSpec	If ReturnCode is OK, TranslateTableSpec contains the complete specification of the file that ReadXlateTable used. If the ReturnCode is not OK, TranslateTableSpec contains the complete specification of the last file that ReadXlateTable tried to use.
---------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

ReturnCode	Indicates the success or failure of the call. Possible return values are:
-------------------	---------------------------------------------------------------------------

- OK
- ERRORopeningORreadingFILE
- FILEformatINVALID

RTcpExtRupt

The RTcpExtRupt procedure is a version of the TcpExtRupt Pascal procedure and can be called directly from an assembler interrupt handler.

Note: The content of this section is Internal Product Information and must not be used as programming interface information.

The following is a sample of the assembler calling sequence.

	LA	R13,PASCSAVE	
	LA	R1,EXTPARM	
	L	R15,=V(RTCPPEXTR)	
	BALR	R14,R15	
		.	
		.	
RUPTCODE	DS	H	Store interrupt code here before calling XTCPPEXTR
PASCSAVE	DS	18F	Register save area
ENV	DC	F'0'	Zero initially. It will be filled with an environment address. Pass it unchanged in subsequent calls to RTCPPEXTR.
EXTPARM	DC	A(ENV)	
	DC	A(RUPTCODE)	

The RTcpExtRupt procedure has no operands.

RTcpVmcfRupt

The RTcpVmcfRupt procedure is a version of the TcpVmcfRupt Pascal procedure and can be called directly from an assembler interrupt handler.

Note: The content of this section is Internal Product Information and must not be used as programming interface information.

The following is a sample assembler calling sequence.

	LA	R13,PASCSAVE	
	LA	R1,VMCFPARAM	
	L	R15,=V(RTCPVMCF)	
	BALR	R14,R15	
		.	
		.	
PASCSAVE	DS	18F	Register save area
ENV	DC	F'0'	Zero initially. It will be filled with an environment address. Pass it unchanged in subsequent calls to RTCPVMCF.
VMCFPARAM	DC	A(ENV)	
	DC	A(VMCFBUF)	Address of your VMCF interrupt buffer.

The RTcpVmcfRupt procedure has no operands.

SayCalRe

The SayCalRe function returns a printable string describing the return code passed in CallReturn.

function SayCalRe
)
CallReturn: integer
);
WordType;
external;

Operand

Description

CallReturn

Specifies the return code to be described.

SaySslRe

The SaySslRe function returns a printable string describing the AlertDescription returned when a handshake completes. The AlertDescription is passed in CallReturn.

```
function SaySslRe
)
    CallReturn: SignedHalfwordType
):
WordType;
external;
```

Operand

Description

CallReturn

Specifies the return code to be described.

SayConSt

The SayConSt function returns a printable string describing the connection state passed in State. For example, if SayConSt is invoked with the type identifier RECEIVINGOnly, it returns the message *Receiving only*.

```
function SayConSt
(
    State: ConnectionStateType
):
Wordtype;
external;
```

Operand

Description

State Specifies the connection state to be described.

SayIntAd

The SayIntAd function converts the internet address specified by InternetAddress to a printable string. The address is looked up in HOSTS ADDRINFO file, and the name is returned if found. If it is not found, the dotted-decimal format of the address is returned.

```
function SayIntAd
(
    InternetAddress: InternetAddressType
):
WordType;
external;
```

Operand

Description

InternetAddress

Specifies the internet address to be converted.

SayIntNum

The SayIntNum function converts the internet address specified by InternetAddress to a printable string, in dotted-decimal form.

```
function SayIntNum
(
    InternetAddress: InternetAddressType
):
Wordtype;
external;
```

Operand

Description

InternetAddress

Specifies the internet address to be converted.

SayNotEn

The SayNotEn function returns a printable string describing the notification enumeration type passed in Notification. For example, if SayNotEn is invoked with the type identifier EXTERNALinterrupt, it returns the message, *Other external Interrupt received*.

```
function SayNotEn
(
    Notification: NotificationEnumType
):
Wordtype;
external;
```

Operand

Description

Notification

Specifies the notification enumeration type to be described.

SayPorTy

The SayPorTy function returns a printable string describing the port number passed in Port, if it is a well-known port number such as the Telnet port. Otherwise, the EBCDIC representation of the number is returned.

```
function SayPorTy
(
    Port: PortType
):
WordType;
external;
```

Operand

Description

Port Specifies the port number to be described.

SayProTy

The SayProTy function converts the protocol type specified by Protocol to a printable string, if it is a well-known protocol number such as 6 (TCP). Otherwise, the EBCDIC representation of the number is returned.

```
function SayProTy
(
    Protocol: ProtocolType
):
    WordType;
external;
```

Operand

Description

Protocol

Specifies the number of the protocol to be described.

SetTimer

The SetTimer procedure sets a timer to expire after a specified time interval. Specify the amount of time in seconds. When it times out, you receive the TIMERExpired notification, which contains the data and the timer pointer.

Note: This procedure resets any previous time interval set on this timer.

```
procedure SetTimer
(
    T: TimerPointerType;
    AmountOfTime: integer;
    Data: integer
);
external;
```

Operand

Description

T Specifies a timer pointer, as returned by a previous CreateTimer call.

AmountOfTime

Specifies the time interval in seconds.

Data Specifies an integer value to be returned with the TIMERExpired notification.

StartTcpNotice

The StartTcpNotice procedure establishes your own external interrupt handler. Use this procedure rather than BeginTcpIp when you want to handle simulated external interrupts yourself.

If your program does not use simulated VMCF, set the ClientDoesVmcf parameter to FALSE. For more information about the simulated Virtual Machine Communication Facility interface, see Chapter 3, "Virtual Machine Communication Facility Interface," on page 117. Later, when your program receives a simulated external interrupt that it does not handle, including a VMCF interrupt, inform the TCP interface by calling TcpExtRupt. The TCP interface then processes the interrupt.

If your program uses simulated VMCF itself, set the ClientDoesVmcf parameter to TRUE. Your program must use the VMCF AUTHORIZE function to establish a VMCF interrupt buffer. Later, when your program receives a VMCF interrupt that it does not handle, inform the TCP interface by calling TcpVmcfRupt with the address of your VMCF interrupt buffer. When your program receives a non-VMCF simulated external interrupt that it does not handle, call TcpExtRupt, as explained previously.

```

procedure StartTcpNotice
(
    ClientDoesVmcf: Boolean;
var   ReturnCode: integer
);
external;

```

Operand Description

ClientDoesVmcf

Set to FALSE if your program does not use simulated VMCF. Otherwise, set to TRUE.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- ALREADYclosing
- NOtcpIPservice
- TCPipALREADYstarted
- VIRTUALmemoryTOOsmall
- FATALerror

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

If ReturnCode is OK, you must call EndTcpIp when you have finished with the TCP/IP services.

Tcp6Open and Tcp6WaitOpen

The Tcp6Open or Tcp6WaitOpen procedures initiate a TCP connection. The Tcp6Open or Tcp6WaitOpen should be used for IPv6 connections or for a mix of IPv4 and IPv6 connections. Tcp6Open returns immediately, and connection establishment proceeds asynchronously with your program's other operations. The connection is fully established when your program receives a CONNECTIONstateCHANGED notification with NewState set to OPEN. Tcp6WaitOpen does not return until the connection is established, or until an error occurs.

Tcp6Open and Tcp6WaitOpen

```
procedure Tcp6Open
(
  var ConnectionInfo: Status6Info;
  var ReturnCode: integer;
);
external;

procedure Tcp6WaitOpen
(
  var ConnectionInfo: Status6Info;
  var ReturnCode: integer;
);
external;
```

Operand

Description

ConnectionInfo

Specifies a connection information record.

Connection

Set this field to UNSPECIFIEDconnection. When the call returns, the field contains the number of the new connection if ReturnCode is OK.

ConnectionState

For active open, set this field to TRYINGtoOPEN. For passive open, set this field to LISTENING.

OpenAttemptTimeout

Set this field to specify how long, in seconds, TCP is to continue attempting to open the connection. If the connection is not fully established during that time, TCP reports the error to you. If you used Tcp6Open, you receive a notification. The type of notification that you receive is CONNECTIONstateCHANGED. It has a new state of NONEXISTENT and a reason of TIMEOUToPen. If you used Tcp6WaitOpen, it returns with ReturnCode set to TIMEOUToPen.

Security

This field is reserved. Set it to DEFAULTsecurity.

Compartment

This field is reserved. Set it to DEFAULTcompartment.

Precedence

This field is reserved. Set it to DEFAULTprecedence.

LocalSocket

Active Open: You can use an address of UNSPECIFIEDipV6address (the TCPIP virtual machine uses the home address corresponding to the network interface used to route to the foreign address) and port of UNSPECIFIEDport (the TCPIP virtual machine assigns a port number, in the range of 1024 to 65 534). You can specify the address, the port, or both if particular values are required by your application. The address must be a valid home address for your node and must be specified as an IPv6 address. IPv6 mapped IPv4 addresses are acceptable, refer to RFC 4291 for details. The port must not be reserved via a PORT statement in Profile TCPIP or in use by another application.

Passive Open: A predetermined port number is specified which allows other programs to connect to your program using the port. Alternatively, you can use UNSPECIFIEDport to let the TCPIP virtual machine assign a port number, obtain the port number through Tcp6Status for Tcp6Open or using the NETSTAT CONN command for Tcp6WaitOpen, and transmit it to the other program through an existing TCP connection or manually. (For more information about the NETSTAT CONN command, see *z/VM: TCP/IP User's Guide*). Generally, an address of UNSPECIFIEDipaddress is specified so that the active open to the port succeeds regardless of the home addresses to which it was sent.

ForeignSocket

Active Open: The address and port must both be specified, because the TCPIP virtual machine cannot actively initiate a connection without knowing the destination address and port. The address must be specified as an IPv6 address. IPv6 mapped IPv4 addresses are acceptable, refer to RFC 4291 for details.

Note: Attempting to specify an IPv6 link local address will produce unpredictable results.

Passive Open: If your program is offering a service to anyone who wants it, specify an address of UNSPECIFIEDipaddress and a port of UNSPECIFIEDport. You can specify a particular address and port if you want to accept an active open only from a certain foreign application.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- CONNECTIONalreadyEXISTS
- DROPPEDbyOPERATOR (TcpWaitOpen only)
- IPv6connection
- LOCALportNOTavailable
- MIXEDaddresses
- NOsuchCONNECTION
- NOTyetBEGUN
- OPENrejected (TcpWaitOpen only)
- PARAMlocalADDRESS
- PARAMstate
- PARAMtimeout
- PARAMunspecADDRESS
- PARAMunspecPORT
- REMOTEreset (TcpWaitOpen only)
- SOFTWAREerror
- TCPipSHUTDOWN
- TIMEOUConnection (TcpWaitOpen only)
- TIMEOUOpen (TcpWaitOpen only)
- TOOManyOPENS
- UNEXPECTEDsyn (TcpWaitOpen only)
- UNREACHABLEnetwork (TcpWaitOpen only)
- WRONGsecORprc (TcpWaitOpen only)
- ZEROresources

Tcp6Status

The Tcp6Status procedure obtains the current status of a TCP connection. Your program sets the Connection field of the ConnectionInfo record to the number of the connection whose status you want.

```
procedure Tcp6Status
(
  var ConnectionInfo: Status6Info;
  var ReturnCode: integer;
);
external;
```

Operand

Description

ConnectionInfo

If ReturnCode is OK, the following fields are returned:

Field	Description
-------	-------------

OpenAttemptTimeout

If the connection is in the process of being opened (including a passive open), this field is set to the number of seconds remaining before the open is terminated if it has not completed. Otherwise, it is set to WAITforever.

BytesToRead

Specifies the number of bytes of incoming data queued for your program (waiting for TcpReceive, TcpFReceive, or TcpWaitReceive).

UnackedBytes

Specifies the number of bytes sent by your program but not yet sent to the foreign TCP, or the number of bytes sent to the foreign TCP, but not yet acknowledged.

ConnectionState

Specifies the current connection state.

LocalSocket

Specifies the local socket, consisting of a local address and a local port. The local address will be returned as an IPv6 address. If the address is an IPv4 address, it will be returned as a mapped IPv6 address.

ForeignSocket

Specifies the foreign socket, consisting of a foreign address and a foreign port. The foreign address will be returned as an IPv6 address. If the address is an IPv4 address, it will be returned as a mapped IPv6 address.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- NOsuchCONNECTION
- NOTyetBEGUN
- TCPipSHUTDOWN

TcpAbort

The TcpAbort procedure shuts down a specific connection immediately. Data sent by your application on the aborted connection can be lost. TCP sends a reset packet to notify the foreign host that you have aborted the connection, but there is no guarantee that the reset will be received by the foreign host.

```

procedure TcpAbort
(
    Connection: ConnectionType;
var   ReturnCode: integer
);
external;
    
```

Operand Description

Connection

Specifies the connection number, as returned by TcpOpen or TcpWaitOpen in the connection field of the StatusInfoType record for IPv4 connections or by Tcp6Open or Tcp6WaitOpen in the connection field of the Status6InfoType record for IPv6 connections.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- NOsuchCONNECTION
- NOTyetBEGUN
- SSLcloseINprogress
- TCPipSHUTDOWN

The connection is fully terminated when you receive the notification CONNECTIONstateCHANGED with the NewState field set to NONEXISTENT.

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

TcpClose

The TcpClose procedure begins the TCP one-way closing sequence. During this closing sequence, you, the local client, cannot send any more data. Data can be delivered to you until the foreign application also closes. TcpClose also causes all data sent on that connection by your application, and buffered by TCPIP, to be sent to the foreign application immediately.

```

procedure TcpClose
(
    Connection: ConnectionType;
var   ReturnCode: integer
);
external;
    
```

Operand Description

TcpClose

Connection

Specifies the connection number, as returned by `TcpOpen` or `TcpWaitOpen` in the connection field of the `StatusInfoType` record for IPv4 connections or by `Tcp6Open` or `Tcp6WaitOpen` in the connection field of the `Status6InfoType` record for IPv6 connections.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- ALREADYclosing
- NOsuchCONNECTION
- NOTyetBEGUN
- SSLcloseINprogress
- SSLhandshakeINprogress
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note:

1. If you receive the notification `CONNECTIONstateCHANGED` with a `NewState` of `SENDINGonly`, the remote application has done `TcpClose` (or equivalent function) and is receiving only. Respond with `TcpClose` when you have finished sending data on the connection.
2. The connection is fully closed when you receive the notification `CONNECTIONstateCHANGED`, with a `NewState` field set to `NONEXISTENT`.

TcpExtRupt

Use the `TcpExtRupt` procedure when:

1. You initiated the TCP/IP service by calling `StartTcpNotice` with `ClientDoesVmcf` set to `TRUE`, and your external interrupt handler receives a non-VMCF interrupt not handled by your program. For the handling of VMCF interrupts, see “`TcpVmcfRupt`” on page 104.
2. You initiated the TCP/IP service by calling `StartTcpNotice` with `ClientDoesVmcf` set to `FALSE`, and your external interrupt handler receives any interrupt not handled by your program.

`RTcpExtRupt` is a version of `TcpExtRupt`. For more information, see “`RTcpExtRupt`” on page 78 and “`RTcpVmcfRupt`” on page 79.

```
procedure TcpExtRupt
(
  const RuptCode: integer
);
external;
```

Operand

Description

RuptCode

Specifies the external interrupt code you received.

TcpFReceive, TcpReceive, and TcpWaitReceive

TcpFReceive and TcpReceive are the asynchronous ways of specifying a buffer to receive data for a given connection. Both procedures return to your program immediately. A return code of OK means that the request has been accepted. When received data has been placed in your buffer, your program receives a DATAdelivered notification. If your program uses TcpFReceive, it can receive an FRECEIVEerror notification rather than DATAdelivered, indicating that the receive request was rejected, or that it was initially accepted but was later canceled because of connection closing.

TcpWaitReceive is the synchronous interface for receiving data from a TCP connection. TcpWaitReceive does not return to your program until data has been received into your buffer, or until an error occurs. Therefore, it is not necessary that TcpWaitReceive receive a notification when data is delivered. The BytesRead parameter is set to the number of bytes received by the data delivery, but if the number is less than zero, the parameter indicates an error.

TcpReceive uses a complete VMCF transaction (SEND by your virtual machine followed by REJECT by the TCPIP virtual machine) to tell the TCPIP virtual machine that your program is ready to receive, and another complete VMCF transaction (SEND by TCPIP virtual machine followed by RECEIVE by your virtual machine) to deliver the received data. In contrast, the entire TcpFReceive cycle is completed in one VMCF transaction. The TCP interface does a VMCF SEND/RECEIVE to inform TCPIP that your program is ready to receive. This transaction remains uncompleted until data is ready to be placed in your buffer. At that time the TCPIP virtual machine does a VMCF REPLY, completing the transaction.

TcpFReceive requires fewer VMCF transactions to receive data, thus increasing efficiency. The disadvantage is that each outstanding TcpFReceive means an outstanding VMCF transaction. You are limited to 50 outstanding VMCF transactions (for each virtual machine), thus 50 outstanding TcpFReceives.

With TcpReceive, you are not subject to the limit of 50 outstanding receives (for each virtual machine). The disadvantage is that there are twice as many VMCF transactions involved in receiving data, thus more overhead.

The only programming difference between TcpFReceive and TcpReceive is the generation of FRECEIVEerror notifications for TcpFReceive.

```

procedure TcpFReceive
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BytesToRead: integer;
var    ReturnCode: integer
);
external;
    
```

TcpFReceive, TcpReceive, and TcpWaitReceive

```
procedure TcpReceive
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BytesToRead: integer;
var
    ReturnCode: integer
);
external;
```

```
procedure TcpWaitReceive
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BytesToRead: integer;
var
    BytesRead: integer
);
external;
```

Operand Description

Connection

Specifies the connection number, as returned by TcpOpen or TcpWaitOpen in the connection field of the StatusInfoType record for IPv4 connections or by Tcp6Open or Tcp6WaitOpen in the connection field of the Status6InfoType record for IPv6 connections.

Buffer Specifies the address of the buffer to contain the received data.

BytesToRead

Specifies the size of the buffer. TCPIP usually buffers the incoming data until this many bytes are received. Data is delivered sooner if the sender specified the PushFlag, or if the sender does a TcpClose or equivalent. The largest usable buffer is 8192 bytes. Specifying BytesToRead of more than 8192 bytes may not cause an error return, but only 8192 bytes of the buffer are used.

Note: The order of TcpFReceive or TcpReceive calls on multiple connections, and the order of DATAdelivered notifications among the connections, are not necessarily related.

BytesRead

Indicates a value when TcpWaitReceive returns. If it is greater than ZERO, it indicates the number of bytes received into your buffer. If it is less than or equal to ZERO, it indicates an error.

Possible BytesRead values are:

- OK⁺
- ABNORMALcondition
- FATALerror
- TIMEOUTopen⁺
- UNREACHABLEnetwork⁺
- BADlengthARGUMENT
- NOSuchCONNECTION
- NOTyetBEGUN
- NOTyetOPEN
- OPENrejected⁺

TcpFReceive, TcpReceive, and TcpWaitReceive

- RECEIVEstillPENDING
- REMOTEreset⁺
- UNEXPECTEDsyn⁺
- WRONGsecORprc⁺
- DROPPEDbyOPERATOR⁺
- FATALerror⁺
- KILLEDbyCLIENT⁺
- TCPipSHUTDOWN⁺
- TIMEOUTconnection⁺
- REMOTEclose

ReturnCode:

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- BEGUNlengthARGUMENT
- fatalerror
- NOsuchCONNECTION
- NOTyetBEGUN
- NOTyetOPEN
- RECEIVEstillPENDING
- REMOTEclose
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note:

1. For BytesRead OK, the function was initiated, but the connection is no longer receiving for an unspecified reason. Your program does not have to issue TcpClose, but the connection is not completely terminated until a NONEXISTENT notification is received for the connection.
2. For BytesRead REMOTEclose, the foreign host has closed the connection. Your program should respond with TcpClose.
3. If you receive any of the codes marked with ⁺, the function was initiated but the connection has now been terminated (see 2 on page 52). Your program should not issue TcpClose, but the connection is not completely terminated until NONEXISTENT notification is received for the connection.
4. TcpWaitReceive is intended to be used by programs that manage a single TCP connection. It is not suitable for use by multiconnection servers.
5. A return code of TCPipSHUTDOWN can be returned either because the connection initiation has failed, or because the connection has been terminated, because of shutdown. In either case, your program should not issue any more TCP/IP calls.

TcpFSend, TcpSend, and TcpWaitSend

TcpFSend and TcpSend are the asynchronous ways of sending data on a TCP connection. Both procedures return to your program immediately (do not wait under any circumstance).

TcpWaitSend is a simple synchronous method of sending data on a TCP connection. It does not return immediately if the TCPIP virtual machine has insufficient space to accept the data being sent.

TcpFSend, TcpSend, and TcpWaitSend

TcpFSend and TcpSend differ in the way that they handle VMCF when the TCPIP virtual machine has insufficient buffer space to accept the data being sent. Both start by issuing a VMCF SEND function to transfer your data. Normally, the TCPIP virtual machine issues a VMCF RECEIVE, thus completing the VMCF transaction.

In the case of insufficient buffer space, TCPIP responds to TcpSend with a VMCF REJECT, completing the VMCF transaction (unsuccessfully). When space becomes available, another complete VMCF transaction is performed to send a BUFFERspaceAVAILABLE notification.

In the case of a TcpFSend with insufficient buffer space, TCPIP does not respond to the VMCF SEND until buffer space becomes available, at which time the transaction is completed with a VMCF RECEIVE.

TcpSend returns to your program after the VMCF response from TCPIP is received. In contrast, because the VMCF response from TcpFSend may be delayed, TcpFSend returns before the VMCF response is received. An OK return code from TcpFSend indicates only the successful initiation of the VMCF transaction.

The advantage of TcpFSend is that the VMCF transactions necessary to send data are reduced in the case where a program can send data faster than the TCP connection can carry it. Its disadvantages are that it is limited to 50 outstanding VMCF sends and therefore 50 TcpFSends, and is slightly more complicated to use, because you have to wait for an FSENDresponse notification (generated internally by the TCP interface) between successive TcpFSends.

The advantage of TcpSend is that it does not involve an outstanding VMCF transaction. Thus, there is no imposed VMCF-related limit. Also, TcpSend is simpler to use because you can issue successive TcpSends without waiting for a notification. The disadvantage of TcpSend is that it is less efficient than TcpFSend if your program can send data faster than the TCP connection can carry it.

Your program can issue successive TcpWaitSend calls. Buffer shortage conditions are handled transparently. Any errors that occur are likely to be nonrecoverable errors, or are caused by a connection that has terminated.

If you receive any of the codes listed for Reason in the CONNECTIONstateCHANGED notification, except for OK, the connection was terminated for the indicated reason. Your program should not issue a TcpClose, but the connection is not completely terminated until your program receives a NONEXISTENT notification for the connection.

```
procedure TcpFSend
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BufferLength: integer;
    PushFlag: Boolean;
    UrgentFlag: Boolean;
var
    ReturnCode: integer
);
external;
```

```

procedure TcpSend
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BufferLength: integer;
    PushFlag: Boolean;
    UrgentFlag: Boolean;
var ReturnCode: integer
);
external;

```

```

procedure TcpWaitSend
(
    Connection: ConnectionType;
    Buffer: Address31Type;
    BufferLength: integer;
    PushFlag: Boolean;
    UrgentFlag: Boolean;
var ReturnCode: integer
);
external;

```

Operand	Description
----------------	--------------------

Connection

Specifies the connection number, as returned by `TcpOpen` or `TcpWaitOpen` in the connection field of the `StatusInfoType` record for IPv4 connections or by `Tcp6Open` or `Tcp6WaitOpen` in the connection field of the `Status6InfoType` record for IPv6 connections.

Buffer Specifies the address of the buffer containing the data to send.

BufferLength

Specifies the length of data in the buffer. Maximum is 8192.

PushFlag

Forces the data, and previously queued data, to be sent immediately to the foreign application.

UrgentFlag

Marks the data as *urgent*. The semantics of urgent data is dependent on your application.

Note: Use urgent data with caution. If the foreign application follows the Telnet-style use of urgent data, it may flush all urgent data until a special character sequence is encountered.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- BADlengthARGUMENT
- CANNOTsendDATA
- FATALerror
- FSENDstillpending
- NObufferSPACE (`TcpSend` only)
- NOSuchCONNECTION

TcpFSend, TcpSend, and TcpWaitSend

- NOTyetBEGUN
- NOTyetOPEN
- SSLcloseINprogress
- SSLhandshakeINprogress
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note:

1. A successful TcpFSend, TcpSend, and TcpWaitSend means that TCP has received the data to be sent and stored it in its internal buffers. TCP then puts the data in packets and transmits it when the conditions permit.
2. Data sent in a TcpFSend, TcpSend, or TcpWaitSend request may be split up into numerous packets by TCP, or the data may wait in TCP’s buffer space and share a packet with other TcpFSend, TcpSend, or TcpWaitSend, requests.
3. The PushFlag gives the user the ability to affect when TCP sends the data. Setting the PushFlag to FALSE allows TCP to buffer the data and wait until it has enough data to transmit so as to utilize the transmission line more efficiently. There can be some delay before the foreign host receives the data. Setting the PushFlag to TRUE instructs TCP to packetize and transmit any buffered data from previous Send requests along with the data in the current TcpFSend, TcpSend, or TcpWaitSend request without delay or consideration of transmission line efficiency. A successful send does not imply that the foreign application has actually received the data, only that the data will be sent as soon as possible.
4. TcpWaitSend is intended for programs that manage a single TCP connection. It is not suitable for use by multiconnection servers.

TcpNameChange

The TcpNameChange procedure is used if the virtual machine running the TCP/IP program is not using the default name, TCPIP, and is not the same as specified in the TCPIPUSERID statement of the TCPIP DATA file. For more information, see *z/VM: TCP/IP Planning and Customization*.

If required, this procedure must be called before the BeginTcpIp or the StartTcpNotice procedure.

```
procedure TcpNameChange
(
    NewNameOfTcp: DirectoryNameType
);
external;
```

Operand

Description

NewNameOfTcp

Specifies the name of the virtual machine running TCP/IP.

TcpOpen and TcpWaitOpen

The TcpOpen or TcpWaitOpen procedures initiate a TCP IPv4 connection. TcpOpen returns immediately, and connection establishment proceeds asynchronously with your program’s other operations. The connection is fully established when your

program receives a CONNECTIONstateCHANGED notification with NewState set to OPEN. TcpWaitOpen does not return until the connection is established, or until an error occurs.

There are two types of TcpOpen calls: passive open and active open. A passive open call sets the connection state to LISTENING. An active open call sets the connection state to TRYINGtoOPEN.

If a TcpOpen or TcpWaitOpen call returns ZEROresources, and your application handles RESOURCEavailable notifications, you receive a RESOURCEavailable notification when sufficient resources are available to process an open call. The first open your program issues after a RESOURCEavailable notification is guaranteed not to get the ZEROresources return code.

```
procedure TcpOpen
(
  var ConnectionInfo: StatusInfoType;
  var ReturnCode: integer
);
external;
```

```
procedure TcpWaitOpen
(
  var ConnectionInfo: StatusInfoType;
  var ReturnCode: integer
);
external;
```

Operand

Description

ConnectionInfo

Specifies a connection information record.

Connection

Set this field to UNSPECIFIEDconnection. When the call returns, the field contains the number of the new connection if ReturnCode is OK.

ConnectionState

For active open, set this field to TRYINGtoOPEN. For passive open, set this field to LISTENING.

OpenAttemptTimeout

Set this field to specify how long, in seconds, TCP is to continue attempting to open the connection. If the connection is not fully established during that time, TCP reports the error to you. If you used TcpOpen, you receive a notification. The type of notification that you receive is CONNECTIONstateCHANGED. It has a new state of NONEXISTENT and a reason of TIMEOUTopen. If you used TcpWaitOpen, it returns with ReturnCode set to TIMEOUTopen.

Security

This field is reserved. Set it to DEFAULTsecurity.

TcpOpen and TcpWaitOpen

Compartment

This field is reserved. Set it to DEFAULTcompartment.

Precedence

This field is reserved. Set it to DEFAULTprecedence.

LocalSocket

Active Open: You can use an address of UNSPECIFIEDaddress (the TCPIP virtual machine uses the home address corresponding to the network interface used to route to the foreign address) and a port of UNSPECIFIEDport (the TCPIP virtual machine assigns a port number, in the range of 1024 to 65 534). You can specify the address, the port, or both if particular values are required by your application. The address must be a valid home address for your node, and the port must be available (not reserved, and not in use by another application).

Passive Open: A predetermined port number is specified which allows other programs to connect to your program using the port. Alternatively, you can use UNSPECIFIEDport to let the TCPIP virtual machine assign a port number, obtain the port number through TcpStatus for TcpOpen or using the NETSTAT CONN command for TcpWaitOpen, and transmit it to the other program through an existing TCP connection or manually. (For more information about the NETSTAT CONN command, see *z/VM: TCP/IP User's Guide*). Generally, an address of UNSPECIFIEDaddress is specified so that the active open to the port succeeds regardless of the home addresses to which it was sent.

ForeignSocket

Active Open: The address and port must both be specified, because the TCPIP virtual machine cannot actively initiate a connection without knowing the destination address and port.

Passive Open: If your program is offering a service to anyone who wants it, specify an address of UNSPECIFIEDaddress and a port of UNSPECIFIEDport. You can specify a particular address and port if you want to accept an active open only from a certain foreign application.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- CONNECTIONalreadyEXISTS
- DROPPEDbyOPERATOR (TcpWaitOpen only)
- IPv6connection
- LOCALportNOTavailable
- NOsuchCONNECTION
- NOTyetBEGUN
- OPENrejected (TcpWaitOpen only)
- PARAMlocalADDRESS
- PARAMstate
- PARAMtimeout
- PARAMunspecADDRESS
- PARAMunspecPORT
- REMOTEreset (TcpWaitOpen only)

- SOFTWAREerror
- TCPipSHUTDOWN
- TIMEOUTconnection (TcpWaitOpen only)
- TIMEOUTopen (TcpWaitOpen only)
- TOOManyOPENS
- UNEXPECTEDsyn (TcpWaitOpen only)
- UNREACHABLEnetwork (TcpWaitOpen only)
- WRONGsecORprc (TcpWaitOpen only)
- ZEROresources

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

TcpOption

The TcpOption procedure sets an option for a TCP connection.

```

procedure TcpOption
(
    Connection: ConnectionType
    OptionName: integer;
    OptionValue: integer;
var
    ReturnCode: integer
);
external;
    
```

Operand

Description

Connection

Specifies the connection number, as returned by TcpOpen or TcpWaitOpen in the connection field of the StatusInfoType record for IPv4 connections or by Tcp6Open or Tcp6WaitOpen in the connection field of the Status6InfoType record for IPv6 connections.

OptionName

Specifies the code for the option.

OPTIONtcpKEEPALIVE

If OptionValue is zero, the keep-alive mechanism is deactivated for the connection. If OptionValue is nonzero, the keep-alive mechanism is activated for the connection. This mechanism sends a packet on an otherwise idle connection. If the remote TCP does not respond to the packet, the connection state will be changed to NONEXISTENT with TIMEOUTconnection as the reason.

OptionValue

Specifies the value for the option.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOsuchCONNECTION
- NOTyetBEGUN
- TCPipSHUTDOWN
- INVALIDrequest

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

TcpSCient

Indicates to the SSL server that the connection is to be secure and that the SSL server needs to initiate an outbound handshake.

```
procedure TcpSCient
(
  Connection:           ConnectionType;
  Wait:                 boolean;
  SecureClientDetail:  SecureDetailType;
  var HandshakeCompleteDetail: SecureHSCompleteDetailType;
  var ReturnCode:      CallReturnCodeType
);
external;
```

Operand

Description

Connection

Specifies the connection number, as returned by `TcpOpen` or `TcpWaitOpen` in the connection field of the `StatusInfoType` record.

Wait Set to true if your program should wait for the `Close_Notify` to complete. Set to false otherwise.

SecureClientDetail

Sets up the details of the request to be sent to the SSL server.

```

SecureDetailType =
  record
    TLSLabel:          DirectoryNameType;
    TLSTimeout:        integer;
    RequestClientCert: boolean;
    ValidatePeerCert:  ValidateCertType;
    CipherRequest:     CipherSuiteType;
    Reserved1:         UnsignedByteType;
    Keyring:           KeyringType;
    Buffer:             string(255);
  end;

KeyringType = packed array (. 1.. KEYRINGlength .) of char;
KEYRINGlength = 50;

ValidateCertType =
  (
    Full_Check,          { check for certificate errors }
    No_Check             { do not check for certificate errors }
  );
CipherSuiteType =
  (
    Default,            { default cipher suite values will be used }
    NoV2                { V2 is not allowed }
  );

Operand           Description
TLSLabel            Label associated with the certificate in the certificate
                   database.
TLSTimeout          This function is currently not implemented. The field must
                   be set to 0.
RequestClientCert   This function is currently not implemented and must be 0.
ValidatePeerCert    Indicates if the certificate itself should be checked for
                   errors.
CipherRequest       This field is set to NoV2 for those clients that do not wish
                   to use SSL Version 2.
Reserved1           Reserved for future use and must be set to 0.
Keyring             This function is not implemented at this time and must be
                   null.
Buffer              Contains the string that the SSL server will send out on the
                   connection prior to waiting for the handshake. Once this
                   command is sent, the initiation of the handshake is expected
                   on the connection. If an empty buffer is sent, a
                   READYforHANDSHAKE notification will be sent to indicate that
                   this side of the connection is waiting for the handshake.

```

HandshakeCompleteDetail

When the Wait flag is set to true, the results of the handshake will be returned here. If the wait flag is set to false the results of the handshake will be reflected in the SecureHandshakeComplete notification (see SECUREhandshakeCOMPLETE).

ReturnCode

Indicates the success or failure of the call. Possible return values include:

- OK
- BACKlevelSSL
- KEYRINGnotPERMITTED
- KEYRINGnotRECOGNIZED
- LABELnotPERMITTED
- LABELnotRECOGNIZED
- NOsuchCONNECTION
- NOTyetBEGUN

TcpSClient

- SOFTWAREerror
- SSLcloseINprogress
- TCPipSHUTDOWN
- TLSnotAVAILABLE
- UNAUTHORIZEDuser
- ALREADYsecured
- STATICALLYsecured
- INVALIDrequest
- ALREADYclosing
- ZeroResources

TcpSClose

Perform Close_Notify on a TLS connection but leave the TCP session up.

```
procedure TcpSClose
(
    Connection:      ConnectionType;
    Wait:            boolean;
    Buffer:           string(255);
    var ReturnCode: CallReturnCodeType
);
```

Operand

Description

Connection

Specifies the connection number, as returned by TcpOpen or TcpWaitOpen in the connection field of the StatusInfoType record.

Wait Set to true if your program should wait for the Close_Notify to complete. Set to false otherwise.

Buffer Contains a string of data that the SSL server will send out on the connection prior to switching the connection to clear text.

ReturnCode

Indicates the success or failure of the call. Possible return codes include:

- OK
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- SSLcloseINprogress
- TCPipSHUTDOWN
- TLSnotAVAILABLE
- UNAUTHORIZEDuser

TcpSServer

The TcpSServer procedure indicates to the SSL server that the connection is to be secure and that the SSL server needs to wait for an incoming handshake.

```

procedure TcpSServer
(
    Connection:      ConnectionType;
    SecureServerDetail: SecureDetailType;
    var ReturnCode:  CallReturnCodeType
);
external;

```

Operand
Description

Connection

Specifies the connection number, as returned by TcpOpen or TcpWaitOpen in the connection field of the StatusInfoType record.

SecureServerDetail

Sets up the details of the request to be sent to the SSL server. See SecureDetailType.

ReturnCode

Indicates the success or failure of the call. Possible return values include:

- OK
- BACKlevelSSL
- KEYRINGnotPERMITTED
- KEYRINGnotRECOGNIZED
- LABELnotPERMITTED
- LABELnotRECOGNIZED
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- SSLcloseINprogress
- TCPipSHUTDOWN
- TLSnotAVAILABLE
- UNAUTHORIZEDuser
- ALREADYsecured
- STATICALLYsecured
- INVALIDrequest
- ALREADYclosing
- ZeroResources

TcpSStatus

The TcpSStatus procedure returns details about a session such as whether or not it is secure and the encryption suite.

```

procedure TcpSStatus
(
    Connection:      ConnectionType;
    var Secure:      SecureType;
    var CipherDetails: CipherDetailsType;
    var ReturnCode:  CallReturnCodeType
);
external;

```

Operand
Description

TcpSStatus

Connection

Specifies the connection number, as returned by `TcpOpen` or `TcpWaitOpen` in the connection field of the `StatusInfoType` record.

Secure

Describes how the connection is secured.

`SecureType = (SecNone, SecStatic, SecDynamic)`

SecNone

The connection is not secure.

SecStatic

The connection is statically secured.

SecDynamic

The connection is dynamically secured.

Cipher Details

When a connection is secure, this field describes the cipher details that are in effect.

```
CipherDetailsType =
Record
  CipherClass:      CipherClassType;
  CipherHash:      CipherHashType;
  CipherAlgorithm: CipherSymmetricAlgorithmType;
  CipherPkAlgorithm: CipherPkAlgorithmType;
  CipherReserved:  UnsignedByteType;
  CipherKeyLength: integer;
end;

CipherClassType = ( NULLclass, SSLV2, SSLV3, TLS );
CipherHashType = ( SHA1, MD5, NULLhash, SHA2 );
CipherSymmetricAlgorithmType = ( NULLAlgorithm, RC2, RC4, DES, 3DES,
                                FIPSDDES, FIPS3DES, AES, AESGCM );
CipherPkAlgorithmType = ( NULLpkAlgorithm, RSA, DH_DSS,
                          DH_RSA, DHE_DSS, DHE_RSA );
```

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UNAUTHORIZEDDuser

TcpStatus

The `TcpStatus` procedure obtains the current status of a TCP connection. Your program sets the `Connection` field of the `ConnectionInfo` record to the number of the connection whose status you want.

```

procedure TcpStatus
(
  var ConnectionInfo: StatusInfoType;
  var ReturnCode: integer
);
external;

```

Operand

Description

ConnectionInfo

If ReturnCode is OK, the following fields are returned:

Field Description

OpenAttemptTimeout

If the connection is in the process of being opened (including a passive open), this field is set to the number of seconds remaining before the open is terminated if it has not completed. Otherwise, it is set to WAITforever.

BytesToRead

Specifies the number of bytes of incoming data queued for your program (waiting for TcpReceive, TcpFReceive, or TcpWaitReceive).

UnackedBytes

Specifies the number of bytes sent by your program but not yet sent to the foreign TCP, or the number of bytes sent to the foreign TCP, but not yet acknowledged.

ConnectionState

Specifies the current connection state.

LocalSocket

Specifies the local , consisting of a local address and a local port.

ForeignSocket

Specifies the foreign , consisting of a foreign address and a foreign port.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- IPv6Connection
- NOsuchCONNECTION
- NOTyetBEGUN
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

Note: Your program cannot monitor connection state changes exclusively through polling with TcpStatus. It must receive CONNECTIONstateCHANGED notifications through GetNextNote, for the TCP interface to work properly.

TcpVmcfRupt

The `TcpVmcfRupt` procedure is used when you initiate the TCP/IP service by calling `StartTcpNotice` with `ClientDoesVmcf` set to `TRUE`, and your external interrupt handler receives a VMCF interrupt not handled by your program.

`RTcpVmcfRupt` is a version of `TcpVmcfRupt` that can be called directly from an assembler interrupt handler. For more information, see “`RTcpExtRupt`” on page 78 and “`RTcpVmcfRupt`” on page 79.

```

procedure TcpVmcfRupt
(
    VmcfHeaderAddress: integer
);
external;
    
```

Operand	
	Description

VmcfHeaderAddress	Indicates the address of your VMCF interrupt buffer as specified in the VMCF AUTHORIZE function that your program issued at initialization.
--------------------------	---------------------------------------------------------------------------------------------------------------------------------------------

Udp6Open

The `Udp6Open` procedure requests acceptance of UDP datagrams on the specified socket and allows datagrams to be sent from the specified socket. `Udp6Open` should be used for IPv6 connections, or for a mix of IPv4 and IPv6 connections. When the socket port is unspecified, UDP selects a port and returns it to the socket port field. When the socket address is unspecified, UDP uses the default local address. If specified, the address must be a valid home address for your node.

Note: When the local address is specified, only the UDP datagrams addressed to it are delivered.

If the `ReturnCode` indicates the open was successful, use the returned `ConnIndex` value on any further actions pertaining to this UDP socket.

```

procedure Udp6Open
(
    var LocalSocket: Socket6Type;
    var ConnIndex: ConnectionIndexType;
    var ReturnCode: CallReturnCodeType
);
external;
    
```

Operand	
	Description

LocalSocket	Specifies the local socket (address and port pair).
--------------------	-----------------------------------------------------

ConnIndex	Specifies the <code>ConnIndex</code> value returned from <code>UdpOpen</code> .
------------------	---------------------------------------------------------------------------------

ReturnCode	Indicates the success or failure of the call. Possible return values are:
-------------------	---------------------------------------------------------------------------

- OK
- ABNORMALcondition
- FATALerror
- LOCALportNOTavailable
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UDPlocalADDRESS
- UDPzeroRESOURCES

For a description of Pascal ReturnCodes, see Appendix B, “Pascal Return Codes,” on page 405.

Note: If a Udp6Open call returns UDPzeroRESOURCES, and your application handles UDPresourcesAVAILABLE notifications, you receive a UDPresourcesAVAILABLE notification when sufficient resources are available to process a Udp6Open call. The first Udp6Open your program issues after a UDPresourcesAVAILABLE notification is guaranteed not to get the UDPzeroRESOURCES return code.

Udp6Send

The Udp6Send procedure sends a UDP datagram to the specified foreign socket. Udp6send should be used for IPv6 connections, or for a mix of IPv4 and IPv6 connections. The source socket is the local socket selected in the Udp6Open that returned the ConnIndex value that was used. The buffer does not include the UDP header. This header is supplied by the TCPIP virtual machine.

When there is no buffer space to process the data, an error is returned. In this case, wait for a subsequent UDPdatagramSPACEavailable notification.

```

procedure Udp6Send
(
    ConnIndex: ConnectionIndexType;
    ForeignSocket: Socket6Type;
    BufferAddress: integer;
    Length: integer;
var    ReturnCode: CallReturnCodeType
);
external;

```

Operand

Description

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

ForeignSocket

Specifies the foreign socket (address and port) to whom the datagram is to be sent.

BufferAddress

Specifies the address of your buffer containing the UDP datagram to be sent, excluding UDP header.

Length

Specifies the length of the datagram to be sent, excluding UDP header. Maximum is 8192 bytes.

Udp6Send

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- BADlengthARGUMENT
- MIXEDaddress
- NObufferSPACE
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UDPunspecADDRESS
- UDPunspecPORT

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

UdpClose

The UdpClose procedure closes the UDP specified in the ConnIndex field. All incoming datagrams on this connection are discarded.

```
procedure UdpClose
(
    ConnIndex: ConnectionIndexType;
var   ReturnCode: CallReturnCodeType
);
external;
```

Operand

Description

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

UdpNReceive

The UdpNReceive procedure notifies the TCPIP virtual machine that you can receive UDP datagram data. This call returns immediately. The data buffer is not valid until you receive a UDPdatagramDELIVERED notification.

```

procedure UdpNReceive
(
    ConnIndex: ConnectionIndexType;
    BufferAddress: integer;
    BufferLength: integer;
var    ReturnCode: CallReturnCodeType
);
external;

```

Operand Description

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

BufferAddress

Specifies the address of your buffer that will be filled with a UDP datagram.

BufferLength

Specifies the length of your buffer. If you specify a length larger than 8192 bytes, only the first 8192 bytes are used.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- NOsuchCONNECTION
- NOTyetBEGUN
- RECEIVEstillPENDING
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

UdpOpen

The UdpOpen procedure requests acceptance of UDP datagrams on the specified socket and allows datagrams to be sent from the specified socket. When the socket port is unspecified, UDP selects a port and returns it to the socket port field. When the socket address is unspecified, UDP uses the default local address. If specified, the address must be a valid home address for your node.

Note: When the local address is specified, only the UDP datagrams addressed to it are delivered.

If the ReturnCode indicates the open was successful, use the returned ConnIndex value on any further actions pertaining to this UDP socket.

UdpOpen

```
procedure UdpOpen
(
  var LocalSocket: SocketType;
  var ConnIndex: ConnectionIndexType;
  var ReturnCode: CallReturnCodeType
);
external;
```

Operand Description

LocalSocket

Specifies the local socket (address and port pair).

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- LOCALportNOTavailable
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UDPlocalADDRESS
- UDPzeroRESOURCES

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

Note: If a UdpOpen call returns UDPzeroRESOURCES, and your application handles UDPresourcesAVAILABLE notifications, you receive a UDPresourcesAVAILABLE notification when sufficient resources are available to process a UdpOpen call. The first UdpOpen your program issues after a UDPresourcesAVAILABLE notification is guaranteed not to get the UDPzeroRESOURCES return code.

UdpReceive

The UdpReceive procedure notifies the TCPIP virtual machine that you are willing to receive UDP datagram data.

UdpReceive is for compatibility with old programs only. New programs should use the UdpNReceive procedure, which allows you to specify the size of your buffer.

If you use UdpReceive, TCPIP can put a datagram of up to 2012 bytes in your buffer. If a larger datagram is sent to your port when UdpReceive is pending, the datagram is discarded without notification.

Note: No data is transferred from the TCPIP virtual machine in this call. It only tells TCPIP that you are waiting for a datagram. Data has been transferred when a UDPdatagramDELIVERED notification is received.

```

procedure UdpReceive
(
    ConnIndex: ConnectionIndexType;
    DatagramAddress: integer;
var    ReturnCode: CallReturnCodeType
);
external;

```

Operand Description

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

DatagramAddress

Specifies the address of your buffer that will be filled with a UDP datagram.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPIP SHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

UdpSend

The UdpSend procedure sends a UDP datagram to the specified foreign socket. The source socket is the local socket selected in the UdpOpen that returned the ConnIndex value that was used. The buffer does not include the UDP header. This header is supplied by the TCPIP virtual machine.

When there is no buffer space to process the data, an error is returned. In this case, wait for a subsequent UDPdatagramSPACEavailable notification.

```

procedure UdpSend
(
    ConnIndex: ConnectionIndexType;
    ForeignSocket: SocketType;
    BufferAddress: integer;
    Length: integer;
var    ReturnCode: CallReturnCodeType
);
external;

```

Operand Description

ConnIndex

Specifies the ConnIndex value returned from UdpOpen.

UdpSend

ForeignSocket

Specifies the foreign socket (address and port) to whom the datagram is to be sent.

BufferAddress

Specifies the address of your buffer containing the UDP datagram to be sent, excluding UDP header.

Length

Specifies the length of the datagram to be sent, excluding UDP header. Maximum is 8192 bytes.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- BADlengthARGUMENT
- NObufferSPACE
- NOsuchCONNECTION
- NOTyetBEGUN
- SOFTWAREerror
- TCPipSHUTDOWN
- UDPunspecADDRESS
- UDPunspecPORT

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

Unhandle

The Unhandle procedure specifies that you no longer want to receive notifications in the given set.

If you request to unhandle the DATAdelivered notification, the Unhandle procedure returns with a code of INVALIDrequest.

```
procedure Unhandle
(
    Notifications: NotificationSetType;
    var    ReturnCode: integer
);
external;
```

Operand

Description

Notifications

Specifies the set of notifications that you no longer want to receive.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- ABNORMALcondition
- FATALerror
- INVALIDrequest
- NOTyetBEGUN
- TCPipSHUTDOWN

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

UnNotifyIo

The UnNotifyIo routine is used to indicate that you no longer wish to be sent a notification when an I/O interrupt occurs on the specified virtual address.

```

procedure UnNotifyIo
(
    DeviceAddress: integer;
var   ReturnCode: integer
);
external;

```

Operand

Description

DeviceAddress

Specifies the address of the device for which IOinterrupt notifications are no longer to be generated.

ReturnCode

Indicates the success or failure of the call. Possible return values are:

- OK
- NOsuchCONNECTION
- SOFTWAREerror

For a description of Pascal ReturnCodes, see Appendix B, "Pascal Return Codes," on page 405.

Sample Pascal Program

The following is an example of a sample Pascal program.

```
%UHEADER 5741-A05 (C) COPYRIGHT 1991, 2004 BY IBM, PSAMPLE.
```

```

{
    Licensed Materials - Property of IBM
    This product contains "Restricted Materials of IBM"
    5741-A05 (C) Copyright IBM Corp. - 1991, 2004
    All rights reserved.
    US Government Users Restricted Rights -
    Use, duplication or disclosure restricted by GSA ADP Schedule
    Contract with IBM Corp.
    See IBM Copyright Instructions.
}

{
    Change Activity
    VREBA - IPv6 Stage 1 line item
}

{*****}
{*                                           *}
{* Memory-to-memory Data Transfer Rate Measurement *}
{*                                           *}
{* Pseudocode: Establish access to TCP/IP Services *}
{* Prompt user for operation parameters *}
{* Open a connection (Sender:passive, Receiver:active) *}
{* If Sender: *}
{* Send 5M of data using TcpFSend *}

```

Sample Pascal Program

```

{*          Use GetNextNote to know when Send is complete      *}
{*          Print transfer rate after every 1M of data         *}
{*          else Receiver:                                     *}
{*          Receive 5M of data using TcpFReceive              *}
{*          Use GetNextNote to know when data is delivered    *}
{*          Print transfer rate after every 1M of data         *}
{*          Close connection                                   *}
{*          Use GetNextNote to wait until connection is closed *}
{*          *}
{*****}
program PSAMPLE;

%include CMALLCL
%include CMINTER
%include CMRESGLB

const
  BUFFERlength = 8192;          { same as MAXdataBUFFERsize   }
  PORTnumber   = 9876;          { constant on both sides   }
  CLOCKunitsPERthousandth = '3E8000'x;

static
  Buffer          : packed array (1..BUFFERlength.) of char;
  BufferAddress   : Address31Type;
  ConnectionInfo : StatusInfoType;
  Count          : integer;
  DataRate       : real;
  Difference     : TimeStampType;
  HostAddress    : IPAddressType;          { @VRFBAQP }
  AddrSpec      : IPv6AddrSpecType;       { @VRFBAQP }
  Lookup        : LookupSetType;          { @VRFBAQP }
  IbmSeconds    : integer;
  Ignored       : integer;
  Line          : string(80);
  Note          : NotificationInfoType;
  PushFlag      : boolean;                { for TcpFSend   }
  RealRate      : real;
  ReturnCode    : integer;
  SendFlag      : boolean;                { are we sending or receiving }
  StartingTime  : TimeStampType;
  Thousandths   : integer;
  TotalBytes    : integer;
  UrgentFlag    : boolean;                { for TcpFSend   }

var RoundRealRate : integer;

{*****}
{* Print message, release resources and reset environment      *}
{*****}
procedure Restore ( const Message: string;
                   const ReturnCode: integer );
begin
  Write(Message);
  if ReturnCode <> OK then
    { * Write(SayCaRe(ReturnCode));
      Writeln(''); * }
    Msg1(Output,1, addr(SayCaRe(ReturnCode)) )
  else Msg0(Output,2);

  EndTcpIp;
  Close (Input);
  Close (Output);
end;

begin
  TermOut (Output);

```

```

TermIn (Input);

{ Establish access to TCP/IP services }
BeginTcpIp (ReturnCode);
if ReturnCode <> OK then begin
{* Writeln('BeginTcpi: ',SayCalRe(ReturnCode)); *}
  Msg1(Output,4, addr(SayCalRe(ReturnCode)) );
  return;
end;

{ Inform TCPIP which notifications will be handled by the program }
Handle ((.DATAdelivered, BUFFERspaceAVAILABLE,
        CONNECTIONstateCHANGED, FRECEIVEerror,
        FSendResponse.), ReturnCode);
if ReturnCode <> OK then begin
  Restore ('Handle: ', ReturnCode);
  return;
end;

{ Prompt user for operation parameters }
{* Writeln('Transfer mode: (Send or Receive)'); *}
Msg0(Output,5);
ReadLn (Line);
if (Substr(Ltrim(Line),1,1) = 's')
or (Substr(Ltrim(Line),1,1) = 'S') then
  SendFlag := TRUE
else
  SendFlag := FALSE;

{* Writeln('Host Name or Internet Address :'); *}
Msg0(Output,6);
ReadLn (Line);
Lookup := [IPv4];
if not (GetIPAddr(Trim(Ltrim(Line)), HostAddress,
                AddrSpec, Lookup)) then
begin
  Restore ('GetIPAddr failed. ', OK);
  return;
end;

{ Open a TCP connection: active for Send and passive for Receive }
{ - Connection value will be returned by TcpIp }
{ - initialize IBM reserved fields: Security, Compartment }
{ and Precedence }
{ for Active open - set Connection State to TRYINGtoOPEN }
{ - must initialize foreign socket }
{ for Passive open - set ConnectionState to LISTENING }
{ - may leave foreign socket uninitialized to }
{ accept any open attempt }
with ConnectionInfo do begin
  Connection := UNSPECIFIEDconnection;
  OpenAttemptTimeout := WAITforever;
  Security := DEFAULTsecurity;
  Compartment := DEFAULTcompartment;
  Precedence := DEFAULTprecedence;
  if SendFlag then begin
    ConnectionState := TRYINGtoOPEN;
    LocalSocket.Address := UNSPECIFIEDaddress;
    LocalSocket.Port := UNSPECIFIEDport;
    ForeignSocket.Address := HostAddress.IPv4Addr;
    ForeignSocket.Port := PORTnumber;
  end
  else begin
    ConnectionState := LISTENING;
    LocalSocket.Address := HostAddress.IPv4Addr;
    LocalSocket.Port := PORTnumber;
    ForeignSocket.Address := UNSPECIFIEDaddress;
  end
end

```

Sample Pascal Program

```
        ForeignSocket.Port    := UNSPECIFIEDport;
    end;
end;
TcpWaitOpen (ConnectionInfo, ReturnCode);
if ReturnCode <> OK then begin
    Restore ('TcpWaitOpen: ', ReturnCode);
    return;
end;

{ Initialization }
BufferAddress := Addr(Buffer(.1.));
StartingTime := ClockTime;
TotalBytes    := 0;
Count        := 0;
PushFlag     := false;    { let TcpIp buffer data for efficiency }
UrgentFlag   := false;    { none of out data is Urgent }

{ Issue first TcpFSend or TcpFReceive }
if SendFlag then
    TcpFSend (ConnectionInfo.Connection, BufferAddress,
              BUFFERlength, PushFlag, UrgentFlag, ReturnCode)
else
    TcpFReceive (ConnectionInfo.Connection, BufferAddress,
                 BUFFERlength, ReturnCode);

if ReturnCode <> OK then begin
    { * Writeln('TcpSend/Receive: ', SayCaRe(ReturnCode)); * }
    Msg1(Output,7, addr(SayCaRe(ReturnCode)) );
    return;
end;

{ Repeat until 5M bytes of data have been transferred }
while (Count < 5) do begin
    { Wait until previous transfer operation is completed }
    GetNextNote(Note, True, ReturnCode);
    if ReturnCode <> OK then begin
        restore('GetNextNote :',ReturnCode);
        return;
    end;

    { Proceed with transfer according to the Notification received }
    { Notifications Expected : }
    { DATAdelivered - TcpFReceive function call is now complete }
    { - receive buffer contains data }
    { FSENDresponse - TcpFSend function call is now complete }
    { - send buffer is now available for use }
    { FRECEIVEerror - if there was an error on TcpFReceive function }
    case Note.NotificationTag of
        DATAdelivered:
            begin
                TotalBytes := TotalBytes + Note.BytesDelivered;
                {issue next TcpFReceive }
                TcpFReceive (ConnectionInfo.Connection, BufferAddress,
                              BUFFERlength, ReturnCode);
                if ReturnCode <> OK then begin
                    Restore('TcpFReceive: ',Note.SendTurnCode);
                    return;
                end;
            end;
        FSENDresponse:
            begin
                if Note.SendTurnCode <> OK then begin
                    Restore('FSENDresponse: ',Note.SendTurnCode);
                    return;
                end
            end
        else begin
```

Sample Pascal Program

```
        {issue next TcpFSend }
        TotalBytes := TotalBytes + BUFFERlength;
        TcpFSend (ConnectionInfo.Connection, BufferAddress,
            BUFFERlength, PushFlag, UrgentFlag, ReturnCode);
        if ReturnCode <> OK then begin
            Restore('TcpFSend: ', Note.SendTurnCode);
            return;
        end;
    end;
end;
FRECEIVEerror:
begin
    Restore('FRECEIVEerror: ', Note.ReceiveTurnCode);
    return;
end;
OTHERWISE
begin
    Restore('UnExpected Notification ', OK);
    return;
end;
end; { Case on Note.NotificationTag }

{ is it time to print transfer rate? }
if TotalBytes < 1048576 then
    continue;

{ Print transfer rate after every 1M bytes of data transferred }
DoubleSubtract (ClockTime, StartingTime, Difference);
DoubleDivide (Difference, CLOCKunitsPERthousandth, Thousandths,
    Ignored);
RealRate := (TotalBytes/Thousandths) * 1000.0;
{* Writeln('Transfer Rate ', RealRate:1:0, ' Bytes/sec. '); *}
RoundRealRate := Round(RealRate);
Msg1(Output, 8, addr(RoundRealRate) );

StartingTime := ClockTime;
TotalBytes := 0;
Count := Count + 1;
end; {Loop while Count < 5 }

{ Close TCP connection and wait till partner also drops connection }
TcpClose (ConnectionInfo.Connection, ReturnCode);
if ReturnCode <> OK then begin
    Restore ('TcpClose: ', ReturnCode);
    return;
end;

{ when partner also drops connection, program will receive }
{ CONNECTIONstateCHANGED notification with NewState = NONEXISTENT }
repeat
    GetNextNote (Note, True, ReturnCode);
    if ReturnCode <> OK then begin
        Restore ('GetNextNote: ', ReturnCode);
        return;
    end;
until (Note.NotificationTag = CONNECTIONstateCHANGED) &
    ((Note.NewState = NONEXISTENT) |
    (Note.NewState = CONNECTIONclosing));

Restore ('Program terminated successfully. ', OK);
end.
```

Sample Pascal Program

Chapter 3. Virtual Machine Communication Facility Interface

The Virtual Machine Communication Facility (VMCF) is part of the Control Program (CP) of VM. VMCF enables virtual machines to send data to and receive data from any other virtual machine.

You can communicate directly with the TCPIP virtual machine using VMCF calls, rather than Pascal API or C socket calls. You can use VMCF calls when:

- You want to write your program in assembler.
- You add TCP/IP communication to an existing complex program, and it can be difficult or impossible for your program to monitor TCP/IP events through the Pascal GetNextNote interface.

If your program drives the VMCF interface directly, do not link any of the TCP interface library modules with your program. Consequently, you cannot use any of the auxiliary routines, such as the Say functions and timer routines. (You must use VM timer support, or support provided by your existing program). VMCF consists of data transfer functions, control functions, a special external interrupt for pending messages, and an external interrupt message header to pass control information and data to another virtual machine.

For more information about the VMCF interface, see *VM/ESA: CP Programming Services*.

General Information

The following section describes the data structure of the VMCF interrupt header used by TCP/IP for VM. The section also lists the VMCF functions available with TCP/IP for VM. Tables summarizing the CALLCODE for making VMCF requests and receiving notifications from TCPIP virtual machine are provided. The remainder of the chapter describes these CALLCODE calls in details.

Data Structures

VMCF is implemented with functions invoked using DIAGNOSE X'68' and a special 40-byte parameter list. A VMCF function is requested by a particular function subcode in the FUNC field in the parameter list.

Your program uses the standard 40-byte VMCF parameter list to submit VMCF requests to the TCPIP virtual machine. The TCPIP virtual machine returns VMCF interrupts results in the similar 40-byte VMCF parameter list. The parameter list is the interrupt header being stored in your virtual machine. In this chapter, fields in the parameter list and interrupt header are referred to using the data structure header names in Figure 24 on page 118.

V1	DS	X
V2	DS	X
FUNC	DS	H
MSGID	DS	F
JOBNAME	DS	CL8
VADA	DS	A
LENA	DS	F
VADB	DS	A
LENB	DS	F
* User-doubleword field is divided into the following fields:		
ANINTEGR	DS	F
CONN	DS	H
CALLCODE	DS	X
RETCODE	DS	X

Figure 24. Assembler Format of the VMCF Parameter List Fields

VMCF Parameter List Fields

The following describes the VMCF parameter list fields.

V1 Used for security and data integrity. You can enable your virtual machine for VMCF communication to the TCPIP virtual machine by executing the **AUTHORIZE** control function. The **AUTHORIZE** control function is set by issuing a **DIAGNOSE** Code X'68' Subcode X'0000' assembler call. If you do not set the **AUTHORIZE** function in V1, check the **JOBNAME** field when processing each interrupt to ensure that interrupts from other virtual machines are not misinterpreted as coming from TCPIP. V1 must be zero for all VMCF functions other than **AUTHORIZE**. To terminate VMCF activities for a virtual machine, issue the **UNAUTHORIZE** control function. The **UNAUTHORIZE** control function is set by issuing a **DIAGNOSE** Code X'68' Subcode X'0001' assembler call.

FUNC The IUCV operation.

V2 Reserved for IBM use, and should be X'00' initially.

MSGID

Contains a unique message identifier associated with a transaction. You must use a unique, even number for each outstanding transaction. A simple method is to use consecutive, even numbers for each transaction.

JOBNAME

Specifies the user ID of the virtual machine making VMCF requests. You must set this field to the user ID of the TCPIP virtual machine.

VADA Contains the address of the source or destination address depending on the VMCF function requested.

LENA Contains the length of the data sent by a user, the length of a **RECEIVE** buffer, or the length of an external interrupt buffer, whichever is specified in the **VADA** field.

VADB Contains the address of a source virtual machine's **REPLY** buffer for VMCF request.

LENB Specifies the length of the source virtual machine's **REPLY** buffer.

The use of each field is described individually for each TCP/IP function.

VMCF Interrupt Header Fields

The following describes the VMCF parameter list fields for the interrupt header.

V1 Sets the VMCMRESP flag, which is the interrupt in response to a transaction initiated by your virtual machine. If the TCPIP virtual machine responds using the REJECT function, the VMCMRJCT flag is also set. This flag by itself does not usually indicate that the transaction was unsuccessful. Your program should check the completion status code in the RETCODE field, as described for each function.

ANINTEGR

Checks the status of VMCF transactions. It is a field, of fullword length (four bytes), used to check the status of VMCF transactions. The field is described for each function.

CONN

Establishes a TCP connection. If a connection between your virtual machine and TCPIP virtual machine was established successfully and the RETCODE field indicates OK, the connection number of the new connection is stored in this field.

CALLCODE

Calls instructions to be passed by your program when initiating a VMCF function to interface with TCPIP virtual machine. If the interrupt is in response to a transaction initiated by your virtual machine (VMCMRESP flag set in V1), the CALLCODE value is the same as the value set by your program when it initiated the transaction.

RETCODE

Contains the completion status codes of a transaction. Return codes reported in this field are taken from the same set used by Pascal programs (see Appendix B, "Pascal Return Codes," on page 405). Further information is given in the description of each function.

VMCF Functions

Table 18 lists the available VMCF functions, with descriptions, to communicate with the TCPIP virtual machine.

Table 18. Available VMCF Functions

Function	Code	Description
AUTHORIZE	Control	Initializes VMCF for a given virtual machine. Once AUTHORIZE is executed, the virtual machine can execute other VMCF functions and receive messages or requests from other users.
UNAUTHORIZE	Control	Terminates VMCF activity.
SEND	Data	Directs a message or block of data to another virtual machine.
SEND/RECV	Data	Directs a message or block of data to another virtual machine, and requests a reply.
RECEIVE	Data	Allows you to accept selective messages or data sent using the SEND or SEND/RECV functions.
REPLY	Data	Allows you to direct data back to the originator of a SEND/RECV function, simulating duplex communication.
REJECT	Data	Allows you to reject specific SEND or SEND/RECV requests pending for your virtual machine.

Table 18. Available VMCF Functions (continued)

Function	Code	Description
Note:		
Data		Indicates a data transfer
Control		Indicates a VMCF control function

VMCF TCPIP Communication CALLCODE Requests

Table 19 lists the equate values and available calls for initiating a VMCF TCPIP request; it also includes a description of each CALLCODE request.

Table 19. VMCF TCPIP CALLCODE Requests

Call Code	Equates	Description
CONNECTIONclosing	00	Data may no longer be transmitted on this connection since the TCP/IP service is in the process of closing down the process.
LISTENING	01	Waiting for a foreign site to open a connection.
NONEXISTENT	02	The connection no longer exists.
OPEN	03	Data can go either way on the connection.
RECEIVINGonly	04	Data can be received but not sent on this connection, because the client has done a one-way close.
SENDINGonly	05	Data can be sent out but not received on this connection. This means that the foreign site has done a one way close.
TRYINGtoOPEN	06	Trying to contact a foreign site to establish a connection.
V6OPENTcp	33	Initiates a TCP connection (IPv4 or IPv6).
V6STATUStcp	34	Obtains the IPv6 Connection Information Record giving the current status of a TCP connection (IPv4 or IPv6).
ABORTtcp	100	Terminates a TCP connection.
BEGINtcpIPservice	101	Initializes a TCP/IP connection between your program and the TCPIP virtual machine.
CLOSEtcp	102	Initiates the closing of a TCP connection.
CLOSEudp	103	Initiates the closing of a UDP connection.
ENDtcpIPservice	104	Terminates the use of TCPIP services. All existing TCP connections are reset, all open UDP ports are canceled, and all IP protocols are released.
HANDLEnotice	105	Specifies the types of notifications to be received from TCPIP.
IShostLOCAL	106	Determines whether a given internet address is one of your host's local addresses.
MONITORcommand	107	Instructs TCPIP to obey a file of commands.
MONITORquery	108	Obtains status information from the TCPIP virtual machine or requests that it performs certain functions.
OPENTcp	110	Initiates a TCP connection for IPv4 only.
OPENudp	111	Initiates a UDP connection for IPv4 only.

Table 19. VMCF TCPIP CALLCODE Requests (continued)

Call Code	Equates	Description
OPTIONtcp	112	Sets an option for a TCP connection.
RECEIVEtcp	113	Tells TCPIP that you are ready to receive data on a specified TCP connection.
NRECEIVEudp	115	Tells TCPIP that your program is ready to receive a UDP datagram on a particular port.
SENDtcp	118	Sends data on a TCP connection. The SENDtcp transaction is unsuccessful if the receiving TCPIP virtual machine has insufficient buffer space to receive the data.
SENDudp	119	Sends a UDP datagram.
STATUStcp	120	Obtains a Connection Information Record giving the current status of a TCP IPv4 connection.
FRECEIVEtcp	121	Tells TCPIP virtual machine that you are ready to receive data on a specified TCP connection. TCPIP does not respond or send a notification until the data has been placed in the receiving buffer or the connection has been closed.
FSENDtcp	122	Sends data to a TCP connection. FSENDtcp waits for available receiving buffer space in the TCPIP virtual machine before completing the VMCF transaction.
CLOSErawIP	123	Tells TCPIP that your program does not handle the protocol any longer. Any queued incoming packets are discarded.
OPENrawIP	124	Initiates a connection and tells TCPIP virtual machine that your program is ready to send and receive packets of a specified IP protocol.
RECEIVERawIP	125	Tells TCPIP that your program is ready to receive raw IP packets of a given protocol. Your program receives a RAWIPpacketsDELIVERED notification when a packet arrives.
SENDrawIP	126	Tells TCPIP virtual machine to send raw IP packets of a given protocol number.
PINGreq	127	Sends an ICMP echo request to a specified host and wait a specified time for a response.
TLSQuery	128	Sends a query to determine if the SSL server is available and, if so, if the label specified is known.
TLSCLOSEtcp	132	Indicates to the SSL Server that secure communication on this connection should stop and communication should continue in the clear.
TLSSSTATUStcp	129	Returns details about a session, such as whether or not it is secure and the encryption suite.
TLSSSERVERtcp	130	Indicates to the SSL server that the connection is to be secure and that the SSL server needs to wait for an incoming handshake.
TLSSCLIENTtcp	131	Indicates to the SSL server that the connection is to be secure and that the SSL server needs to initiate an outbound connection.
V6OPENudp	135	Initiates a UDP connection (IPv4 or IPv6).
V6SENDudp	136	Sends a UDP datagram (IPv4 or IPv6).

VMCF TCPIP Communication CALLCODE Notifications

Table 20 lists the equate values for the CALLCODE field when VMCF TCPIP sends a notification to your program. The table includes a description of each CALLCODE response.

Table 20. VMCF TCPIP CALLCODE Notifications

Notification Code	Equates	Description
BUFFERspaceAVAILABLE	10	Notification that there is space available to send data on this connection. The space is currently set to 8192 bytes of buffer space.
CONNECTIONstateCHANGED	11	Notification that the state of the connection between the TCPIP virtual machine and your program has changed.
DATAdelivered	12	Notification that the TCPIP virtual machine data was delivered to your program, after issuing a RECEIVEtcp or FRECEIVEtcp call.
URGENTpending	15	Notification that there is queued data on a TCP connection not yet received by your program.
UDPdatagramDELIVERED	16	Notification that UDP datagram has been delivered to your program after issuing a NRECEIVEudp call to the TCPIP virtual machine.
UDPdatagramSPACEavailable	17	Notification that buffer space is available to process the data, after an error occurred performing a SENDudp call.
RAWIPpacketsDELIVERED	24	Notification that your buffer has received the raw IP packets.
RAWIPspaceAVAILABLE	25	Notification that buffer space is available to process the data. This notification is sent after the SENDrawip call was rejected by TCPIP virtual machine.
RESOURCESavailable	28	Notification that the resources needed to initiate a TCP connection are now available. This notification is sent only if a previous OPENTcp call received a ZEROresources return code.
UDPresourcesAVAILABLE	29	Notification that the resources needed to initiate a UDP connection are now available. This notification is sent only if a previous OPENudp call received a UDPzeroRESOURCES return code.
PINGresponse	30	Notification that your ping request from the PINGreq call has been received or that the time-out limit or your request has been reached.
DUMMYprobe	31	Notification that the TCPIP virtual machine is monitoring your machine
ACTIVEprobe	32	Notification that the TCPIP virtual machine is monitoring your machine for responsiveness

Table 20. VMCF TCPIP CALLCODE Notifications (continued)

Notification Code	Equates	Description
CLEARtextRESUMED	32	Notification that the SSL Server has stopped secure communication on the connection
QUERYtlsCOMPLETE	33	Notification that the SSL server has completed verification of the label
SECUREhandshakeCOMPLETE	34	Notification that the Inbound or Outbound handshake has completed.
READYforHANDSHAKE	35	Notification that the server side is set up to receive a secure handshake.

TCP/UDP/IP Initialization and Termination Procedures

This section contains information about procedures for initializing and terminating TCP/UDP/IP connections.

BEGINtcpIPservice

Your program performs the BEGINtcpIPservice call after doing a VMCF AUTHORIZE function, but before performing any other TCP/IP functions. The BEGINtcpIPservice call informs TCPIP that your virtual machine uses TCPIP services. An ENDtcpIPservice call is logically performed first, in the case where your virtual machine already has TCPIP resources allocated.

```

FUNC:      SEND
VADA:      0
LENA:      1
VADB:      0 or, if your application supports probe messages (see the
           descriptions of the DUMMYprobe and ACTIVEprobe CALLCODE
           notifications), X'80000000'
LENB:      0
CONN:      0 or, if your application does not provide the client level in
           ANINTEGR, any non-zero value
ANINTEGR:  the client level, in the form X'vvr10000', where 'vv' is the
           version number, 'r' is the release number, and '1' is the
           level number
CALLCODE:  BEGINtcpIPservice

```

The TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header, stored in your virtual machine by the response interrupt, contains a return code in the RETCODE field. The return code can be any of those listed for the BeginTcpIp Pascal procedure (see “BeginTcpIp” on page 63).

The VMCF interrupt header also includes values in the CONN and ANINTEGR fields that reflect the level information for the TCPIP virtual machine. If CONN is zero, then ANINTEGR contains the TCPIP virtual machine's level; otherwise, no level information is returned.

HANDLEnotice

Your program performs the HANDLEnotice call to specify the types of notifications to be received from TCPIP. The VADB field in the VMCF parameter list contains a notification mask, with 1 bit set for each notification you want to handle. The bit to be set for each notification type is shown in Figure 25 on page 124.

VMCF Interface

Figure 25 shows the equates used for notification mask in the HANDLEnotice call.

MaskBUFFERspaceAVAILABLE	EQU	X'00000001'
MaskCONNECTIONstateCHANGED	EQU	X'00000002'
MaskDATAdelivered	EQU	X'00000004'
MaskURGENTpending	EQU	X'00000020'
MaskUDPdatagramDELIVERED	EQU	X'00000040'
MaskUDPdatagramSPACEavailable	EQU	X'00000080'
MaskRAWIPpacketsDELIVERED	EQU	X'00004000'
MaskRAWIPspaceAVAILABLE	EQU	X'00008000'
MaskRESOURCESavailable	EQU	X'00040000'
MaskUDPresourcesAVAILABLE	EQU	X'00080000'
MaskPINGresponse	EQU	X'00100000'

Figure 25. Equates for Notification Mask in the HANDLEnotice Call

Each HANDLEnotice call must specify all the notification types to be handled. Notification types specified in previous HANDLEnotice calls are not stored.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	Note mask
LENB:	0
CALLCODE:	HANDLEnotice

The TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header contains a return code in the RETCODE field. The return code can be any of those listed for the Handle Pascal procedure (see "Handle" on page 68).

ENDtcpIPservice

Your program performs the ENDtcpIPservice call when it has finished using TCPIP services. All existing TCP connections are reset (aborted), all open UDP port opens are canceled, and all IP protocols are released.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	0
CALLCODE:	ENDtcpIPservice

The TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header indicates a return code of OK in the RETCODE field.

TCP CALLCODE Requests

The following sections describe the VMCF interrupt headers that are stored in your virtual machine for CALLCODE calls used to make TCP requests.

OPENTcp

The OPENTcp call initiates a TCP connection for IPv4 only. Your program sends a Connection Information Record to TCPIP. Figure 26 on page 125 gives the

assembler format of the record. Figure 27 gives the equates for the assorted constants used to set up the record. For more information about the usage of the fields of the Connection Information Record, see “TcpOpen and TcpWaitOpen” on page 94.

Connection	DS	H
OpenAttemptTimeout	DS	F
Security	DS	H
Compartment	DS	H
Precedence	DS	X
BytesToRead	DS	F
UnackedBytes	DS	F
ConnectionState	DS	X
LocalSocket.Address	DS	F
LocalSocket.Port	DS	H
ForeignSocket.Address	DS	F
ForeignSocket.Port	DS	H

Figure 26. Assembler Format of the Connection Information Record for VM

UNSPECIFIEDconnection	EQU	-48
DEFAULTsecurity	EQU	0
DEFAULTcompartment	EQU	0
DEFAULTprecedence	EQU	0
UNSPECIFIEDaddress	EQU	0
UNSPECIFIEDport	EQU	X'FFFF'
ANintegerFLAGrequestERR	EQU	X'80000000'

Figure 27. Miscellaneous Assembler Constants

FUNC:	SEND/RCV
VADA:	Address of Connection Information Record initialized by your program
LENA:	Length of Connection Information Record
VADB:	Address of Connection Information Record to be filled in with TCPIP reply
LENB:	Length of Connection Information Record
CONN:	UNSPECIFIEDconnection
CALLCODE:	OPENTcp

If the open attempt cannot be initiated, the TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header, contains a return code in the RETCODE field. The return code can be any of those listed for the Tcp6Open Pascal procedure.

If the OPENTcp call was rejected because not enough TCPIP resources were available, a ZEROresources code is returned. When the TCPIP resources are available, a notice of RESOURCESavailable is sent to your program.

If the open attempt is not immediately rejected, the TCPIP virtual machine uses the VMCF RECEIVE function to receive the Connection Information Record describing the connection to be opened. If the connection then cannot be initiated, TCPIP responds using the VMCF REJECT function. The RETCODE field in the VMCF interrupt header is set as described in the previous paragraph.

VMCF Interface

If the open was successfully initiated, the TCPIP virtual machine responds using the VMCF REPLY function to send back the updated Connection Information Record. The Connection field of the Connection Information Record contains the connection number of the new connection. The RETCODE field in the VMCF interrupt header indicates OK, and the CONN field also contains the connection number of the new connection. The connection is not yet open; your program receives notification(s) during the opening sequence. For more information about NotificationInfoType, see the section on the Pascal under "Notification Record" on page 50 and see also "CALLCODE Notifications" on page 140.

SENDtcp and FSENDtcp

The SENDtcp or FSENDtcp calls send data on a TCP connection. For the advantages and disadvantages of using each function, and for information about sending TCP data, see "TcpFSend, TcpSend, and TcpWaitSend" on page 91.

FUNC:	SEND
VADA:	Address of data
LENA:	Length of data
VADB:	1 if push desired, else 0
LENB:	1 if urgent data, else 0
CONN:	Connection number from open
CALLCODE:	SENDtcp or FSENDtcp

If TCPIP can successfully queue the data for sending, it responds with the VMCF RECEIVE function. The VMCF interrupt header indicates a RETCODE of OK.

If TCPIP cannot queue the data for sending, it responds with the VMCF REJECT function. The RETCODE field indicates the type of error. The return code can be any of those listed for the TcpSend Pascal procedure. For a list of the return codes, see "TcpFSend, TcpSend, and TcpWaitSend" on page 91.

If the SENDtcp transaction is unsuccessful, because of insufficient space in the buffer of the receiving TCPIP virtual machine, a return code of NObufferSPACE is placed in the RETCODE field. A notification of BUFFERspaceAVAILABLE is sent, on this connection, when the space is available to process data.

TcpFSend is the same as FSENDtcp. If TCPIP cannot accept the data, because of a buffer shortage, it does not respond immediately. Instead, it waits until space is available, and then uses VMCF RECEIVE to receive the data. While it is waiting, if the connection is reset, it responds with VMCF REJECT, with a return code as described previously. In summary, TCPIP may not respond immediately to FSENDtcp, and the response, after waiting, may indicate either success or failure. If TCPIP responds with REJECT, your program can check the ANintegerFLAGrequestERR bit in the ANINTEGR field to determine if the request was rejected during initial or retry processing (bit on) or because of connection closing (bit off).

Your program does not need to wait for a response from SENDtcp or FSENDtcp VMCF transaction. It can issue functions involving other connections, before receiving a response from making a SENDtcp or FSENDtcp VMCF transaction.

There is a limit of 50 outstanding VMCF transactions for each virtual machine; therefore, your program can have FSENDtcp functions outstanding on only 50 connections at a time. If your application needs more outstanding sends, use the SENDtcp function.

FRECEIVtcp

The FRECEIVtcp call tells TCPIP that you are ready to receive data on a specified TCP connection. TCPIP does not respond or send a notification notice until data is received or the connection is closed. Consequently, each outstanding FRECEIVtcp function results in an outstanding VMCF transaction. There is a limit of 50 outstanding VMCF transactions for each virtual machine; you can therefore have FRECEIVtcp functions outstanding on only 50 connections at one time. If your application needs more outstanding receives, use the RECEIVtcp function.

Your program does not need to wait for a response from FRECEIVtcp. It can issue functions involving other connections, before receiving a response from FRECEIVtcp.

For general information about receiving TCP data, see the TcpFReceive Pascal procedure under "TcpFReceive, TcpReceive, and TcpWaitReceive" on page 89.

FUNC:	SEND/RCV
VADA:	0
LENA:	1
VADB:	Address of buffer to receive data
LENB:	Length of buffer to receive data
CONN:	Connection number from open
CALLCODE:	FRECEIVtcp

If TCPIP accepts the request, your program receives no response until TCPIP is ready to deliver data to your buffer, or until the request is canceled, because the connection has closed without delivering data.

When TCPIP is ready to deliver data for this connection, it issues a VMCF REPLY function. Significant fields in the VMCF interrupt header are:

LENB Indicates the residual count. Subtract this from the size of your buffer (LENB value in parameter list) to determine the number of bytes actually delivered.

ANINTEGR

Contains a value where the high-order byte is nonzero if data was pushed; otherwise, it is zero. The low-order three bytes are interpreted as a 24-bit integer, indicating the offset of the byte following the last byte of urgent data, measured from the first byte of data delivered to your buffer. If it is zero or a negative number, then there is no urgent data pending.

CONN

Specifies the connection number.

RETCODE

OK

If TCPIP responds with the VMCF REJECT function (VMCFRJCT flag set in the VMCF interrupt header), then one of the following occurred:

- TCPIP did not accept the request, in which case the ANintegerFLAGrequestERR bit in ANINTEGR is on.
- TCPIP accepted the request initially, but the connection closed before data was delivered. ANintegerFLAGrequestERR bit in ANINTEGR is off. In this case, the

VMCF Interface

RETCODE field indicates one of the reason codes listed for CONNECTIONstateCHANGED with the NewState field set to NONEXISTENT. For more information, see 2 on page 52.

Note: Your program does not have to take any special action in this case, because it receives one or more CONNECTIONstateCHANGED notifications indicating that the connection is closing.

RECEIVEtcp

The RECEIVEtcp call tells TCPIP that you are ready to receive data on a specified TCP connection. Unlike FRECEIVEtcp, TCPIP responds immediately to RECEIVEtcp. You can have more than 50 receive requests pending using RECEIVEtcp without exceeding the limit of 50 outstanding VMCF transactions.

For more information about receiving TCP data, see the TcpReceive Pascal procedure under "TcpFReceive, TcpReceive, and TcpWaitReceive" on page 89.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	Length of buffer to receive data
CONN:	Connection number from open
CALLCODE:	RECEIVEtcp

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer indicates whether the request was successful. If the request was successful, with a RETCODE of OK, the data is delivered to your buffer and a notification of DATAdelivered is sent to your program. If the request was not successful, then the return code is one of those listed for the TcpReceive Pascal procedure.

CLOSEtcp

The CLOSEtcp call initiates the closing of a TCP connection. For more information about the close connection call, see the Pascal procedure, "TcpClose" on page 87.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	0
CONN:	Connection number from open
CALLCODE:	CLOSEtcp

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code. The return code is one of those listed for the TcpClose Pascal procedure, see "TcpClose" on page 87.

ABORTtcp

The ABORTtcp call terminates a TCP connection. For more information about the abort connection call, see the Pascal procedure, "TcpAbort" on page 87.

```

FUNC:    SEND
VADA:    0
LENA:    1
VADB:    0
LENB:    0
CONN:    Connection number from open
CALLCODE: ABORTtcp

```

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code. It is one of those listed for the TcpAbort Pascal procedure.

STATUStcp

The STATUStcp call obtains a Connection Information Record giving the current status of a TCP connection for IPv4 only. For the assembler format of the Connection Information Record, see Figure 26 on page 125. For more information about the connection status call, see the Pascal procedure, "TcpStatus" on page 102.

```

FUNC:    SEND/RECV
VADA:    0
LENA:    1
VADB:    Address of Connection Information Record to fill in
LENB:    Length of Connection Information Record to fill in
CONN:    Connection number from open
CALLCODE: STATUStcp

```

TCPIP responds with the VMCF REPLY function, filling in the record whose address you supplied in LENB. The record is valid only if the return code, in the RETCODE field of the VMCF interrupt header, returns OK. Otherwise, the return code is one of those listed for the TcpStatus Pascal procedure.

OPTIONtcp

The OPTIONtcp call sets an option for a TCP connection for IPv4 only. For more information about the connection options, see the Pascal procedure, "TcpOption" on page 97.

```

FUNC:    SEND
VADA:    0
LENA:    1
VADB:    Option name
LENB:    Option value
CONN:    Connection number from open
CALLCODE: OPTIONtcp

```

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code. The return code is one of those listed for the Pascal TcpOption procedure.

TLSSSTATUStcp

The TLSSSTATUStcp call returns details about a session, such as whether or not it is secure and the encryption suite. For more information about the connections security status, see the Pascal Procedure, "TcpSStatus" on page 101.

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```
FUNC:    SEND/RCV
VADA:    0
LENA:    1
VADB:    Address of CipherDetails Record to be filled in
LENB:    Length of CipherDetails Record to be filled in
CONN:    Connection number from open
CALLCODE: TLSSSTATUStcp
```

See “TcpSStatus” on page 101 for details of the CipherDetails structure. TCPIP responds with the VMCF REPLY function, filling in the record whose address you supplied in VADB. The record is only valid if the return code, in the RETCODE field of the VMCF interrupt header, returns OK; otherwise, the return code is one of those listed for the TcpSStatus Pascal Procedure.

TLSSSERVERtcp

The TLSSSERVERtcp call indicates to the SSL server that the connection is to be secure and that the SSL server needs to wait for an incoming handshake. For more information about the secure server call, see “TcpSClient” on page 98.

```
FUNC:    SEND/RCV
VADA:    Address of SecureDetailType record
LENA:    Length of SecureDetailType record
VADB:    0
LENB:    1
CONN:    Connection number from open
CALLCODE: TLSSSERVERtcp
```

See “TcpSServer” on page 100 for details of the SecureDetailType structure.

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code from the preprocessing of this command. The return code is one of those listed for the TcpSServer procedure. The results of the actual handshake will be returned with the SECUREhandshakeCOMPLETE notification.

TLSSCLIENTtcp

The TLSSCLIENTtcp call indicates to the SSL server that the connection is to be secure and that the SSL server needs to initiate an outbound connection. For more information about the secure client call, see the Pascal Procedure , “TcpSClient” on page 98.

```
FUNC:    SEND/RCV
VADA:    Address of SecureDetailType record
LENA:    Length of SecureDetailType record
VADB:    0
LENB:    1
CONN:    Connection number from open
CALLCODE: TLSSCLIENTtcp
```

See “TcpSClient” on page 98 for details of the SecureDetailType structure.

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code from the preprocessing of this

command. The return code is one of those listed for the TcpSClient procedure. The results of the actual handshake will be returned with the SECUREhandshakeCOMPLETE notification.

TLSSCLOSEtcp

The TLSSCLOSEtcp call indicates to the SSL Server that the connection should no longer be secure. The SSL server issues a Close_Notify command on the connection and sends a notification to indicate that data transmission can continue in the clear. For more information about the secure close call, see the Pascal Procedure, "TcpSClose" on page 100.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	1
CONN:	Connection number from open
CALLCODE:	TLSSCLOSEtcpFUNC: SEND/RECV

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt buffer contains the return code from the pre-processing of this command. The return code is one of those listed for the TcpSClose procedure. The results of the actual Close_Notify command will be returned with the CLEARtextRESUMED notification.

V6OPENTcp

The V6OPENTcp call initiates a TCP connection. Your program sends an IPv6 Connection Information Record to TCPIP. Figure 28 gives the assembler format of the record. Figure 29 on page 132 gives the equates for the assorted constants used to set up the record. For more information about the usage of the fields of the Connection Information Record, see "Tcp6Open and Tcp6WaitOpen" on page 83.

Connection	DS	H
OpenAttemptTimeout	DS	F
Security	DS	H
Compartment	DS	H
Precedence	DS	X
BytesToRead	DS	F
UnackedBytes	DS	F
ConnectionState	DS	X
LocalSocket.Address	DS	XL16
LocalSocket.Port	DS	H
ForeignSocket.Address	DS	XL16
ForeignSocket.Port	DS	H

Figure 28. Assembler Format of the IPv6 Connection Information Record for VM

VMCF Interface

UNSPECIFIEDconnection	EQU	-48
DEFAULTsecurity	EQU	0
DEFAULTcompartment	EQU	0
DEFAULTprecedence	EQU	0
UNSPECIFIEDipv6address	EQU	0
UNSPECIFIEDport	EQU	X'FFFF'
ANintegerFLAGrequestERR	EQU	X'80000000'

Figure 29. Miscellaneous Assembler Constants

FUNC:	SEND/RCV
VADA:	Address of the IPv6 Connection Information Record initialized by your program
LENA:	Length of IPv6 Connection Information Record
VADB:	Address of the IPv6 Connection Information Record to be filled in with TCPIP reply
LENB:	Length of IPv6 Connection Information Record
CONN:	UNSPECIFIEDconnection
CALLCODE:	V60PENTcp

If the open attempt cannot be initiated, the TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header, contains a return code in the RETCODE field. The return code can be any of those listed for the TcpOpen Pascal procedure.

If the V60PENTcp call was rejected because not enough TCPIP resources were available, a ZEROresources code is returned. When the TCPIP resources are available, a notice of RESOURCESavailable is sent to your program.

If the open attempt is not immediately rejected, the TCPIP virtual machine uses the VMCF RECEIVE function to receive the Connection Information Record describing the connection to be opened. If the connection then cannot be initiated, TCPIP responds using the VMCF REJECT function. The RETCODE field in the VMCF interrupt header is set as described in the previous paragraph.

If the open was successfully initiated, the TCPIP virtual machine responds using the VMCF REPLY function to send back the updated IPv6 Connection Information Record. The Connection field of the Connection Information Record contains the connection number of the new connection. The RETCODE field in the VMCF interrupt header indicates OK, and the CONN field also contains the connection number of the new connection. The connection is not yet open; your program receives notification(s) during the opening sequence. For more information about NotificationInfoType, see the section on the Pascal under "Notification Record" on page 50 and see also "CALLCODE Notifications" on page 140.

V6STATUStcp

The V6STATUStcp call obtains an IPv6 Connection Information Record giving the current status of a TCP connection. For the assembler format of the IPv6 Connection Information Record, see Figure 28 on page 131. For more information about the connection status call, see the Pascal procedure, "Tcp6Status" on page 86.

```

FUNC:    SEND/RCV
VADA:    0
LENA:    1
VADB:    Address of the IPv6 Connection Information Record to fill in
LENB:    Length of IPv6 Connection Information Record to fill in
CONN:    Connection number from open
CALLCODE: V6STATUStcp

```

TCPIP responds with the VMCF REPLY function, filling in the record whose address you supplied in LENB. The record is valid only if the return code, in the RETCODE field of the VMCF interrupt header, returns OK. Otherwise, the return code is one of those listed for the Tcp6Status Pascal procedure.

UDP CALLCODE Requests

The following sections describe the VMCF interrupt headers, which are stored in your virtual machine, for CALLCODE calls used to make UDP requests.

OPENudp

The OPENudp call opens a UDP port. For more information about the UDP open function, see the Pascal procedure, “UdpOpen” on page 107.

```

FUNC:    SEND
VADA:    0
LENA:    1
VADB:    Local port number or UNSPECIFIEDport
LENB:    Local address
CONN:    Connection number: An arbitrary number, which your program
          uses in subsequent actions involving this port.
CALLCODE: OPENudp

```

TCPIP responds with the VMCF REJECT function. The RETCODE field in the VMCF interrupt header can be any of the return codes listed for the UdpOpen Pascal procedure. If the OPENudp call was rejected, because not enough TCPIP resources were available, a UDPzeroRESOURCES code is returned. When the TCPIP resources are available, a notice of UDPresourcesAVAILABLE is sent to your program.

SENDudp

The SENDudp call sends a UDP datagram. For more information about the UDP send function, see the Pascal procedure, “UdpSend” on page 109.

```

FUNC:    SEND
VADA:    Address of datagram data
LENA:    Length of datagram data (up to 8492 bytes)
VADB:    Destination port number
LENB:    Destination address
CONN:    Connection number
CALLCODE: SENDudp

```

If TCPIP can send the datagram, it responds with the VMCF RECEIVE function. The RETCODE field in the VMCF interrupt header contains a return code of OK. If TCPIP cannot send the datagram, it responds with the VMCF REJECT function.

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The RETCODE field contains one of the return codes listed for the UdpSend Pascal procedure. When the buffer space is not available to process the data, an error is returned. The notification message of UDPdatagramSPACEavailable is sent to your program when the buffer space is available to process data.

NRECEIVEudp

The NRECEIVEudp call tells TCPIP that your program is ready to receive a UDP datagram on a particular port. TCPIP responds immediately to inform you whether it accepted the request. If TCPIP has accepted your request, your program receives a UDPdatagramDELIVERED notification when a datagram arrives. For more information about receiving UDP datagrams, see the Pascal procedure, "UdpNReceive" on page 106.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	Size of your buffer to receive datagram
CONN:	Connection number
CALLCODE:	NRECEIVEudp

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the UdpNReceive Pascal procedure.

CLOSEudp

The CLOSEudp call closes a UDP port. For more information about the CLOSEudp call, see the Pascal procedure, "UdpClose" on page 106.

FUNC:	SEND
VADA:	0
LENA:	1
VADB:	0
LENB:	0
CONN:	Connection number
CALLCODE:	CLOSEudp

TCPIP responds with the VMCF REJECT function. The RETCODE field in the VMCF interrupt header can be any of the return codes listed for the UdpClose Pascal procedure. If the return code is OK, and your program specified UNSPECIFIEDport as the port number, the actual port number assigned is encoded in the CONN field of the interrupt header. Add the value of 32 768 to the value in the CONN field, using unsigned arithmetic, to compute the port number.

V6OPENudp

The V6OPENudp call opens a UDP port. For more information about the UDP open function, see the Pascal procedure, "Udp6Open" on page 104.

```

FUNC:    SEND/RCV
VADA:    Address of the local socket
LENA:    Length of the local socket
VADB:    0
LENB:    0
CONN:    Connection number: An arbitrary number, which your program
          uses in subsequent actions involving this port.
CALLCODE: V6OPENudp

```

If the open attempt cannot be initiated, the TCPIP virtual machine responds using the VMCF REJECT function. The VMCF interrupt header, contains a return code in the RETCODE field. The return code can be any of those listed for the Udp6Open Pascal procedure.

If the V6OPENudp call was rejected, because not enough TCPIP resources were available, a UDPzeroRESOURCES code is returned. When the TCPIP resources are available, a notice of UDPresourcesAVAILABLE is sent to your program.

If the open attempt is not immediately rejected, the TCPIP virtual machine uses the VMCF RECEIVE function to receive the local socket information. If the connection then cannot be initiated, TCPIP responds using the VMCF REJECT function. The RETCODE field in the VMCF interrupt header is set as described in the previous paragraph.

V6SENDudp

The V6SENDudp call sends a UDP datagram. Your program sends an IPv6 Datagram Information Record to TCPIP. Figure 30 gives the pascal format of the record. It includes foreign socket, datagram data, and length of datagram data. For more information about the UDP send function, see the Pascal procedure, "Udp6Send" on page 105.

```

UdpSendPacket6InfoType = record
  Socket: Socket6Type;
  BufferLen: integer;
  Packet: packed array (.1..65535.) of char ;
end;

```

Figure 30. Pascal Format of the IPv6 Datagram Information Record for VM

```

FUNC:    SEND/RECEIVE
VADA:    Address of IPv6 Datagram Information Record initialized
          by your program
LENA:    Length of IPv6 Datagram Information Record
VADB:    0
LENB:    0
CONN:    Connection number
CALLCODE: V6SENDudp

```

TCPIP virtual machine will first responds with the VMCF RECEIVE function to get the IPv6 Datagram Information Record. Then if TCPIP can send the datagram, it responds with the VMCF REJECT function and the RETCODE field in the VMCF interrupt header contains a return code of OK. If TCPIP cannot send the datagram, it responds with the VMCF REJECT function. The RETCODE field contains one of the return codes listed for the Udp6Send Pascal procedure. When the buffer space

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| is not available to process the data, an error is returned. The notification message
| of UDPdatagramSPACEavailable is sent to your program when the buffer space is
| available to process data.

IP CALLCODE Requests

The following sections describe the VMCF interrupt headers, which are stored in your virtual machine, for CALLCODE calls used to make IP requests.

OPENrawip

The OPENrawip call tells TCPIP that your program is ready to send and receive packets of a specified IP protocol. For more information, see the Pascal procedure, "RawIpOpen" on page 75.

FUNC:	SEND/RECV
VADA:	0
LENA:	1
VADB:	0
LENB:	0
CONN:	Protocol number
CALLCODE:	OPENrawip

TCPIP uses the VMCF REJECT function to respond to the request. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the RawIpOpen Pascal procedure.

SENDrawip

The SENDrawip call sends raw IP packets of a given protocol number. For more information, see the Pascal procedure, "RawIpSend" on page 76.

FUNC:	SEND/RECV
VADA:	Address of buffer containing packets to send
LENA:	Length of buffer
VADB:	0
LENB:	0
CONN:	(Number of packets shifted left 8 bits) + protocol number
CALLCODE:	SENDrawip

If TCPIP immediately determines that the request cannot be fulfilled, It responds with the VMCF REJECT function. Otherwise, it uses the VMCF RECEIVE function to receive your data, followed by VMCF REJECT. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the RawIpSend Pascal procedure. If TCPIP virtual machine is out of buffers, the data is rejected and a return code of NObufferSPACE is returned. When buffer space is available, the notification of RAWIPspaceAVAILABLE is sent to your program.

RECEIVERawip

The RECEIVERawip call tells TCPIP that your program is ready to receive raw IP packets of a given protocol. Your program receives a RAWIPpacketsDELIVERED notification when a packet arrives. For information about the RAWIPpacketsDELIVERED notification record, see the Pascal procedure, "RawIpReceive" on page 75, and the section on the Pascal NotificationInfoType

under “Notification Record” on page 50.

```

FUNC:    SEND/RCV
VADA:    0
LENA:    1
VADB:    0
LENB:    Length of your buffer
CONN:    Protocol number
CALLCODE: RECEIVErawip

```

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the RawIpReceive Pascal procedure.

CLOSErawip

The CLOSErawip call tells TCPIP that your program is ready to cease sending and receiving packets of a specified IP protocol. For more information, see the Pascal procedure, “RawIpClose” on page 74.

```

FUNC:    SEND/RCV
VADA:    0
LENA:    1
VADB:    0
LENB:    0
CONN:    Protocol number
CALLCODE: CLOSErawip

```

TCPIP uses the VMCF REJECT function to respond to the request. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the RawIpClose Pascal procedure.

CALLCODE System Queries

The following sections describe the VMCF interrupt headers, which are stored in your virtual machine, for CALLCODE calls used to make system queries.

IShostLOCAL

The IShostLOCAL call determines whether a given internet address is one of your host’s local addresses. For more information about this procedure, see the Pascal procedure “IsLocalAddress” on page 69.

```

FUNC:    SEND
VADA:    0
LENA:    1
VADB:    Internet address to be tested
LENB:    0
CONN:    UNSPECIFIEDconnection
CALLCODE: IShostLOCAL

```

TCPIP responds with the VMCF REJECT function. The RETCODE field of the VMCF interrupt header contains the return code, as described in the IsLocalAddress Pascal procedure section.

MONITORcommand

The MONITORcommand call instructs TCPIP to obey a file of commands. For more information, see the Pascal procedure, "MonCommand" on page 70, and for more information about the OBEYFILE command, which uses the MonCommand procedure, see *z/VM: TCP/IP Planning and Customization*.

Owner	DS	CL8
DatasetPassword	DS	CL8
FullDatasetName	DS	CL44
MemberName	DS	CL8
DDName	DS	CL8

Figure 31. Assembler Format of the SpecOfFileType Record for VM

FUNC:	SEND/RCV
VADA:	Address of SpecOfFile record
LENA:	Length of SpecOfFile record
VADB:	0
LENB:	0
CONN:	UNSPECIFIEDconnection
CALLCODE:	MONITORcommand

If TCPIP cannot process the request, it responds immediately with the VMCF REJECT function. Otherwise, it uses the VMCF RECEIVE function to receive the SpecOfFile record provided by your program. It then attempts to process the file, and uses the VMCF REJECT function to report the return code. In either case, the return code is one of those specified for the MonCommand Pascal procedure.

MONITORquery

The MONITORquery call obtains status information from the TCPIP virtual machine or to request that it performs certain functions. For more information, see the Pascal procedure, "MonQuery" on page 71. Assembler formats of constants and records used with MONITORquery are:

COMMANDcpCMD	EQU	6
COMMANDdropCONNECTION	EQU	8
QUERYhomeONLY	EQU	9

Figure 32. Equates for MonQueryRecordType used in the MONITORquery Call

QueryType	DS	X
* For QueryType = QUERYhomeONLY: No other fields		
* For QueryType = COMMANDcpCMD:		
CpCmd	DS	H Length of command
	DS	100C Command
* For QueryType = COMMANDdropCONNECTION:		
	ORG	CpCmd
Connection	DS	H

Figure 33. Assembler Format of the MonQueryRecordTypefor VM

The Pascal type HomeOnlyListType is an array of 64 InternetAddressType elements found in the COMMMAC MACLIB file. The size of InternetAddressType is a fullword.

```

FUNC:    SEND/RCV
VADA:    Address of MonQueryRecord describing request
LENA:    Length of MonQueryRecord
VADB:    Address of return buffer
LENB:    Length of return buffer
CONN:    UNSPECIFIEDconnection
CALLCODE: MONITORquery

```

If TCPIP cannot process the request, it responds immediately with the VMCF REJECT function. Otherwise, it uses the VMCF RECEIVE function to receive the MonQueryRecord describing your request, followed by either a VMCF REPLY to send the response to your return buffer (not applicable to COMMANDdropCONNECTION), or a VMCF REJECT to send a return code but no return data. For information about the return codes and the data returned (if any), see the Pascal procedure, “MonQuery” on page 71.

PINGreq

The PINGreq call sends an ICMP echo request (PING request) to a specified host and wait a specified time for a response. For more information, see the Pascal procedure “PingRequest” on page 73.

```

FUNC:    SEND
VADA:    0
LENA:    1
VADB:    Internet address of foreign host
LENB:    Length of ping packet
ANINTEGR: Timeout
CALLCODE: PINGreq

```

TCPIP uses the VMCF REJECT function to respond to the request. The RETCODE field of the VMCF interrupt header contains one of the return codes listed for the PingRequest Pascal procedure. If the return code is OK, your program receives a PINGresponse notification later.

TLSQuery

The TLSQuery call sends a query to determine if the SSL server is available, and if so, if the label specified is known. For more information, see the Pascal Procedure, “QueryTLS” on page 73.

```

QueryLabel    DS    CL8
QueryKeyring  DS    CL50

```

Figure 34. Assembler format of the QueryRequest record for VM

```

FUNC:    SEND/RCV
VADA:    Address of QueryRequest record
LENA:    Length of QueryRequest record
VADB:    0
LENB:    0
CIBB:    UNSPECIFIED
CALLCODE: TLSQuery

```

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TCPIP responds with the VMCF REPLY function. The RETCODE field of the VMCF interrupt buffer contains the return code from the preprocessing of this command. The return code is one of those listed for the QueryTLS procedure. The results of the actual query will be returned with the QUERYtlsCOMPLETE notification.

CALLCODE Notifications

The following sections describe the VMCF interrupt headers that are stored in your virtual machine for the various types of notifications. The action that your program should take is also indicated.

For more information about the various notification types, see the Pascal NotificationInfoType record under "Notification Record" on page 50.

The VMCF transaction for a notification must be completed before TCPIP sends your program another notification. You must ensure that your program takes the VMCF actions in the following sections, or TCPIP cannot communicate further with your program.

BUFFERspaceAVAILABLE

This interrupt header notifies you that there is space available to send data on this connection. The space is currently set to 8192 bytes of buffer space. The notification is sent after making a SENDtcp call and receiving an unsuccessful return code of NObufferSPACE in the RETCODE field.

```
FUNC:    SEND
JOBNAME: Name of the TCPIP virtual machine
VADB:    Space available to send on this connection, in bytes.
          Currently always 8192
CONN:    Connection number
CALLCODE: BUFFERspaceAVAILABLE
RETCODE: OK
```

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:      0
V2:      0
FUNC:    REJECT
```

CLEARtextRESUMED

The interrupt header notifies you that the Close_Notify on the connection is complete and data transmission is now in the clear.

```
FUNC:    SEND
JOBNAME: Name of TCPIP virtual machine
VADB:    0
CONN:    Connection number
CALLCODE: CLEARtextRESUMED
RETCODE: OK
```

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:      0
V2:      0
FUNC:    REJECT
```

CONNECTIONstateCHANGED

This interrupt header notifies you that the state of the connection between the TCPIP virtual machine and your program has changed.

```
FUNC:     SEND
JOBNAME:  Name of the TCPIP virtual machine
VADB:     New connection state
LENB:     Reason for state change, if new state is NONEXISTENT
CONN:     Connection number
CALLCODE: CONNECTIONstateCHANGED
RETCODE:  OK
```

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:      0
V2:      0
FUNC:    REJECT
```

DATAdelivered

This interrupt header notifies you that the TCPIP virtual machine data was delivered to your program, after issuing a RECEIVEtcp or FRECEIVEtcp call.

```
FUNC:     SEND
JOBNAME:  Name of the TCPIP virtual machine
LENA:     Length of data being delivered
VADB:     Non-zero if data was pushed, else zero.
LENB:     The offset of the byte following the last byte of urgent
           data, measured from the first byte of data delivered to your
           buffer. If zero or negative then there is no urgent data
           pending.
CONN:     Connection number
CALLCODE: DATAdelivered
RETCODE:  OK
```

Your program should issue the VMCF RECEIVE function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:      0
V2:      0
FUNC:    RECEIVE
VADA:    Address of your buffer to receive data. Buffer should be
           at least as long as indicated by LENA. LENA is no
           larger than the buffer length you specified using the
           RECEIVEtcp function.
```

URGENTpending

This interrupt header notifies you that there is queued incoming data on a TCP connection not yet received by your program.

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```
FUNC: SEND
JOBNAME: Name of the TCPIP virtual machine
VADB: Number of bytes of queued incoming data not yet received
      by your program.
LENB: Subtract 1 from LENB to get the offset of the byte following
      the last byte of urgent data, measured from the first byte not
      yet received by your program. If this quantity is zero or
      negative then there is no urgent data pending.
CONN: Connection number
CALLCODE: URGENTpending
RETCODE: OK

Your program should issue the VMCF REJECT function, with VMCF parm
list copied from the interrupt header, with the following fields changed:

V1: 0
V2: 0
FUNC: REJECT
```

UDPdatagramDELIVERED

This interrupt header notifies you that the UDP datagram has been delivered to your program after issuing a NRECEIVEudp call to the TCPIP virtual machine.

```
FUNC: SEND
JOBNAME: Name of the TCPIP virtual machine
LENA: Length of data being delivered.
VADB: Source port
LENB: Source address
ANINTEGR: Length of entire datagram excluding UDP header. If larger
          than LENA then the
          datagram was too large to fit into the buffer size specified
          in NRECEIVEudp call, and has been truncated.
CONN: Connection number
CALLCODE: UDPdatagramDELIVERED
RETCODE: OK

Your program should issue the VMCF RECEIVE function, with VMCF parm
list copied from the interrupt header, with the following fields changed:

V1: 0
V2: 0
FUNC: RECEIVE
VADA: Address of your buffer to receive data. Buffer should be
      at least as long as indicated by LENA.
```

UDPdatagramSPACEavailable

This interrupt header notifies you that buffer space is available to process the data, after an error occurred performing a SENDudp call.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
CONN:      Connection number
CALLCODE:  UDPdatagramSPACEavailable
RETCODE:   OK

```

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```

V1:        0
V2:        0
FUNC:      REJECT

```

RAWIPpacketsDELIVERED

This interrupt header notifies you that your buffer has received the raw IP packets.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
ANINTEGR:  Total length of datagram being delivered (including IP header)
LENA:      Length of data (including IP header) that TCPIP
           delivers to you.
CONN:      Low-order byte is protocol number, 3 high order bytes
           is number of packets, currently always 1.
CALLCODE:  RAWIPpacketsDELIVERED
RETCODE:   OK

```

Your program should issue the VMCF RECEIVE function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```

V1:        0
V2:        0
FUNC:      RECEIVE
VADA:      Address of your buffer to receive data. Buffer should be
           at least as long as indicated by LENA.

```

RAWIPspaceAVAILABLE

This interrupt header notifies you that buffer space is available to process the data. This notification is sent after the SENDrawip call was rejected by TCPIP virtual machine because of insufficient buffer space.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
LENB:      Space available. Always equals maximum IP datagram size.
CONN:      Protocol number
CALLCODE:  RAWIPspaceAVAILABLE
RETCODE:   OK

```

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```

V1:        0
V2:        0
FUNC:      REJECT

```

RESOURCESavailable

This interrupt header notifies you that the resources needed to initiate a TCP connection are now available. This notification is sent only if a previous OPENtcp call received a ZEROresources return code.

```
FUNC:    SEND
JOBNAME: Name of the TCPIP virtual machine
CALLCODE: RESOURCESavailable
RETCODE: OK

Your program should issue the VMCF REJECT function, with VMCF parm
list copied from the interrupt header, with the following fields changed:

V1:      0
V2:      0
FUNC:    REJECT
```

UDPresourcesAVAILABLE

This interrupt header notifies you that the resources needed to initiate a UDP connection are now available. This notification is sent only if a previous OPENudp call received a UDPzeroRESOURCES return code.

```
FUNC:    SEND
JOBNAME: Name of the TCPIP virtual machine
CALLCODE: UDPresourcesAVAILABLE
RETCODE: OK

Your program should issue the VMCF REJECT function, with VMCF parm
list copied from the interrupt header, with the following fields
changed:

V1:      0
V2:      0
FUNC:    REJECT
```

PINGresponse

This interrupt header notifies you that your ping request from the PINGreq call has been received or that the time-out limit or your request has been reached.

```
FUNC:    SEND
JOBNAME: Name of the TCPIP virtual machine
VADB:    High order word of elapsed time, in TOD clock format
          Valid only if ANINTEGR is zero
LENB:    Low order word of elapsed time, in TOD clock format
          Valid only if ANINTEGR is zero
ANINTEGR: Return code from ping operation
CALLCODE: PINGresponse
RETCODE: OK

Your program should issue the VMCF REJECT function, with VMCF parm
list copied from the interrupt header, with the following fields changed:

V1:      0
V2:      0
FUNC:    REJECT
```

DUMMYprobe

This interrupt header notifies you that the TCPIP virtual machine is monitoring your machine so it can determine if it logs off or resets unexpectedly.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
CALLCODE:  DUMMYprobe
RETCODE:   OK

Your program should leave this message pending.

```

ACTIVEprobe

This interrupt header notifies you that the TCPIP virtual machine is monitoring your machine so it can determine if it is still responsive.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
CALLCODE:  ACTIVEprobe
RETCODE:   OK

Your program should issue the VMCF REJECT function, with the VMCF
parameter list copied from the interrupt header and with the
following fields changed:

V1:        0
V2:        0
FUNC:      REJECT

The response to this message must be made within one minute after the
associated interrupt is received.

```

QUERYtIsCOMPLETE

The interrupt header notifies you that the Query is complete and returns the status of the query.

```

FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
VADB:      0
CONN:      UNSPECIFIEDconnection.
CALLCODE:  QUERYtIsCOMPLETE
RETCODE:   return code. If 0, indicates that the label is ok.

Your program should issue the VMCF REJECT function, with the VMCF parm list copied
from the interrupt header, with the following fields changed:

V1:        0
V2:        0
FUNC:      REJECT

```

READYforHANDSHAKE

The interrupt header notifies you whether or not this connection is ready for the initiation of an SSL handshake.

VMCF Interface

```
FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
VADB:      0
CONN:      Connection Number
CALLCODE:  REAQDYforHANDSHAKE
RETCODE:   Return code. If 0, indicates that a handshake can be
initiated on this connection
```

Your program should issue the VMCF REJECT function, with the VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:        0
V2:        0
FUNC:      REJECT
```

SECUREhandshakeCOMPLETE

The interrupt header notifies you that the SSL handshake on this connection is complete and indicates the status of that handshake.

```
FUNC:      SEND
JOBNAME:   Name of the TCPIP virtual machine
VADB:      SecureHSCompleteDetail
CONN:      Connection Number
CALLCODE:  SECUREhandshakeCOMPLETE
RETCODE:   OK
```

Refer to "Notification Record" on page 50 for details of SecureHSCompleteDetail.

Your program should issue the VMCF REJECT function, with VMCF parm list copied from the interrupt header, with the following fields changed:

```
V1:        0
V2:        0
FUNC:      REJECT
```

Chapter 4. Inter-User Communication Vehicle Sockets

The Inter-User Communication Vehicle (IUCV) socket API is an assembler language application programming interface that can be used with TCP/IP. While not every C socket library function is provided, all of the basic operations necessary to communicate with other socket programs are present.

Prerequisite Knowledge

This chapter assumes you have a working knowledge of IUCV, as documented in *z/VM: CP Programming Services*.

You must also know how and when to use the CMS CMSIUCV macro or the GCS IUCVCOM macro, depending on the execution environment, as documented in *z/VM: CMS Application Development Guide for Assembler* or *z/VM: Group Control System*, respectively.

You should also have a working knowledge of TCP/IP sockets.

Available Functions

Only these functions are available when you use the IUCV socket interface:

ACCEPT	READ
BIND	READV
CLOSE	RECV
CONNECT	RECVFROM
FCNTL	RECVMSG
GETCLIENTID	SELECT
GETHOSTID	SELECTEX
GETHOSTNAME	SEND
GETPEERNAME	SENDMSG
GETSOCKNAME	SENDTO
GETSOCKOPT	SETSOCKOPT
GIVESOCKET	SHUTDOWN
IOCTL	SOCKET (AF_INET sockets only)
LISTEN	TAKESOCKET
MAXDESC	WRITE
	WRITEV

Socket Programming with IUCV

TCP/IP sockets are manipulated by using the following assembler macros:

Macro	Library	Description
IUCV	HCPGPI	Provides the mechanisms for setting values in the IUCV input parameter list and for executing the IUCV instruction
IPARML	HCPGPI	Mapping macro for the IUCV parameter list and the external interrupt buffer.

IUCV Sockets

Macro	Library	Description
HNDIUCV	DMSGPI	Informs CMS that your program wishes to handle IUCV or APPC/VM interrupts. Only those interrupts occurring on IUCV paths that your application created will be routed to your program.
CMSIUCV	DMSGPI	Used to perform IUCV CONNECT and SEVER functions. It enables multiple IUCV or APPC/VM applications to run at the same without interference.
IUCVINI	GCTGPI	Similar to HNDIUCV, but for the GCS execution environment.
IUCVCOM	GCTGPI	Similar to CMSIUCV, but for the GCS execution environment. In addition to providing multiple application support, it provides a way for GCS programs running in problem state to use IUCV services.

A typical socket application uses only four IUCV operations: CONNECT, SEND (with reply), PURGE, and SEVER. CONNECT establishes the IUCV connection with the TCP/IP virtual machine, SEND performs initialization and socket operations, PURGE cancels an outstanding socket operation, and SEVER deletes the IUCV connection.

If an IUCV operation completes with condition code 0, the requested operation was successfully started. An IUCV interrupt will be received when the operation completes. When your interrupt routine receives control, it receives a pointer to the *external interrupt buffer* which contains information about the IUCV function that completed. The IPTYPE field of the external interrupt buffer (mapped by IPARML) identifies the interrupt:

IPTYPE	Interrupt Name	Description
X'02'	Connection Complete	Acknowledgement that TCP/IP has accepted your request to establish an IUCV connection (IUCV CONNECT)
X'03'	Connection Severed	Your IUCV connection has been deleted by TCP/IP
X'07'	Message complete	The requested socket function has completed

Note: IPTYPE is byte 3 of the external interrupt buffer.

While there are other types of IUCV interrupts, they are not normally seen on TCP/IP IUCV socket paths. *z/VM: CP Programming Services* has a complete description of each interrupt type.

If an IUCV operation completes with condition code 1, the requested function could not be performed. The exact cause of the error is stored in byte 3 of the IUCV parameter list (IPRCODE). See the description of each IUCV function in *z/VM: CP Programming Services* for the possible return codes.

Note: CMSIUCV and IUCVCOM use return codes in general register 15 to indicate the success or failure of the operation. Refer to *z/VM: CMS Application Development Guide for Assembler* or *z/VM: Group Control System* for details on these system services.

If an IUCV PURGE operation completes with condition code 2, it means that TCP/IP has already finished processing the socket request.

Preparing to use the IUCV Socket API

Before the socket functions can be used, an IUCV socket API environment must be established. This is done in two steps:

1. Establish an IUCV connection to the TCP/IP service virtual machine.
2. Send an initialization message to TCP/IP, identifying your application and defining how the IUCV connection will be used.

Establishing an IUCV connection to TCP/IP

To create an IUCV connection to the TCP/IP service virtual machine, issue IUCV CONNECT with the following parameters:

Keyword

Value

USERID

The user ID of the TCP/IP virtual machine.

PRTY NO

PRMDATA

YES

QUIESCE

NO

MSGLIM

If this IUCV connection may have more than one outstanding socket function on it at the same time, set MSGLIM to the maximum number of socket calls that may be outstanding simultaneously on this path. Otherwise, set it to zero.

USERDTA

Binary zeros

CONTROL

NO

If IUCV CONNECT returns condition code 0, you subsequently receive either a Connection Complete external interrupt or a Connection Severed external interrupt. If you receive a Connection Severed interrupt now or later, see “Severing the IUCV Connection” on page 151 for more information.

To ensure that your program does not interfere with other IUCV or APPC/VM applications, your program should use the HNDIUCV and CMSIUCV macros in CMS, or the IUCVINI and IUCVCOM macros in GCS.

Initializing the IUCV Connection

If you receive a Connection Complete interrupt in response to IUCV CONNECT, then TCP/IP has accepted the connection request.

Your program responds by sending an *initialization message* using IUCV SEND to TCP/IP, identifying your application and the way that it will use the IUCV socket interface.

IUCV Sockets

When the IUCV SEND completes, then, if the IPAUDIT field shows no error, the reply buffer has been filled. The *maxsock* field indicates that maximum number of sockets you can open on this IUCV path at the same time.

Your program can now issue any supported socket call. See “Issuing Socket Calls” on page 152.

The initialization message is sent using an IUCV SEND with the following parameters:

Keyword
Value

TRGCLS
0

DATA BUFFER

BUFLen
20

TYPE 2WAY

ANSLEN
8

PRTY NO

BUFFER
Points to a buffer in the following format:

Offset	Name	Length	Comments
0		8	Constant 'IUCVAPI '. The trailing blank is required.
8		2	Halfword integer. Maximum number of sockets that can be established on this IUCV connection. minimum: 50, Default: 50.
10	<i>apitype</i>	2	X'0002'. Provided for compatibility with prior implementations of TCP/IP. Use X'0003' instead. X'0003'. Any number of socket requests may be outstanding on this IUCV connection at the same time. For AF_INET sockets only. X'0004'. Any number of socket requests may be outstanding on this IUCV connection at the same time. For AF_INET6 sockets only. For more information, see “Overlapping Socket Requests” on page 153.
12	<i>subtaskname</i>	8	Eight printable characters. The combination of your user ID and <i>subtaskname</i> uniquely identifies the TCP/IP client using this path. This value is displayed by the NETSTAT CLIENT command.

Keyword
Value

ANSBUF
Points to a buffer to contain the reply from TCP/IP:

Offset	Name	Length	Comments
0		4	Reserved
4	<i>maxsock</i>	4	The maximum socket number that your application can use on this path. The minimum socket number is always 0. Your application chooses a socket number for the accept, socket, and takesocket calls.

Note: A single virtual machine can establish more than one IUCV path to TCP/IP, but a different *subtaskname* must be specified on each IUCV path. If the same *subtaskname* is specified for more than one IUCV path, TCP/IP severs the existing path with that *subtaskname*.

Severing the IUCV Connection

An IUCV connection to TCP/IP can be severed (deleted) by your application or by TCP/IP at any time.

Sever by the Application

Your application can sever a socket API IUCV path at any time by calling IUCV SEVER with USERDTA specified as 16 bytes of binary zeros. TCP/IP cleans up all sockets associated with the IUCV path.

Clean-Up of Stream Sockets

The TCP connection corresponding to each stream socket associated with the IUCV path is reset. In the case of a listening socket, all connections in the process of opening, or already open and in the accept queue, are reset.

If your program closed a stream socket earlier, the corresponding TCP connection might still be in the process of closing. Such connections, which are no longer associated with any socket, are *not* reset when your program severs the IUCV path.

Sever by TCP/IP

TCP/IP severs a socket API IUCV path only in case of shutdown or an unexpected error. The 16-byte IPUSER field in the SEVER external interrupt indicates the reason for the sever. The reason is coded in EBCDIC. The following are possible reason codes and explanations:

Reason Code

Explanation

BAD API TYPE

The *apitype* field in your initialization message contained an incorrect value.

BAD INIT MSG LEN

Your program sent an initialization message that was not of the expected length.

BAD PATH ID

An attempt was made to exceed the maximum number of IUCV connections support by the target TCPIP virtual machine.

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IPV6 NOT ENABLED

Your program sent an initialization message with *apitype* 4, but TCP/IP is not enabled for IPv6 communications.

IUCVCHECKRC

IUCV error detected. This code is used only before or during processing of the initialization message.

NO CCB!!!!

A software error occurred in TCP/IP. Contact your system support personnel or the IBM Support Center.

NO MORE CCBS

Your IUCV path cannot be accepted because there are no more client control blocks available in the TCPIP virtual machine.

NULL SAVED NAME

A software error occurred in TCP/IP. This code is used only before or during processing of the initialization message.

REQUIREDCONSTANT

The first 8 bytes of your initialization message were not "IUCVAPI ".

RESTRICTED

Your virtual machine is not permitted to use TCP/IP.

SHUTTINGDOWN

TCP/IP service is being shut down. This code is used only in response to the Pending Connection interrupt.

Issuing Socket Calls

The following section describes how to issue an IUCV socket call.

All socket calls are invoked by issuing an IUCV SEND with the following parameters:

Keyword

Value

TRGCLS

The high-order halfword specifies the socket call. For most calls, the low-order halfword specifies the socket descriptor.

DATA BUFFER or PRMMSG, depending on call

BUFLIST

If DATA=BUFFER, then either YES or NO as desired. If DATA=PRMMSG, not applicable.

BUFFER

If DATA=BUFFER, points to the buffer (or buffer list) in the format required by the call. If DATA=PRMMSG, not applicable.

BUFLEN

If DATA=BUFFER, length of buffer. If DATA=PRMMSG, not applicable.

PRMMSG

If DATA=PRMMSG, data as required by the call. DATA=PRMMSG is not allowed when ANSLIST=YES. If DATA=BUFFER, not applicable.

TYPE 2WAY

ANSLIST

Either YES or NO as desired. DATA=PRMMSG is not allowed when ANSLIST=YES.

ANSBUF

Points to a buffer to contain the reply from TCP/IP.

ANSLEN

Length of the reply buffer

PRTY NO

SYNC YES or NO as desired. Applications that need to serve multiple clients at the same time should specify SYNC=NO. SYNC=YES will block the entire virtual machine from execution until the function is complete.

Overlapping Socket Requests

Your program may have more than one socket call outstanding on the same IUCV path. There are some restrictions on the types of calls that are queued simultaneously for the same socket descriptor.

The following list describes the restrictions for each type of socket call:

- Multiple read-type calls (READ, READV, RECV, RECVMFROM, RECVMMSG) and multiple write-type calls (WRITE, WRITEV, SEND, SENDTO, SENDMSG), for the same socket, can be queued simultaneously. The read-type calls are satisfied in order, independently of the write-type calls. Similarly, the write-type calls are satisfied in order, independently of the read-type calls.
- Multiple ACCEPT calls, for the same listening stream socket, can be queued simultaneously. They are satisfied in order.
- Multiple SELECT calls, referring to any combination of sockets, can be queued simultaneously on an IUCV path. TCP/IP checks all queued SELECT calls when an event occurs and responds to any that are satisfied.
- Calls other than the read-type, write-type, ACCEPT, and SELECT calls, cannot be queued simultaneously for the same socket. For example, your program must wait for TCP/IP's response to a write-type call before issuing a CLOSE call for the same socket.

TCP/IP Response to an IUCV Request

TCP/IP's response to your socket call is signaled by the Message Complete external interrupt. When the Message Complete external interrupt is received, if the IPAUDIT field shows no error, your program's reply buffer has been filled. The IPBFLN2F field indicates how many bytes of the reply buffer were not used.

If the IPADRJCT bit of the IPAUDIT field is set, then TCP/IP was unable to use IUCV REPLY to respond, and instead used IUCV REJECT. Your program issues the special LASTERRNO function (see "LASTERRNO" on page 185) to retrieve the return code and *errno* for the rejected call. TCP/IP's use of IUCV REJECT does not necessarily mean the socket call failed.

The following *errno* values (shown in decimal) are seen only by a program using the IUCV socket interface.

Errno Value**Description**

- | | |
|-------------|--------------------------------------------------------------------------------------------------------|
| 1000 | An unrecognized socket call constant was found in the high-order halfword of the Target Message Class. |
|-------------|--------------------------------------------------------------------------------------------------------|

IUCV Sockets

- 1001 A request or reply length field is incorrect
- 1002 The socket number assigned by your program for ACCEPT, SOCKET, or TAKESOCKET is out of range.
- 1003 The socket number assigned by your program for ACCEPT, SOCKET, or TAKESOCKET is already in use.
- 1008 This request conflicts with a request already queued on the same socket (see “Overlapping Socket Requests” on page 153).
- 1009 The request was canceled by the CANCEL call (see “CANCEL and CANCEL2” on page 159).
- 1011 The user ID issuing this request does not match the user ID specified on the SSLServerID statement in the configuration file.

Encrypting Data on an IUCV Socket

Once a connection has been established, `ioctl()` commands can be used to direct the data through the TLS/SSL server so that it is encrypted when sent and decrypted when received. Refer to the section, “Secure Connection Considerations” on page 24 for details.

Cancelling a Socket Request

Your socket program can use the CANCEL call to cancel a previously issued socket call. Read-type calls, write-type calls, ACCEPT calls, and SELECT calls can be canceled using this function. See “CANCEL and CANCEL2” on page 159 for more information about using the CANCEL call.

IUCV PURGE can also be used to cancel a call, but it does not stop TCP/IP processing the same way as the CANCEL call.

Each IUCV SEND operation that completes with condition code zero is assigned a unique message identification number. This number is placed in the IUCV parameter list. To use the CANCEL or IUCV PURGE functions, your program must keep track of the message ID numbers assigned to each socket request.

IUCV Socket Call Syntax

Each of the IUCV Socket calls described includes the C language syntax for the call. IUCV SEND parameters and buffer contents are described using variable names from the C syntax. Call types are in capital letters. For example, the accept call is ACCEPT.

The parameter lists for some C language socket calls include a pointer to a data structure defined by a C *structure*. When using the IUCV socket interface, the contents of the data structure are passed in the send buffer, the reply buffer, or both. Table 21 shows the C structures used, and the corresponding assembler language syntax.

Table 21. C Structures in Assembler Language Format

C Structure	Assembler Language Equivalent
<pre>struct sockaddr_in { short sin_family; ushort sin_port; struct in_addr sin_addr; char sin_zero[8]; };</pre>	<pre>FAMILY DS H PORT DS H ADDR DS F ZERO DC XL8'00'</pre>

Table 21. C Structures in Assembler Language Format (continued)

C Structure	Assembler Language Equivalent
<pre> struct sockaddr_in6 { short sin6_family; ushort sin6_port; uint sin6_flowinfo; struct in6_addr sin6_addr; uint sin6_scope_id; }; </pre>	<pre> FAMILY DS H PORT DS H FLOWINFO DS F ADDR6 DS 4F SCOPEID DS F </pre>
<pre> struct timeval { long tv_sec; long tv_usec; }; </pre>	<pre> TVSEC DS F TVUSEC DS F </pre>
<pre> struct linger { int l_onoff; int l_linger; }; </pre>	<pre> ONOFF DS F LINGER DS F </pre>
<pre> struct ifreq { #define IFNAMSIZ 16 char ifr_name[IFNAMSIZ]; union { struct sockaddr ifru_addr; struct sockaddr ifru_dstaddr; struct sockaddr ifru_broadaddr; short ifru_flags; int ifru_metric; caddr_t ifru_data; } ifr_ifru; }; </pre>	<pre> NAME DS CL16 ADDR.FAMILY DS H ADDR.PORT DS H ADDR.ADDR DS F ADDR.ZERO DC XL8'00' ORG ADDR.FAMILY DST.FAMILY DS H DST.PORT DS H DST.ADDR DS F DST.ZERO DC XL8'00' ORG ADDR.FAMILY BRD.FAMILY DS H BRD.PORT DS H BRD.ADDR DS F BRD.ZERO DC XL8'00' ORG ADDR.FAMILY FLAGS DS H ORG ADDR.FAMILY METRIC DS F </pre>
<pre> struct ifconf { int ifc_len; union { caddr_t ifcu_buf; struct ifreq *ifcu_req; } ifc_ifcu; }; </pre>	<pre> IFCLEN DS F IGNORED DS F </pre>
<pre> struct clientid { int domain; char name[8]; char subtaskname[8]; char reserved[20]; }; </pre>	<pre> DOMAIN DS F NAME DS CL8 SUBTASK DS CL8 RESERVED DC XL20'00' </pre>

Table 21. C Structures in Assembler Language Format (continued)

C Structure	Assembler Language Equivalent		
<pre> struct Securedetail { char TLSLabel(8); int TLStimeout; char requestClientCert; char validatePeerCert; char cipher_request; char reserved1; char keyring(50); short buflen; char buffer(255); }; </pre>	<pre> TLSLabel1 DS CL8 TLStimeout DS F requestClientCert DS X validatePeerCert DS X cipher_request DS X reserved1 DS X keyring DS CL50 buflen DS H buffer DS CL255 </pre>		
<p>TLStimeout - currently not used and must be 0 requestClientCert - currently not implemented and must be 0 validatePeerCert - client only - 0 = Full Check; 1 = No Check cipher_request - may use SSLV2? 0 = default cipher suite used; 1 = V2 is not allowed keyring - currently not used and must be blank</p>			
<pre> struct QueryTls { char TLSLabel(8); char TLSKeyring(50); }; </pre>	<pre> TLSLabel1 DS CL8 TLSKeyring DS CL50 </pre>		
<p>TLSKeyring - not currently used and must be blank</p>			
<pre> struct CloseReq { short CloseLen; char CloseBuff(255); }; </pre>	<pre> CloseLen DS H CloseBuff DS CL255 </pre>		
<pre> struct SecStatus { int SecLevel; char CipherClass; char CipherHash; char CipherAlgorithm; char CipherPKAlgorithm; int CipherKeyLength; }; </pre>	<pre> SecLevel1 DS F CipherClass DS X CipherHash DS X CipherAlgorithm DS X CipherPKAlgorithm DS X CipherKeyLength DS F </pre>		
<p>SecLevel: 0 = Not Secure; 1 = Statically Secured; 2 = Dynamically Secured CipherClass: 0 = NULLclass; 1 = SSLV2; 2 = SSLV3; 3 = TLS CipherHash: 0 = SHA1, 1 = MD5; 2 = NULLhash; 3 = SHA2 CipherAlgorithm: 0 = NULLalgorithm; 1 = RC2; 2 = RC4; 3 = DES; 4 = DES3; 5 = AES; 6 = AESGCM CipherPKAlgorithm: 0 = NULL; 1 = RSA; 2 = DH_DSS; 3 = DH_RSA; 4 = DHE_DSS; 5 = DHE_RSA</p>			

IUCV Socket Calls

This section provides the C language syntax, parameters, and other appropriate information for each IUCV socket call supported by TCP/IP. For information about C socket calls, see Chapter 1, "z/VM C Socket Application Programming Interface," on page 1.

Note: In the following socket descriptions, structures labelled “For AF_INET:” are for the AF_INET address family and structures labelled “For AF_INET6:” are for the AF_INET6 address family.

ACCEPT

The ACCEPT call is issued when the server receives a connection request from a client. ACCEPT points to a socket that was created with a socket call and marked by a LISTEN call. ACCEPT can also be used as a blocking call. Concurrent server programs use the ACCEPT call to pass connection requests to child servers.

When issued, the ACCEPT call:

1. Accepts the first connection on a queue of pending connections
2. Creates a new socket with the same properties as the socket used in the call and returns the address of the client for use by subsequent server calls. The new socket cannot be used to accept new connections, but can be used by the calling program for its own connection. The original socket remains available to the calling program for more connection requests.
3. Returns the new socket descriptor to the calling program.

For AF_INET:

```
ns = accept(s, addr, addrlen)
int ns, s;
struct sockaddr_in *addr;
int *addrlen;
```

For AF_INET6:

```
ns = accept(s, addr, addrlen)
int ns, s;
struct sockaddr_in6 *addr;
int *addrlen;
```

Keyword

Value

TRGCLS

High-order halfword = 1

Low-order halfword = s

DATA PRMMSG

PRMMSG

High-order fullword = 0

Low-order fullword = socket number for the new socket, chosen by your program, in the range 0 through *maxsock*. If you wish the stack to choose an available socket number for you, specify any negative value (bit 0 is 1). See “Initializing the IUCV Connection” on page 149 for more information on *maxsock*.

ANSLEN

For AF_INET: 24

For AF_INET6: 36

ANSBUF

Points to a buffer to contain the reply from TCP/IP:

ACCEPT

Offset	Name	Length	Comments
0	<i>ns</i>	4	The new socket number assigned to this connection. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>ns</i> is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*addr</i>	For AF_INET: 16 For AF_INET6: 28	The remote address and port of the new socket. See Table 21 on page 154 for format.

BIND

In a typical server program, the BIND call follows a SOCKET call and completes the new socket creation process.

The BIND call can either specify the port or let the system choose the port. A listener program should always bind to the same well-known port so that clients know what socket address to use when issuing a CONNECT call.

For AF_INET:

```
rc = bind(s, name, namelen)
int rc, s;
struct sockaddr_in *name;
int namelen;
```

For AF_INET6:

```
rc = bind(s, name, namelen)
int rc, s;
struct sockaddr_in6 *name;
int namelen;
```

Keyword

Value

TRGCLS

High-order halfword = 2

Low-order halfword = s

DATA BUFFER

BUFLLEN

For AF_INET: 16

For AF_INET6: 28

BUFFER

Points to a buffer in the following format:

Offset	Name	Length	Comments
0	<i>*name</i>	For AF_INET: 16 For AF_INET6: 28	The local address and port to which the socket is to be bound. See Table 21 on page 154 for format.

ANSLEN
8

ANSBUF
Points to a buffer to contain the reply from TCP/IP:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the BIND call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

CANCEL and CANCEL2

The CANCEL and CANCEL2 calls are used to cancel a previously issued socket call. For the CANCEL call, TCP/IP responds to the canceled call with a return code of -1 and an *errno* value of 1009. For the CANCEL2 call, TCP/IP does not send a response to the canceled call. CANCEL2 is supported only for AF_INIT.

Keyword
Value

TRGCLS
High-order halfword = 42 (CANCEL)
High-order halfword = 43 (CANCEL2 is for AF_INIT only)
Low-order halfword = Low-order halfword of TRGCLS from call to be canceled.

DATA PRMMSG

PRMMSG
High-order fullword = High-order halfword of TRGCLS from call to be canceled.
Low-order fullword = IUCV message ID of call to be canceled.

ANSLEN
8

ANSBUF
Points to a buffer to contain the reply from TCP/IP:

CANCEL

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the CANCEL call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Possible <i>errno</i> values are: 3 Specifies that the call cannot be found. TCP/IP might have already responded to it. 22 Specifies that the call is not a type that may be canceled.

CLOSE

The CLOSE call shuts down the socket and frees the resources that are allocated to the socket.

```
rc = close(s)
int rc, s;
```

Keyword

Value

TRGCLS

High-order halfword = 3

Low-order halfword = *s*

DATA PRMMSG

PRMMSG

Binary zeros

ANSLEN

8

ANSBUF

Points to a buffer to contain the reply from TCP/IP:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the CLOSE call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

CONNECT

The CONNECT call is used by a client to establish a connection between a local socket and a remote socket.

For stream sockets, the CONNECT call:

- Completes the binding process for a stream socket if a BIND call has not been previously issued.
- Attempts a connection to a remote socket. This connection must be completed before data can be transferred.

For datagram sockets, a CONNECT call is not essential, but you can use it to send messages without including the destination.

For AF_INET:

```
rc = connect(s, name, namelen)
int rc, s;
struct sockaddr_in *name;
int namelen;
```

For AF_INET6:

```
rc = connect(s, name, namelen)
int rc, s;
struct sockaddr_in6 *name;
int namelen;
```

Keyword

Value

TRGCLS

High-order halfword = 4

Low-order halfword = s

DATA BUFFER

BUFLen

For AF_INET: 16

For AF_INET6: 28

BUFFER

Points to a buffer in the following format:

Offset	Name	Length	Comments
0	<i>*name</i>	For AF_INET: 16 For AF_INET6: 28	The remote address and port to which the socket is to be connected. See Table 21 on page 154 for format.

ANSLEN

8

ANSBUF

The pointer to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the CONNECT call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

FCNTL

The blocking mode for a socket can be queried or set using the FNDELAY flag described in the FCNTL call.

See "IOCTL" on page 169 for another way to control blocking for a socket.

```
retval = fcntl(s, cmd, arg)
int retval;
int s, cmd, arg;
```

Keyword

Value

TRGCLS

High-order halfword = 5

Low-order halfword = s

DATA PRMMSG

PRMMSG

High-order fullword:

F_GETFL	(X '00000003')
F_SETFL	(X '00000004')

The low-order fullword is used only for the F_SETFL command:

Zero	(X '00000000') Socket will block
FNDELAY	(X '00000004') Socket is non-blocking

ANSLEN

8

ANSBUF

Points to a buffer that is filled with a reply in the format described as follows:

Offset	Name	Length	Comments
0	<i>retval</i>	4	For F_SETFL, the return code. A value of zero indicates FNDELAY flag was set. For F_GETFL, the value of the FNDELAY flag. Zero means the socket will block. A value of FNDELAY (4) means the socket is non-blocking. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

GETCLIENTID

The GETCLIENTID call returns the identifier by which the calling application is known to the TCP/IP address space. The client ID structure that is returned is used in the GIVESOCKET and TAKESOCKET calls.

```
rc = getclientid(domain, clientid)
int rc, domain;
struct clientid *clientid;
```

Keyword**Value****TRGCLS**

High-order halfword = 30

Low-order halfword = 0

DATA PRMMSG**PRMMSG**

Binary zeros

ANSLEN

48

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GETCLIENTID call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*clientid</i>	40	See Table 21 on page 154 for format.

Note: *domain* is not passed to TCP/IP. It is implicitly AF_INET.

GETHOSTID

The GETHOSTID call gets the unique 32-bit identifier for the current host. This value is the default home internet address.

```
hostid = gethostid
unsigned long hostid;
```

Keyword**Value****TRGCLS**

High-order halfword = 7

Low-order halfword = 0

DATA PRMMSG**PRMMSG**

Binary zeros

ANSLEN

8

GETHOSTID

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>hostid</i>	4	The default home internet address.
4		4	Your program should ignore this field.

GETHOSTNAME

The GETHOSTNAME call returns the name of the host processor on which the program is running. Up to *namelen* characters are copied into the name field.

```
rc = gethostname(name, namelen)
int rc;
char *name;
int namelen;
```

Keyword

Value

TRGCLS

High-order halfword = 8

Low-order halfword = 0

DATA PRMMSG

PRMMSG

Binary zeros

ANSLEN

namelen + 8

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GETHOSTNAME call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*name</i>	<i>namelen</i>	The host name, not null-terminated.

GETPEERNAME

The GETPEERNAME call returns the name of the remote socket to which the local socket is connected.

For AF_INET:

```
rc = getpeername(s, name, namelen)
int rc, s;
struct sockaddr_in *name;
int *namelen;
```

For AF_INET6:

```
rc = getpeername(s, name, namelen)
int rc, s;
struct sockaddr_in6 *name;
int *namelen;
```

Keyword

Value

TRGCLS

High-order halfword = 9

Low-order halfword = s

DATA PRMMSG

PRMMSG

Binary zeros

ANSLEN

For AF_INET: 24

For AF_INET6: 36

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GETPEERNAME call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*name</i>	For AF_INET: 16 For AF_INET6: 28	The remote address and port to which the socket is connected. See Table 21 on page 154 for format.

GETSOCKNAME

The GETSOCKNAME call stores the name of the socket into the structure pointed to by the name parameter and returns the address to the socket that has been bound. If the socket is not bound to an address, the call returns with the *family* field completed and the rest of the structure set to zeros.

GETSOCKNAME

For AF_INET:

```
rc = getsockname(s, name, namelen)
int rc, s;
struct sockaddr_in *name;
int *namelen;
```

For AF_INET6:

```
rc = getsockname(s, name, namelen)
int rc, s;
struct sockaddr_in6 *name;
int *namelen;
```

Keyword

Value

TRGCLS

High-order halfword = 10

Low-order halfword = s

DATA PRMMSG

PRMMSG

Binary zeros

ANSLEN

For AF_INET: 24

For AF_INET6: 36

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GETSOCKNAME call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*name</i>	For AF_INET: 16 For AF_INET6: 28	The local address and port to which the socket is bound. See Table 21 on page 154 for format.

GETSOCKOPT

The GETSOCKOPT call returns the current setting of an option for a specific socket. Some of these options are under program control and can be changed using the SETSOCKOPT call.

```
rc = getsockopt(s, level, optname, optval, &optlen)
int rc, s, level, optname, optlen;
char *optval;
```

Keyword**Value****TRGCLS**

High-order halfword = 11

Low-order halfword = *s***DATA PRMMSG****PRMMSG**High-order fullword = *level*. Possible values are:

Value	C Symbol	Comments
X'FFFF'	SOL_SOCKET	Socket option
X'0006'	IPPROTO_TCP	TCP protocol option

Low-order fullword = *optname*. Possible values are:

Value	Option Name	Returned Value								
X'0001'	SO_DEBUG	Returns current setting.								
X'0004'	SO_REUSEADDR	Returns current setting.								
X'0008'	SO_KEEPALIVE	Returns current setting.								
X'0010'	SO_DONTROUTE	Returns current setting.								
X'0020'	SO_BROADCAST	Returns current setting.								
X'0080'	SO_LINGER	Returns current setting in a C language <i>struct linger</i> . See Table 21 on page 154 for the assembler language equivalent.								
X'0100'	SO_OOINLINE	Returns current setting.								
X'1001'	SO_SNDBUF	Returns the size of the TCP/IP send buffer.								
X'1007'	SO_ERROR	Returns any pending error code and clears any error status conditions.								
X'1008'	SO_TYPE	Socket type is returned: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Value</th> <th>Type</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Stream</td> </tr> <tr> <td>2</td> <td>Datagram</td> </tr> <tr> <td>3</td> <td>Raw</td> </tr> </tbody> </table>	Value	Type	1	Stream	2	Datagram	3	Raw
Value	Type									
1	Stream									
2	Datagram									
3	Raw									
X'0001'	TCP_NODELAY	Returns current setting. Note: This option applies only to <i>level=IPPROTO_TCP</i>								

ANSLEN

16 for option SO_LINGER, 12 for all other options

ANSBUF

Points to a buffer to contain the reply from TCP/IP:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GETSOCKOPT call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.

GETSOCKOPT

Offset	Name	Length	Comments
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*optval</i>	4 or 8	The value of the requested option. If the option SO_LINGER was requested, 8 bytes are returned. For all other options, 4 bytes are returned.

GIVESOCKET

The GIVESOCKET call makes the socket available for a TAKESOCKET call issued by another program. The GIVESOCKET call can specify any connected stream socket. Typically, the GIVESOCKET call is issued by a concurrent server program that creates sockets to be passed to a child server.

The GIVESOCKET sequence is:

- To pass a socket, the concurrent server first calls GIVESOCKET. If the optional parameters, name of the child server's virtual machine and subtask ID are specified in the GIVESOCKET call, only a child with a matching virtual machine and subtask ID can take the socket.
- The concurrent server then starts the child server and passes it the socket descriptor and concurrent server's ID that were obtained from earlier SOCKET and GETCLIENTID calls.
- The child server calls TAKESOCKET, with the concurrent server's ID and socket descriptor.
- The concurrent server issues the select call to test the socket for the exception condition, TAKESOCKET completion.
- When the TAKESOCKET has successfully completed, the concurrent server issues the CLOSE call to free the socket.

```
rc = givesocket(s, clientid)
int rc, s;
struct clientid *clientid;
```

Keyword

Value

TRGCLS

High-order halfword = 31

Low-order halfword = s

DATA BUFFER

BUFLEN

40

BUFFER

Points to the message in the following format:

Offset	Name	Length	Comments
0	<i>*clientid</i>	40	See Table 21 on page 154 for format.

ANSLEN

8

ANSBUF

The pointer to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the GIVESOCKET call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

IOCTL

The IOCTL call is used to control certain operating characteristics for a socket.

Before you issue an IOCTL call, you must load a value representing the characteristic that you want to control into the *cmd* field.

```
rc = ioctl(s, cmd, arg)
int rc, s;
unsigned long cmd;
char *arg;
```

Keyword

Value

TRGCLS

High-order halfword = 12

Low-order halfword = *s*

DATA BUFFER**BUFLen**

Request *arg* length + 4

BUFFER

The pointer to the message in the format described in the following format:

Offset	Name	Length	Comments
0	<i>cmd</i>	4	The type of request. See Table 22 on page 170 for values.
4	<i>*arg</i>	See Table 22 on page 170.	The request data, if any.

ANSLEN

Reply *arg* length + 8

ANSBUF

The pointer to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.

Offset	Name	Length	Comments
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*arg</i>	See Table 22.	The response data, if any.

Table 22. Values for cmd Argument in ioctl Call

C Symbol	Value	Request <i>arg</i> Length	Reply <i>arg</i> Length	Comments
FIONBIO	X'8004A77E'	4	0	Request <i>arg</i> data is a fullword integer.
FIONREAD	X'4004A77F'	0	4	Reply <i>arg</i> data is a fullword integer.
SIOCADDRT	X'8030A70A'	48	0	For IBM use only.
SIOCATMARK	X'4004A707'	0	4	Reply <i>arg</i> data is a fullword integer.
SIOCDELRT	X'8030A70B'	48	0	For IBM use only.
SIOCGIBMIFMTU	X'C020D903'	32	32	For IBM use only.
SIOCGIFADDR	X'C020A70D'	32	32	<i>arg</i> data is the C language <i>struct ifreq</i> . See Table 21 on page 154 for the assembler language equivalent.
SIOCGIFBRDADDR	X'C020A712'	32	32	<i>arg</i> data is the C language <i>struct ifreq</i> . See Table 21 on page 154 for the assembler language equivalent.
SIOCGIFCONF	X'C008A714'	8	*	Request <i>arg</i> data is the C-language <i>struct ifconf</i> . See Table 21 on page 154 for the assembler language equivalent. Your program sets <i>ifc_len</i> to the reply length. The other field is ignored. Response <i>arg</i> data is an array of C language <i>struct ifreq</i> structures, one for each defined interface. Note: * = the maximum number of interfaces multiplied by 32.
SIOCGIFDSTADDR	X'C020A70F'	32	32	<i>arg</i> data is the C language <i>struct ifreq</i> . See Table 21 on page 154 for the assembler language equivalent.
SIOCGIFFLAGS	X'C020A711'	32	32	<i>arg</i> data is the C language <i>struct ifreq</i> . See Table 21 on page 154 for the assembler language equivalent.
SIOCGIFMETRIC	X'C020A717'	32	32	For IBM use only.

Table 22. Values for cmd Argument in ioctl Call (continued)

C Symbol	Value	Request arg Length	Reply arg Length	Comments
SIOCGIFNETMASK	X'C020A715'	32	32	arg data is the C language struct ifreq. See Table 21 on page 154 for the assembler language equivalent.
SIOCSECCLIENT	X'8143DA01'	323	0	arg data is the C language struct SecDetail. See Table 21 on page 154 for assembler language equivalent. ¹
SIOCSECSERVER	X'8143DA02'	323	0	arg data is the C language struct SecDetail. See Table 21 on page 154 for assembler language equivalent. ¹
SIOCTLSQRY	X'803ADA03'	58	0	arg data is the C language struct QueryTLS. See Table 21 on page 154 for assembler language equivalent. ¹
SIOCSECCLOSE	X'8101DA04'	257	0	arg data is the C language struct CloseReq. See Table 21 on page 154 for assembler language equivalent. ¹
SIOCSECSTATUS	X'400CDA05'	0	12	arg data is the C language struct SecStatus. See Table 21 on page 154 for assembler language equivalent. ¹
SIOCSIFDSTADDR	X'8020A70E'	32	0	For IBM use only.
SIOCSIFFLAGS	X'8020A710'	32	0	For IBM use only.
SIOCSIFMETRIC	X'8020A718'	32	0	For IBM use only.
SIOCGIBMOP	X'C048D900'	72	*	For IBM use only.
SIOCSIBMOP	X'8048D900'	*	0	For IBM use only.

LISTEN

The LISTEN call:

- Completes the bind, if BIND has not already been called for the socket.
- Creates a connection-request queue of a specified length for incoming connection requests.

The LISTEN call is typically used by a concurrent server to receive connection requests from clients. When a connection request is received, a new socket is created by a later ACCEPT call. The original socket continues to listen for additional connection requests. The LISTEN call converts an active socket to a passive socket and configures it to accept connection requests from client programs. If a socket is passive it cannot initiate connection requests.

1. For additional information on using secure ioctls, refer to "Secure Connection Considerations" on page 24.

LISTEN

```
rc = listen(s, backlog)
int rc, s, backlog;
```

Keyword

Value

TRGCLS

High-order halfword = 13

Low-order halfword = *s*

DATA PRMMSG

PRMMSG

High-order fullword = 0

Low-order fullword = *backlog*

ANSLEN

8

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the LISTEN call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

MAXDESC

Your program specifies the maximum number of Internet domain (AF_INET and AF_INET6) sockets in the *initialization message*. For more information about the initialization message, see "Initializing the IUCV Connection" on page 149.

READ, READV

From the point of view of TCP/IP, the READ and READV calls are identical. From the point of view of the application, they differ only in that the buffer for READ is contiguous in storage, while the buffer for READV might not be contiguous.

Your program, utilizing the direct IUCV socket interface, can use the ANSLIST=YES parameter on IUCV SEND to specify a noncontiguous READ buffer. You can choose to use ANSLIST=YES even if your READ buffer is contiguous, so that the reply area for *cc* and *errno* need not adjoin the READ buffer in storage.

This section does not distinguish between READ and READV. IUCV usage is described in terms of variable names from the C language syntax of READ.

```
cc = read(s, buf, len)
int cc, s;
char *buf;
int len;
```

Keyword

Value

TRGCLS

High-order halfword = 14

Low-order halfword = *s*

DATA PRMMSG

PRMMSG

Binary zeros

ANSLLEN

For AF_INET: *len* + 24

For AF_INET6: *len* + 36

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>cc</i>	4	The number of bytes read. A value of zero means the partner has closed the connection. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>cc</i> is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8		For AF_INET: 16 For AF_INET6: 28	Your program should ignore this field.
24	<i>*buf</i>	<i>len</i>	The received data.

RECV, RECVFROM, RECVMSG

From the point of view of TCP/IP, the RECV, RECVFROM, and RECVMSG calls are identical.

From the point of view of the application, RECVFROM differs from RECV in that RECVFROM additionally provides the source address of the message. Your program, using the direct IUCV socket interface, must provide space to receive the source address of the message, even if the source address is not required.

From the point of view of the application, RECVMSG differs from RECVFROM in that RECVMSG additionally allows the buffer to be in noncontiguous storage. Your program, utilizing the direct IUCV socket interface, can use the ANSLIST=YES parameter on IUCV SEND to specify a noncontinuous read buffer. You can choose to use ANSLIST=YES even if your read buffer is contiguous, so that the reply area for *cc* and *errno*, and the space to receive the source address of the message, need not adjoin the read buffer in storage.

RECV, RECVFROM, RECVMSG

For AF_INET:

```
cc = recvfrom(s, buf, len, flags, from, fromlen)
int cc, s;
char *buf;
int len, flags;
struct sockaddr_in *from;
int *fromlen;
```

For AF_INET6:

```
cc = recvfrom(s, buf, len, flags, from, fromlen)
int cc, s;
char *buf;
int len, flags;
struct sockaddr_in6 *from;
int *fromlen;
```

Keyword

Value

TRGCLS

High-order halfword = 16

Low-order halfword = *s*

DATA PRMMSG

PRMMSG

High-order fullword = 0.

Low-order fullword = *flags*:

MSG_OOB	(X'00000001')
MSG_PEEK	(X'00000002')

ANSLEN

For AF_INET: *len* + 24

For AF_INET6: *len* + 36

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>cc</i>	4	The number of bytes read. A value of zero indicates that communication is closed. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>cc</i> is -1, this field contains a reason code. Note: The rest of the reply buffer is filled only if the call was successful.
8	<i>*from</i>	For AF_INET: 16 For AF_INET6: 28	The source address and port of the message. See Table 21 on page 154 for format.
24	<i>*buf</i>	<i>len</i>	The received data.

SELECT, SELECTEX

From the point of view of the TCP/IP, the SELECT and SELECTEX calls are identical. From the point of view of the application, they differ in that return from SELECTEX can be triggered by the posting of an ECB as well as the selection of a descriptor or a time-out.

Multiple SELECT calls, referring to any combination of sockets, can be queued simultaneously on an IUCV path.

```
nfound = select(nfds, readfds, writefds, exceptfds, timeout)
int nfound, nfds;
fd_set *readfds, *writefds, *exceptfds;
struct timeval *timeout;
```

Descriptor Sets

A descriptor set is an array of fullwords. The following is the required array size in integer arithmetic:

```
number_of_fullwords = (nfds + 31) / 32
number_of_bytes = number_of_fullwords * 4
```

DESCRIPTOR_SET, FD_CLR, FD_ISSET Calls

The following describes how to perform the function of these C language calls, which set, clear, and test the bit in the specified descriptor set corresponding to the specified descriptor number.

You can compute the offset of the fullword containing the bit (integer arithmetic) as follows:

```
offset = (descriptor_number / 32) * 4
```

Compute a mask to locate the bit within the fullword by:

```
bitmask = X'00000001' << (descriptor_number modulo 32)
```

("<<" is the left-shift operator).

Then use the mask, or a complemented copy of the mask, to set, clear, or test the bit, as appropriate.

The IUCV SEND parameters particular to select are:

Keyword

Value

TRGCLS

High-order halfword = 19

Low-order halfword = descriptor set size in bytes (*fdsize*). See "Descriptor Sets."

DATA BUFFER

BUFLEN

(3**fdsize*)+28

BUFFER

The pointer to the message in the following format:

SELECT, SELECTEX

Offset	Name	Length	Number of file descriptors
0	<i>nfds</i>	4	To improve processing efficiency, <i>nfds</i> should be no greater than one plus the largest descriptor number actually in use.
4		4	Set this field to zero if you want select to block. Otherwise set this field to any nonzero value and fill in <i>*timeval</i> .
8		4	If any descriptor bits are set in <i>readfds</i> , your program sets this field to a nonzero value. If no descriptor bits are set in <i>readfds</i> , your program can set this field to zero, to improve processing efficiency.
12		4	If any descriptor bits are set in <i>writfds</i> , your program sets this field to a nonzero value. If no descriptor bits are set in <i>writfds</i> , your program can set this field to zero to improve processing efficiency.
16		4	If any descriptor bits are set in <i>exceptfds</i> , your program sets this field to a nonzero value. If no descriptor bits are set in <i>exceptfds</i> your program can set this field to zero to improve processing efficiency.
20	<i>*timeval</i>	8	See Table 21 on page 154 for format. If field at offset 4 is zero, then set this field to binary zeros.
28	<i>*readfds</i>	<i>fdsizes</i>	If field at offset 8 is zero, then this field is not used.
28 + <i>fdsizes</i>	<i>*writfds</i>	<i>fdsizes</i>	If field at offset 12 is zero, then this field is not used.
28 + (2 * <i>exceptfds</i>)	<i>*exceptfds</i>	<i>fdsizes</i>	If field at offset 16 is zero, then this field is not used.

ANSLEN

$(3 * \text{fdsizes}) + 16$

ANSBUF

The pointer to the buffer that is filled in with a reply in the following format:

Offset	Name	Length	Comments
0	<i>nfound</i>	4	The total number of ready sockets (in all bit masks). A value of zero indicates an expired time limit. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>nfound</i> is -1, this field contains a reason code.
8		8	Your program ignores this field. Note: The rest of the reply buffer is filled only if the call was successful.
16	<i>*readfds</i>	<i>fdsizes</i>	If field at offset 8 in request data was zero, then your program ignores this field.
16 + <i>fdsizes</i>	<i>*writfds</i>	<i>fdsizes</i>	If field at offset 12 in request data was zero, then your program ignores this field.

Offset	Name	Length	Comments
16 + (2 * <i>fdsize</i>)	<i>*exceptfds</i>	<i>fdsize</i>	If field at offset 16 in request data was zero, then your program ignores this field.

SEND

The SEND call sends datagrams on a specified connected socket.

The *flags* field allows you to:

- Send out-of-band data, for example, interrupts, aborts, and data marked urgent.
- Suppress use of local routing tables. This implies that the caller takes control of routing, writing network software.

For datagram sockets, the entire datagram is sent if the datagram fits into the buffer. Excess data is discarded.

For stream sockets, data is processed as streams of information with no boundaries separating data the data. For example, if a program is required to send 1000 bytes, each call to this function can send any number of bytes, up to the entire 1000 bytes, with the number of bytes sent returned in *errno*. Therefore, programs using stream sockets should place this call in a loop, reissuing the call until all data has been sent.

```
cc = send(s, msg, len, flags)
int cc, s;
char *msg;
int len, flags;
```

Keyword

Value

TRGCLS

High-order halfword = 20

Low-order halfword = *s*

BUFLEN

For AF_INET: *len* + 20

For AF_INET6: *len* + 32

DATA BUFFER

BUFFER

The pointer to the message in the following format:

Offset	Name	Length	Comments
0	<i>flags</i>	4	MSG_OOB (X'00000001') MSG_DONTROUTE (X'00000004')
4		For AF_INET: 16 For AF_INET6: 28	Your program should set this field to binary zeros.
20	<i>*msg</i>	<i>len</i>	The data to be sent.

SEND

ANSLLEN

8

ANSBUF

The pointer to the buffer that is filled in with a reply in the following format:

Offset	Name	Length	Comments
0	<i>cc</i>	4	The number of bytes sent. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>cc</i> is -1, this field contains a reason code.

SENDMSG

From the point of view of TCP/IP, the SENDMSG call with a null *msg->msg_name* parameter is identical to the SEND call. Similarly, the SENDMSG call with a non-null *msg->msg_name* parameter is identical to the SENDTO call.

From the point of view of the application, SENDMSG differs from SEND and SENDTO in that SENDMSG additionally allows the write buffer to be in noncontiguous storage.

Your program, using the direct IUCV socket interface can use the BUFLIST=YES parameter on IUCV SEND to specify a noncontiguous write buffer. You can choose to use BUFLIST=YES even if your write buffer is contiguous, so that the fields preceding the write data in the request format need not adjoin the write data in storage.

See "SEND" on page 177 and "SENDTO" for more information.

SENDTO

SENDTO is similar to SEND, except that it includes the destination address parameter. You can use the destination address on the SENDTO call to send datagrams on a UDP socket that is connected or not connected.

Use the *flags* parameter to :

- Send out-of-band data such as, interrupts, aborts, and data marked as urgent.
- Suppress the local routing tables. This implies that the caller takes control of routing, which requires writing network software.

For datagram sockets, the SENDTO call sends the entire datagram if the datagram fits into the buffer.

For stream sockets, data is processed as streams of information with no boundaries separating the data. For example, if a program is required to send 1000 bytes, each SENDTO call can send any number of bytes, up to the entire 1000 bytes, with the number of bytes sent returned in *errno*. Therefore, programs using stream sockets should place SENDTO in a loop that repeats the call until all data has been sent.

For AF_INET:

```

cc = sendto(s, msg, len, flags, to, tolen)
int cc, s;
char *msg;
int len, flags;
struct sockaddr_in *to;
int tolen;

```

For AF_INET6:

```

cc = sendto(s, msg, len, flags, to, tolen)
int cc, s;
char *msg;
int len, flags;
struct sockaddr_in6 *to;
int tolen;

```

Keyword**Value****TRGCLS**

High-order halfword = 22

Low-order halfword = s

DATA BUFFER**BUFLEN**

For AF_INET: *len* + 20

For AF_INET6: *len* + 32

BUFFER

The pointer to the message in the following format:

Offset	Name	Length	Comments
0	<i>flags</i>	4	MSG_OOB (X'00000001') MSG_DONTROUTE (X'00000004')
4	<i>*to</i>	For AF_INET: 16 For AF_INET6: 28	See Table 21 on page 154 for format.
20	<i>*msg</i>	<i>len</i>	The data to be sent.

ANSLEN

8

ANSBUF

The pointer to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>cc</i>	4	The number of bytes sent. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>cc</i> is -1, this field contains a reason code.

SETSOCKOPT

The SETSOCKOPT call sets the options associated with a socket.

```
rc = setsockopt(s, level, optname, optval, optlen)
int rc, s, level, optname;
char *optval;
int optlen;
```

Keyword

Value

TRGCLS

High-order halfword = 23

Low-order halfword = s

DATA BUFFER

BUFLen

16 for option SO_LINGER, 12 for all other options

BUFFER

Points to a buffer in the following format:

Offset	Name	Length	Comments
0	<i>level</i>	4	X'FFFF' - SOL_SOCKET - Socket option X'0006' - IPPROTO_TCP - TCP protocol option
4	<i>optname</i>	4	Option to set. See Table 23 for values.
8	<i>*optval</i>	4 or 8	The value of the specified option. If the option SO_LINGER is specified, 8 bytes are needed. For all other options, 4 bytes are needed.

Table 23. Option name values for SETSOCKOPT

Value	Option Name	Option Value
X'0001'	SO_DEBUG	On (1) or Off (0). Option may be set, but has no effect.
X'0004'	SO_REUSEADDR	Yes (1) or No (0).
X'0008'	SO_KEEPALIVE	Yes (1) or No (0).
X'0010'	SO_DONTROUTE	Yes (1) or No (0). Option may be set, but has no effect. Use MSG_DONTROUTE on write-type calls instead.
X'0020'	SO_BROADCAST	Yes (1) or No (0).
X'0080'	SO_LINGER	Value is a C language <i>struct linger</i> . See Table 21 on page 154 for the assembler language equivalent.
X'0100'	SO_OOBINLINE	Yes (1) or No (0). Note: The following option applies only to <i>level=IPPROTO_TCP</i>
X'0001'	TCP_NODELAY	Yes (1) or No (0).

ANSLEN

8

ANSBUF

Points to a buffer to contain the reply from TCP/IP:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the SETSOCKOPT call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

SHUTDOWN

The normal way to terminate a network connection is to issue the CLOSE call which attempts to complete all outstanding data transmission requests prior to breaking the connection. The SHUTDOWN call can be used to close one-way traffic while completing data transfer in the other direction. The how parameter determines the direction of the traffic to shutdown.

A client program can use the SHUTDOWN call to reuse a given socket with a different connection.

```
rc = shutdown(s, how)
int rc, s, how;
```

Keyword

Value

TRGCLS

High-order halfword = 24

Low-order halfword = *s*

DATA PRMMSG

PRMMSG

High-order fullword = 0

Low-order fullword = *how*:

0 = receive

1 = send

2 = both

ANSLEN

8

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the SHUTDOWN call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

SOCKET

The SOCKET call creates an endpoint for communication and returns a socket descriptor representing the endpoint. Different types of sockets provide different communication services.

```
s = socket(domain, type, protocol)
int s, domain, type, protocol
```

Keyword

Value

TRGCLS

High-order halfword = 25

Low-order halfword = 0

DATA BUFFER

BUFLEN

16

BUFFER

The pointer to the message in the following format:

Offset	Name	Length	Comments
0	<i>domain</i>	4	Values are: AF_INET (X'00000002') AF_INET6 (X'00000013')
4	<i>type</i>	4	Fullword integer: SOCK_STREAM (X'00000001') SOCK_DGRAM (X'00000002') SOCK_RAW (X'00000003')
8	<i>protocol</i>	4	Fullword integer: IPPROTO_ICMP (X'00000001') IPPROTO_TCP (X'00000006') IPPROTO_UDP (X'00000011') IPPROTO_RAW (X'000000FF')
12	<i>s</i>	4	Socket number for the new socket, chosen by your program, in the range 0 through <i>maxsock</i> . See "Initializing the IUCV Connection" on page 149.

ANSLEN

8

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>s</i>	4	The socket number assigned to this communications end point. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>s</i> is -1, this field contains a reason code.

TAKESOCKET

The TAKESOCKET call acquires a socket from another program and creates a new socket. Typically, a child server issues this call using client ID and socket descriptor data which it obtained from the concurrent server. When TAKESOCKET is issued, a new socket descriptor is returned in *errno*. You should use this new socket descriptor in later calls such as GETSOCKOPT, which require the *s* (socket descriptor) parameter.

Note: Both concurrent servers and iterative servers are used by this interface. An iterative server handles one client at a time. A concurrent server receives connection requests from multiple clients and creates child servers that process the client requests. When a child server is created, the concurrent server gets a new socket, passes the new socket to the child server, and dissociates itself from the connection. The TCP/IP Listener program is an example of a concurrent server.

```
s = takesocket(clientid, hisdesc)
int s;
struct clientid *clientid;
int hisdesc;
```

Keyword

Value

TRGCLS

High-order halfword = 32

Low-order halfword = 0

DATA BUFFER

BUFLLEN

48

BUFFER

The pointer to the message in the following format:

Offset	Name	Length	Comments
0	<i>*clientid</i>	40	See Table 21 on page 154 for format.
40	<i>hisdesc</i>	4	
44	<i>s</i>	4	Socket number for the new socket, chosen by your program, in the range 0 through <i>maxsock</i> . See "Initializing the IUCV Connection" on page 149.

ANSLEN

8

ANSBUF

The pointer to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>s</i>	4	The socket number assigned to this communications end point. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>s</i> is -1, this field contains a reason code.

WRITE, WRITEV

From the point of view of TCP/IP, the WRITE and WRITEV calls are identical. From the point of view of the application, WRITEV differs from WRITE in that WRITEV additionally allows the write buffer to be in noncontiguous storage.

Your program, using the direct IUCV socket interface, can use the BUFLIST=YES parameter on IUCV SEND to specify a noncontiguous write buffer. You can choose to use BUFLIST=YES even if your write buffer is contiguous, so that the 20-byte prefix need not adjoin the write buffer in storage.

This section does not distinguish between WRITE and WRITEV. IUCV usage is described in terms of variable names from the C language syntax of WRITE.

```
cc = write(s, buf, len)
int cc, s;
char *buf;
int len;
```

Keyword**Value****TRGCLS**

High-order halfword = 26

Low-order halfword = *s*

DATA BUFFER**BUFLEN**

For AF_INET: *len* + 20

For AF_INET6: *len* + 32

BUFFER

The pointer to the message in the following format:

Offset	Name	Length	Comments
0		For AF_INET: 20	Your program sets this parameter to binary zeros.
		For AF_INET6: 32	
20	<i>*buf</i>	<i>len</i>	The data to be sent.

ANSLEN

8

ANSBUF

Points to the buffer that is filled with a reply in the following format:

Offset	Name	Length	Comments
0	<i>cc</i>	4	The number of bytes sent. A value of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When <i>cc</i> is -1, this field contains a reason code.

LASTERRNO

As explained in “TCP/IP Response to an IUCV Request” on page 153, if TCP/IP uses IUCV REJECT to respond to a socket request, your program uses the LASTERRNO special request to retrieve the return code and *errno*.

Keyword**Value****TRGCLS**

High-order halfword = 29

Low-order halfword = 0

DATA PRMMSG**PRMMSG**

Binary zeros

ANSLEN

8

ANSBUF

Points to the buffer that is filled in with a reply in the following format:

Offset	Name	Length	Comments
0	<i>rc</i>	4	The return code from the last rejected call. A return code of 0 indicates that the call was successful. A return code of -1 indicates that the function could not be completed and that <i>errno</i> contains a reason code.
4	<i>errno</i>	4	When the return code is -1, this field contains a reason code.

LASTERRNO

Chapter 5. Remote Procedure Calls

This chapter describes the high-level remote procedure calls (RPCs) implemented in TCP/IP, including the RPC programming interface to the C language, and communication between processes.

The RPC protocol permits remote execution of subroutines across a TCP/IP network. RPC, together with the eXternal Data Representation (XDR) protocol, defines a standard for representing data that is independent of internal protocols or formatting. RPCs can communicate between processes on the same or different hosts.

The RPC Interface

To use the RPC interface, you must be familiar with programming in the C language, and you should have a working knowledge of networking concepts.

The RPC interface enables programmers to write distributed applications using high-level RPCs rather than lower-level calls based on sockets.

When you use RPCs, the client communicates with a server. The client invokes a procedure to send a call message to the server. When the message arrives, the server calls a dispatch routine, and performs the requested service. The server sends back a reply message, after which the original procedure call returns to the client program with a value derived from the reply message.

For sample RPC client, server, and raw data stream programs, see “Sample RPC Programs” on page 235. Figure 35 on page 188 and Figure 36 on page 189 provide an overview of the high-level RPC client and server processes from initialization through cleanup.

RPCs

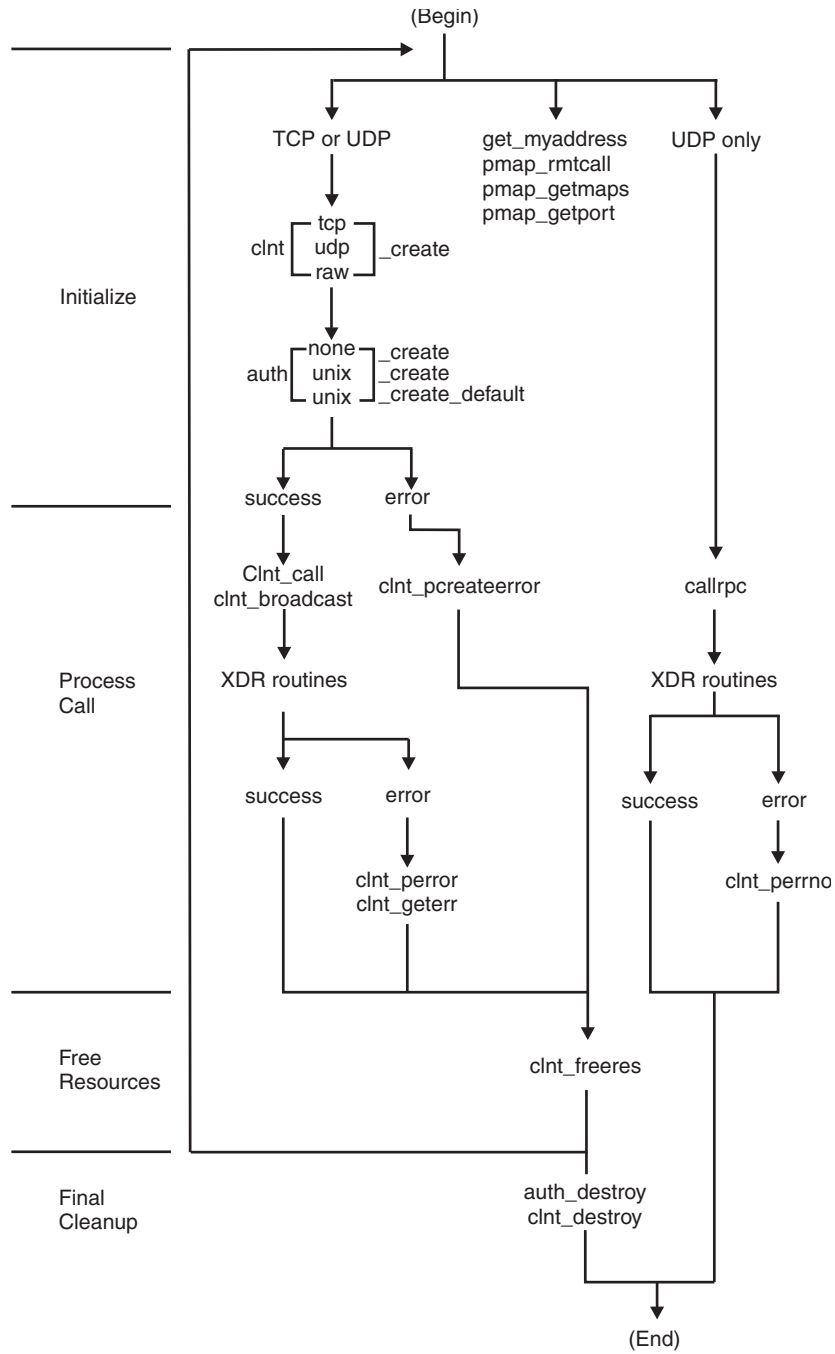


Figure 35. Remote Procedure Call (Client)

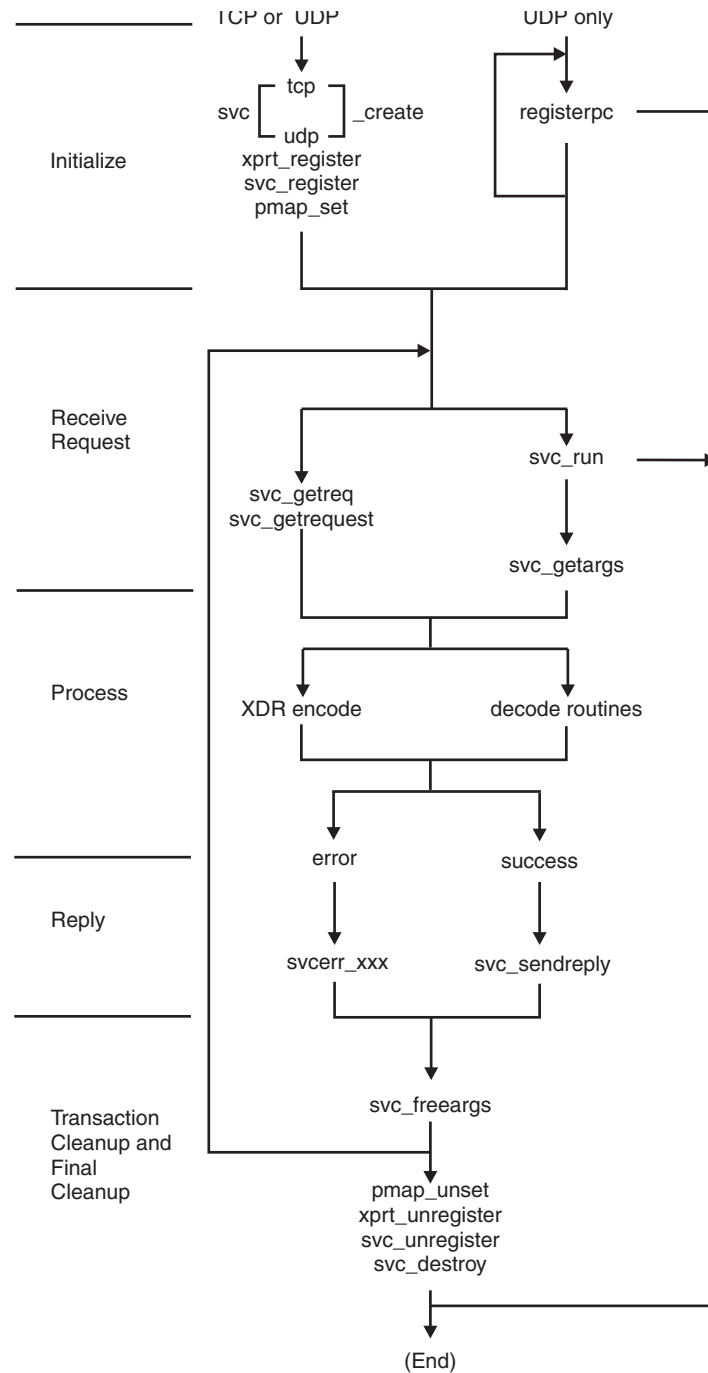


Figure 36. Remote Procedure Call (Server)

Portmapper

Portmapper is the software that supplies client programs with the port numbers of server programs.

You can communicate between different computer operating systems when messages are directed to port numbers rather than to targeted remote programs. Clients contact server programs by sending messages to the port numbers where receiving processes receive the message. Because you make requests to the port number of a server rather than directly to a server program, client programs need

RPCs

a way to find the port number of the server programs they wish to call. Portmapper standardizes the way clients locate the port number of the server programs supported on a network.

Portmapper resides on all hosts on well-known port 111.

The port-to-program information maintained by Portmapper is called the portmap. Clients ask Portmapper about entries for servers on the network. Servers contact Portmapper to add or update entries to the portmap.

Contacting Portmapper

To find the port of a remote program, the client sends an RPC to well-known port 111 of the server's host. If Portmapper has a portmap entry for the remote program, Portmapper provides the port number in a return RPC. The client then requests the remote program by sending an RPC to the port number provided by Portmapper.

Clients can save port numbers of recently called remote programs to avoid having to contact Portmapper for each request to a server.

To see all the servers currently registered with Portmapper, use the RPCINFO command in the following manner:

```
RPCINFO -p host_name
```

For more information about Portmapper and RPCINFO, see *z/VM: TCP/IP User's Guide* and *z/VM: TCP/IP Planning and Customization*.

Target Assistance

Portmapper offers a program to assist clients in contacting server programs. If the client sends Portmapper an RPC with the target program number, version number, procedure number, and arguments, Portmapper searches the portmap for an entry, and passes the client's message to the server. When the target server returns the information to Portmapper, the information is passed to the client, along with the port number of the remote program. The client can then contact the server directly.

RPCGEN Command

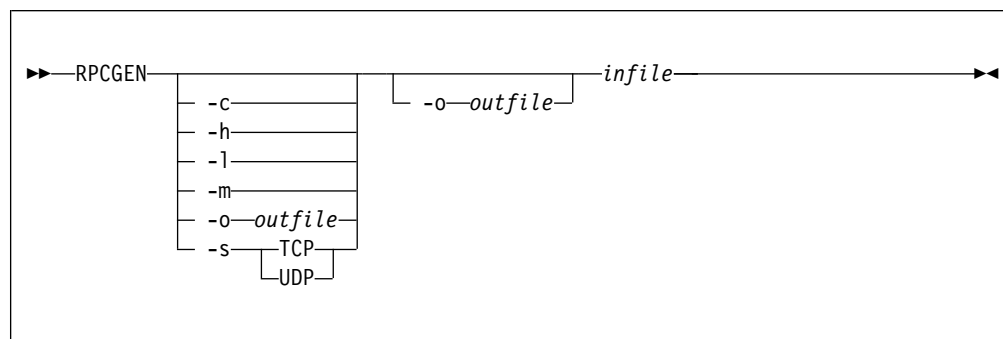
RPCGEN is a tool that generates C code to implement an RPC protocol. The input to RPCGEN is a language similar to C, known as RPC language. For RPCGEN to work correctly you must have access to the CC EXEC that is a part of the C compiler and have accessed the TCPIP Client-code minidisk (usually the TCPMAINT 592).

RPCGEN *infile* is normally used when you want to generate all four of the following output files. For example, if the *infile* is named *proto.x*, RPCGEN generates:

- A header file called PROTO.H
- XDR routines called PROTOX.C
- Server-side stubs called PROTOS.C
- Client-side stubs called PROTOC.C

Note: A temporary file called PROTO.EXPANDED or PROTO.EXPAND is created by the RPCGEN command. During normal operation, this file is also subsequently erased by the RPCGEN command.

For additional information about the RPCGEN command, see the Sun Microsystems publication, *Network Programming*.



Operand

Description

- c** Compiles into XDR routines.
- h** Compiles into C data definitions (a header file).
- l** Compiles into client-side stubs.
- m** Compiles into server-side stubs without generating a main routine. This option is useful for call-back routines and for writing a main routine for initialization.
- s *TCP|UDP*** Compiles into server-side stubs using the given transport. The TCP option supports the TCP transport protocol. The UDP option supports the UDP transport protocol.
- o *outfile*** Specifies the name of the output file. If none is specified, standard output is used for **-c**, **-h**, **-l**, **-m**, and **-s** modes.
- infile*** Specifies the name of the input file written in the RPC language. *infile* should be a variable record format file (RECFM V).

enum clnt_stat Structure

The enumerated set `clnt_stat` structure is defined in the `CLNT.H` header file.

RPCs frequently return the enumerated set `clnt_stat` information. The following is the format and a description of the enumerated set `clnt_stat` structure:

```

enum clnt_stat {
    RPC_SUCCESS=0,           /* call succeeded */
    /*
     * local errors
     */
    RPC_CANTENCODEARGS=1,   /* can't encode arguments */
    RPC_CANTDECODERES=2,   /* can't decode results */
    RPC_CANTSEND=3,         /* failure in sending call */
    RPC_CANTRECV=4,         /* failure in receiving result */
    RPC_TIMEDOUT=5,        /* call timed out */
    /*
     * remote errors
     */
    RPC_VERSIONMISMATCH=6, /* RPC versions not compatible */
    RPC_AUTHERROR=7,       /* authentication error */
}
  
```

RPCs

```
RPC_PROGUNAVAIL=8,      /* program not available */
RPC_PROGVERSMISMATCH=9, /* program version mismatched */
RPC_PROCUNAVAIL=10,    /* procedure unavailable */
RPC_CANTDECODEARGS=11, /* decode arguments error */
RPC_SYSTEMERROR=12,   /* generic "other problem" */
/*
 * callrpc errors
 */
RPC_UNKNOWNHOST=13,    /* unknown host name */
/*
 * create errors
 */
RPC_PMAPFAILURE=14,    /* the pmaper failed in its call */
RPC_PROGNOTREGISTERED=15, /* remote program is not registered */
/*
 * unspecified error
 */
RPC_FAILED=16,         /* call failed */
RPC_UNKNOWNPROTO=17    /* unknown protocol */
};
```

Porting

This section contains information about porting RPC applications.

Accessing System Return Messages

To access system return values, you need only use the `ERRNO.H` include statement supplied with the compiler. To access network return values, you must add the following include statement:

```
#include <tcperrno.h>
```

Printing System Return Messages

To print only system errors, use `perror()`, a procedure available in the C compiler run-time library. To print both system and network errors, use `tcperror()`, a procedure included with TCP/IP.

Enumerations

To account for varying length enumerations, use the `xdr_enum()` and `xdr_union()` macros. `xdr_enum()` cannot be referenced by `callrpc()`, `svc_freeargs()`, `svc_getargs()`, or `svc_sendreply()`. An XDR routine for the specific enumeration must be created. The `xdr_union()` is not eligible for reference by these calls in any RPC environment. For more information, see “`xdr_enum()`” on page 222.

Compiling, Linking, and Running an RPC Program

Note: If your program uses z/VM C sockets, follow the instructions in this section. If your program uses VM TCP/IP C sockets, see “Recompiling with the TCP/IP C Sockets Library” on page 32.

Before you compile and link an RPC program, read the information under “Compiling and Linking a z/VM C Sockets Program” on page 29 and “Running a Sockets Program” on page 33.

To compile, link and run an RPC program:

1. Access the TCP/IP Client-code disk (usually TCPMAINT 592), which contains the header files for RPC and the VMRPC TXTLIB, *after* the disk that contains the Language Environment header files (usually the Y-disk).

- Specify the `_OE_SOCKETS` and VM preprocessor symbols in your source code or on the `c89` command.
- Compile the program using `c89`. The following are examples of how to compile the sample RPC programs shown at the end of this chapter (see “Sample RPC Programs” on page 235):

```
c89 //genesend.c -D_OE_SOCKETS -1//VMRPC
c89 //geneserv.c -D_OE_SOCKETS -1//VMRPC
c89 //rawex.c -D_OE_SOCKETS -1//VMRPC
```

Note the use of the `//` syntax before the name of the `c` part. This convention informs `c89` that the `c` source part will be found in the CMS search order. The previous three `c89` commands will produce the GENESEND MODULE, GENESERV MODULE, and RAWEX MODULE, respectively. Additionally, note that `-DVM` is not specified on these compiles because the define for VM is in the C source.

- Make sure that the SCEERUN LOADLIB is GLOBALed by issuing the command: `GLOBAL LOADLIB SCEERUN`
- Run your program from either the CMS command line or from a POSIX shell command line. For example, run the GENESERV MODULE from the CMS command line as follows:

```
openvm run GENESERV
```

or

```
GENESERV
```

RPC Global Variables

This section describes the RPC global variables, `rpc_createerr`, `svc_fds`, and `svc_fdset`.

`rpc_createerr`

Description: A global variable that is set when any RPC client creation routine fails. Use `clnt_pcreateerror()` to print the message.

```
#include <rpc.h>
struct rpc_createerr rpc_createerr;
```

See Also: `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

`svc_fds`

```
#include <rpc.h>
int svc_fds;
```

Description: A global variable that specifies the read descriptor bit set on the service machine. This is of interest only if the service programmer decides to write an asynchronous event processing routine; otherwise `svc_run()` should be used. Writing asynchronous routines in the VM environment is not simple, because there is no direct relationship between the descriptors used by the socket routines and the Event Control Blocks commonly used by VM programs for coordinating concurrent activities.

svc_fds

Attention: Do not modify this variable.

See Also: `svc_getreq()`.

svc_fdset

```
#include <rpc.h>
fd_set svc_fdset;
```

Description: A global variable that specifies the read descriptor bit set on the service machine. This is of interest only if the service programmer decides to write an asynchronous event processing routine; otherwise `svc_run()` should be used. Writing asynchronous routines in the VM environment is not simple, because there is no direct relationship between the descriptors used by the socket routines and the Event Control Blocks commonly used by VM programs for coordinating concurrent activities.

Attention: Do not modify this variable.

See Also: `svc_getreqset()`.

Remote Procedure and eXternal Data Representation Calls

This section provides the syntax, operands, and other appropriate information for each remote procedure and external data representation call supported by TCP/IP.

auth_destroy()

```
#include <rpc.h>
void auth_destroy(auth)
AUTH *auth;
```

Operand

Description

auth Points to authentication information.

Description: The `auth_destroy()` call deletes the authentication information for *auth*. Once this procedure is called, *auth* is undefined.

See Also: `authnone_create()`, `authunix_create()`, `authunix_create_default()`.

authnone_create()

```
#include <rpc.h>
AUTH *
authnone_create()
```

The `authnone_create()` call has no operands.

Description: The `authnone_create()` call creates and returns an RPC authentication handle. The handle passes the NULL authentication on each call.

See Also: `auth_destroy()`, `authunix_create()`, `authunix_create_default()`.

authunix_create()

```
#include <rpc.h>

AUTH *
authunix_create(host, uid, gid, len, aup_gids)
char *host;
int uid;
int gid;
int len;
int *aup_gids;
```

Operand

Description

- host* Specifies a pointer to the symbolic name of the host where the desired server is located.
- uid* Identifies the user's user ID.
- gid* Identifies the user's group ID.
- len* Specifies the length of the information pointed to by *aup_gids*.
- aup_gids* Specifies a pointer to an array of groups to which the user belongs.

Description: The `authunix_create()` call creates and returns an authentication handle that contains UNIX-based authentication information.

See Also: `auth_destroy()`, `authnone_create()`, `authunix_create_default()`.

authunix_create_default()

```
#include <rpc.h>

AUTH *
authunix_create_default()
```

The `authunix_create_default()` call has no operands.

Description: The `authunix_create_default()` call calls `authunix_create()` with default operands.

See Also: `auth_destroy()`, `authnone_create()`, `authunix_create()`.

callrpc()

callrpc()

```
#include <rpc.h>

enum clnt_stat
callrpc(host, prognum, versnum, procnum, inproc, in, outproc, out)
char *host;
u_long prognum;
u_long versnum;
u_long procnum;
xdrproc_t inproc;
char *in;
xdrproc_t outproc;
char *out;
```

Operand

Description

host Specifies a pointer to the symbolic name of the host where the desired server is located.

prognum Identifies the program number of the remote procedure.

versnum Identifies the version number of the remote procedure.

procnum Identifies the procedure number of the remote procedure.

inproc Specifies the XDR procedure used to encode the arguments of the remote procedure.

in Specifies a pointer to the arguments of the remote procedure.

outproc Specifies the XDR procedure used to decode the results of the remote procedure.

out Specifies a pointer to the results of the remote procedure.

Description: The `callrpc()` call calls the remote procedure described by *prognum*, *versnum*, and *procnum* running on the *host* system. `callrpc()` encodes and decodes the operands for transfer.

Note:

1. `clnt_perrno()` can be used to translate the return code into messages.
2. `callrpc()` cannot call the procedure `xdr_enum`. See “`xdr_enum()`” on page 222 for more information.
3. This procedure uses UDP as its transport layer, see “`clntudp_create()`” on page 205 for more information.

Return Values: `RPC_SUCCESS` indicates success; otherwise, an error has occurred. The results of the remote procedure call are returned to *out*.

See Also: `clnt_broadcast()`, `clnt_call()`, `clnt_perrno()`, `clntudp_create()`, `clnt_sperrno()`, `xdr_enum()`.

clnt_broadcast()

```
#include <rpc.h>

enum clnt_stat
clnt_broadcast(prognum, versnum, procnum, inproc, in, outproc, out, eachresult)
u_long prognum;
u_long versnum;
u_long procnum;
xdrproc_t inproc;
char *in;
xdrproc_t outproc;
char *out;
resultproc_t eachresult;
```

Operand Description

- prognum*
Identifies the program number of the remote procedure.
- versnum*
Identifies the version number of the remote procedure.
- procnum*
Identifies the procedure number of the remote procedure.
- inproc* Specifies the XDR procedure used to encode the arguments of the remote procedure.
- in* Specifies a pointer to the arguments of the remote procedure.
- outproc*
Specifies the XDR procedure used to decode the results of the remote procedure.
- out* Specifies a pointer to the results of the remote procedure.
- eachresult*
Specifies the procedure called after each response.

Note: resultproc_t is a type definition:

```
#include <rpc.h>

typedef bool_t (*resultproc_t) ();
```

Description: The clnt_broadcast() call broadcasts the remote procedure described by *prognum*, *versnum*, and *procnum* to all locally connected broadcast networks. Each time clnt_broadcast() receives a response it calls eachresult(). The format of eachresult() is:

```
#include <rpc.h>

bool_t eachresult(out, addr)
char *out;
struct sockaddr_in *addr;
```

Operand Description

- out* Has the same function as it does for clnt_broadcast(), except that the output of the remote procedure is decoded.
- addr* Points to the address of the machine that sent the results.

clnt_broadcast()

Return Values: If eachresult() returns 0, clnt_broadcast() waits for more replies; otherwise, eachresult() returns the appropriate status.

Note: Broadcast sockets are limited in size to the maximum transfer unit of the data link.

See Also: callrpc(), clnt_call().

clnt_call()

```
#include <rpc.h>

enum clnt_stat
clnt_call(clnt, procnum, inproc, in, outproc, out, tout)
CLIENT *clnt;
u_long procnum;
xdrproc_t inproc;
char *in;
xdrproc_t outproc;
char *out;
struct timeval tout;
```

Operand

Description

clnt Points to a client handle that was previously obtained using clntraw_create(), clnttcp_create(), or clntudp_create().

procnum Identifies the remote procedure number.

inproc Identifies the XDR procedure used to encode *procnum*'s arguments.

in Points to the remote procedure's arguments.

outproc Specifies the XDR procedure used to decode the remote procedure's results.

out Points to the remote procedure's results.

tout Specifies the time allowed for the server to respond.

Description: The clnt_call() call calls the remote procedure (*procnum*) associated with the client handle (*clnt*).

Return Values: RPC_SUCCESS indicates success; otherwise, an error has occurred. The results of the remote procedure call are returned to *out*.

See Also: callrpc(), clnt_broadcast(), clnt_geterr(), clnt_perror(), clnt_sperror(), clntraw_create(), clnttcp_create(), clntudp_create().

clnt_control()

```
#include <rpc.h>

bool_t
clnt_control(clnt, request, info)
CLIENT *clnt;
int request;
void *info;
```

Operand**Description**

- clnt* Specifies the pointer to a client handle that was previously obtained using `clntraw_create()`, `clnttcp_create()`, or `clntudp_create()`.
- request* Determines the operation (either `CLSET_TIMEOUT`, `CLGET_TIMEOUT`, `CLGET_SERVER_ADDR`, `CLSET_RETRY_TIMEOUT`, or `CLGET_RETRY_TIMEOUT`).
- info* Points to information used by the request.

Description: The `clnt_control()` call performs one of the following control operations.

- Control operations that apply to both UDP and TCP transports:

CLSET_TIMEOUT

Sets time-out (*info* points to the `timeval` structure).

CLGET_TIMEOUT

Gets time-out (*info* points to the `timeval` structure).

CLGET_SERVER_ADDR

Gets server's address (*info* points to the `sockaddr_in` structure).

- UDP only control operations:

CLSET_RETRY_TIMEOUT

Sets retry time-out (information points to the `timeval` structure).

CLGET_RETRY_TIMEOUT

Gets retry time-out (*info* points to the `timeval` structure). If you set the timeout using `clnt_control()`, the timeout operand to `clnt_call()` will be ignored in all future calls.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `clnt_create()`, `clnt_destroy()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_create()

```
#include <rpc.h>

CLIENT *
clnt_create(host, prognum, versnum, protocol)
char *host;
u_long prognum;
u_long versnum;
char *protocol;
```

Operand**Description**

- host* Points to the name of the host at which the remote program resides.
- prognum* Specifies the remote program number.
- versnum* Specifies the version number of the remote program.

clnt_create()

protocol

Points to the protocol, which can be either tcp or udp.

Description: The `clnt_create()` call creates a generic RPC client transport handle for the remote program specified by (*prognum, versnum*). The client uses the specified protocol as the transport layer. Default timeouts are set, but can be modified using `clnt_control()`.

Return Values: NULL indicates failure.

See Also: `clnt_create()`, `clnt_destroy()`, `clnt_pcreateerror()`, `clnt_spcreateerror()`, `clnt_spperror()`, `clnttcp_create()`, `clntudp_create()`.

clnt_destroy()

```
#include <rpc.h>

void
clnt_destroy(clnt)
CLIENT *clnt;
```

Operand

Description

clnt Points to a client handle that was previously created using `clnt_create()`, `clntudp_create()`, `clnttcp_create()`, or `clntraw_create()`.

Description: The `clnt_destroy()` call deletes a client RPC transport handle. This procedure involves the deallocation of private data resources, including *clnt*. Once this procedure is used, *clnt* is undefined. If the RPC library opened the associated socket, it will close it also. Otherwise, the socket remains open.

See Also: `clnt_control()`, `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_freeres()

```
#include <rpc.h>

bool_t
clnt_freeres(clnt, outproc, out)
CLIENT *clnt;
xdrproc_t outproc;
char *out;
```

Operand

Description

clnt Points to a client handle that was previously obtained using `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, or `clntudp_create()`.

outproc

Specifies the XDR procedure used to decode the remote procedure's results.

out

Points to the results of the remote procedure.

Description: The `clnt_freeres()` call deallocates any resources that were assigned by the system to decode the results of an RPC.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_geterr()

```
#include <rpc.h>

void
clnt_geterr(clnt, errp)
CLIENT *clnt;
struct rpc_err *errp;
```

Operand

Description

clnt Points to a client handle that was previously obtained using `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, or `clntudp_create()`.

errp Points to the address into which the error structure is copied.

Description: The `clnt_geterr()` call copies the error structure from the client handle to the structure at address *errp*.

See Also: `clnt_call()`, `clnt_pcreateerror()`, `clnt_permno()`, `clnt_perror()`, `clnt_spcreateerror()`, `clnt_sperrno()`, `clnt_sperror()`, `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_pcreateerror()

```
#include <rpc.h>

void
clnt_pcreateerror(s)
char *s;
```

Operand

Description

s Specifies a NULL or NULL-terminated character string. If *s* is non-NULL, `clnt_pcreateerror()` prints the string *s* followed by a colon, followed by a space, followed by the error message, and terminated with a newline character. If *s* is NULL or points to a NULL string, just the error message and the newline character are output.

Description: The `clnt_pcreateerror()` call writes a message to the standard error device, indicating why a client handle cannot be created. This procedure is used after the `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, or `clntudp_create()` calls fail.

See Also: `clnt_create()`, `clnt_geterr()`, `clnt_permno()`, `clnt_perror()`, `clnt_spcreateerror()`, `clnt_sperrno()`, `clnt_sperror()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_perrno()

clnt_perrno()

```
#include <rpc.h>

void
clnt_perrno(stat)
enum clnt_stat stat;
```

Operand

Description

stat Specifies the client status.

Description: The `clnt_perrno()` call writes a message to the standard error device corresponding to the condition indicated by *stat*. This procedure should be used after `callrpc()` if there is an error.

See Also: `callrpc()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perror()`, `clnt_spcreateerror()`, `clnt_sperno()`, `clnt_spperror()`.

clnt_perror()

```
#include <rpc.h>

void
clnt_perror(clnt, s)
CLIENT *clnt;
char *s;
```

Operand

Description

clnt Points to a client handle that was previously obtained using `clnt_create()`, `clntudp_create()`, `clnttcp_create()`, or `clntraw_create()`.

s Specifies a NULL or NULL-terminated character string. If *s* is non-NULL, `clnt_perror()` prints the string *s* followed by a colon, followed by a space, followed by the error message, and terminated with a new-line character. If *s* is NULL or points to a NULL string, just the error message and the new-line character are output.

Description: The `clnt_perror()` call writes a message to the standard error device, indicating why an RPC failed. This procedure should be used after `clnt_call()` if there is an error.

See Also: `clnt_call()`, `clnt_create()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perrno()`, `clnt_spcreateerror()`, `clnt_sperno()`, `clnt_spperror()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_spcreateerror()

```
#include <rpc.h>

char *
clnt_spcreateerror(s)
char *s;
```

Operand**Description**

s Specifies a NULL or NULL-terminated character string. If *s* is non-NULL, `clnt_screateerror()` prints the string *s* followed by a colon, followed by a space, followed by the error message, and terminated with a new-line character. If *s* is NULL or points to a NULL string, just the error message and the new-line character are output.

Description: The `clnt_screateerror()` call returns the address of a message indicating why a client handle cannot be created. This procedure is used after the `clnt_create()`, `clntraw_create()`, `clnttcp_create()`, or `clntudp_create()` calls fail.

Return Values: Returns a pointer to a character string in a static data area. This data area is overwritten with each subsequent call. This function is not thread-safe.

See Also: `clnt_create()`, `clnt_geterr()`, `clnt_perrno()`, `clnt_perror()`, `clnt_pcreateerror()`, `clnt_sperrno()`, `clnt_spperror()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clnt_sperrno()

```
#include <rpc.h>

char *
clnt_sperrno(stat)
enum clnt_stat stat;
```

Operand**Description**

stat Specifies the client status.

Description: The `clnt_sperrno()` call returns the address of a message corresponding to the condition indicated by *stat*. This procedure should be used after `callrpc()` if there is an error.

Return Values: Returns a pointer to a character string ending with a newline. This data area is overwritten with each subsequent call. This function is not thread-safe.

See Also: `callrpc()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_screateerror()`, `clnt_spperror()`, `clnt_perrno()`, `clnt_perror()`.

clnt_spperror()

```
#include <rpc.h>

char *
clnt_spperror(clnt, s)
CLIENT *clnt;
char *s;
```

Operand**Description**

clnt Points to a client handle that was previously obtained using `clnt_create()`, `clntudp_create()`, `clnttcp_create()`, or `clntraw_create()`.

s Specifies a NULL or a NULL-terminated character string. If *s* is non-NULL, `clnt_spperror()` prints the string *s* followed by a colon, followed by a space,

clnt_spperror()

followed by the error message, and terminated with a newline character. If *s* is NULL or points to a NULL string, just the error message and the newline character are output.

Description: The `clnt_spperror()` call returns the address of a message indicating why an RPC failed. This procedure should be used after `clnt_call()` if there is an error.

Return Values: Returns a pointer to a character string in a static data area. This data area is overwritten with each subsequent call. This function is not thread-safe.

See Also: `clnt_call()`, `clnt_create()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perrno()`, `clnt_perror()`, `clnt_spcreateerror()`, `clnt_spperror()`, `clntraw_create()`, `clnttcp_create()`, `clntudp_create()`.

clntraw_create()

```
#include <rpc.h>

CLIENT *
clntraw_create(prognum, versnum)
u_long prognum;
u_long versnum;
```

Operand

Description

prognum

Specifies the remote program number.

versnum

Specifies the version number of the remote program.

Description: The `clntraw_create()` call creates a dummy client for the remote double (*prognum*, *versnum*). Because messages are passed using a buffer within the virtual machine of the local process, the server should also use the same virtual machine, which simulates RPC programs within one virtual machine. For more information, see “`svccraw_create()`” on page 217.

Return Values: NULL indicates failure.

See Also: `clnt_call()`, `clnt_destroy()`, `clnt_freeres()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perror()`, `clnt_spcreateerror()`, `clnt_spperror()`, `clntudp_create()`, `clnttcp_create()`, `svccraw_create()`.

clnttcp_create()

```
#include <rpc.h>

CLIENT *
clnttcp_create(addr, prognum, versnum, sockp, sendsz, recvsz)
struct sockaddr_in *addr;
u_long prognum;
u_long versnum;
int *sockp;
u_int sendsz;
u_int recvsz;
```

Operand**Description**

addr Points to the internet address of the remote program. If the *addr* port number is zero (*addr* -> *sin_port*), *addr* is set to the port on which the remote program is receiving.

prognum
Specifies the remote program number.

versnum
Specifies the version number of the remote program.

sockp Points to the socket. If **sockp* is `RPC_ANYSOCK`, then this routine opens a new socket and sets **sockp*.

sendsz Specifies the size of the send buffer. Specify 0 to choose the default.

rcvsz Specifies the size of the receive buffer. Specify 0 to choose the default.

Description: The `clnttcp_create()` call creates an RPC client transport handle for the remote program specified by (*prognum*, *versnum*). The client uses TCP as the transport layer.

Return Values: NULL indicates failure.

See Also: `clnt_call()`, `clnt_control()`, `clnt_create()`, `clnt_destroy()`, `clnt_freeres()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perror()`, `clnt_spccreateerror()`, `clnt_spperror()`, `clntraw_create()`, `clntudp_create()`.

clntudp_create()

```
#include <rpc.h>

CLIENT *
clntudp_create(addr, prognum, versnum, wait, sockp)
struct sockaddr_in *addr;
u_long prognum;
u_long versnum;
struct timeval wait;
int *sockp;
```

Operand**Description**

addr Points to the internet address of the remote program. If the *addr* port number is zero (*addr*-> *sin_port*), *addr* is set to the port on which the remote program is receiving. The remote portmap service is used for this.

prognum
Specifies the remote program number.

versnum
Specifies the version number of the remote program.

wait Indicates that UDP resends the call request at intervals of *wait* time, until either a response is received or the call times out. The time-out length is set using the `clnt_call()` procedure.

sockp Points to the socket. If **sockp* is `RPC_ANYSOCK`, this routine opens a new socket and sets **sockp*.

clntudp_create()

Description: The `clntudp_create()` call creates a client transport handle for the remote program (*prognum*) with version (*versnum*). UDP is used as the transport layer.

Note: This procedure should not be used with procedures that use large arguments or return large results. While UDP packet size is configurable to a maximum of 64–1 kilobytes, the default UDP packet size is only eight kilobytes.

Return Values: NULL indicates failure.

See Also: `call_rpc()`, `clnt_call()`, `clnt_control()`, `clnt_create()`, `clnt_destroy()`, `clnt_freeres()`, `clnt_geterr()`, `clnt_pcreateerror()`, `clnt_perror()`, `clnt_screateerror()`, `clnt_serror()`, `clntraw_create()`, `clnttcp_create()`.

get_myaddress()

```
#include <rpc.h>

void
get_myaddress(addr)
struct sockaddr_in *addr;
```

Operand

Description

addr Points to the location where the local internet address is placed.

Description: The `get_myaddress()` call puts the local host's internet address into *addr*. The port number (*addr*→*sin_port*) is set to `htons (PMAPPORT)`, which is 111.

See Also: `getrpcport()`, `pmap_getmaps()`, `pmap_getport()`, `pmap_rmtcall()`, `pmap_set()`, `pmap_unset()`.

getrpcport()

```
#include <rpc.h>

u_short
getrpcport(host, prognum, versnum, protocol)
char *host;
u_long prognum;
u_long versnum;
int protocol;
```

Operand

Description

host Points to the name of the foreign host.

prognum Specifies the program number to be mapped.

versnum Specifies the version number of the program to be mapped.

protocol Specifies the transport protocol used by the program (`IPPROTO_TCP` or `IPPROTO_UDP`).

Description: The getrpcport() call returns the port number associated with the remote program (*prognum*), the version (*versnum*), and the transport protocol (*protocol*).

Return Values: The value 0 indicates that the mapping does not exist or that the remote portmap could not be contacted. If Portmapper cannot be contacted, *rpc_createerr* contains the RPC status.

See Also: get_myaddress(), pmap_getmaps(), pmap_getport(), pmap_rmtcall(), pmap_set(), pmap_unset().

pmap_getmaps()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

struct pmaplist *
pmap_getmaps(addr)
struct sockaddr_in *addr;
```

Operand

Description

addr Points to the internet address of the foreign host.

Description: The pmap_getmaps() call returns a list of current program-to-port mappings on the foreign host specified by *addr*.

Return Values: Returns a pointer to a pmaplist structure or NULL.

See Also: getrpcport(), pmap_getport(), pmap_rmtcall(), pmap_set(), pmap_unset().

pmap_getport()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

u_short
pmap_getport(addr, prognum, versnum, protocol)
struct sockaddr_in *addr;
u_long prognum;
u_long versnum;
int protocol;
```

Operand

Description

addr Points to the internet address of the foreign host.

prognum

Identifies the program number to be mapped.

versnum

Identifies the version number of the program to be mapped.

protocol

Specifies the transport protocol used by the program (IPPROTO_TCP or IPPROTO_UDP).

pmap_getport()

Description: The `pmap_getport()` call returns the port number associated with the remote program (*prognum*), the version (*versnum*), and the transport protocol (*protocol*).

Return Values: The value 0 indicates that the mapping does not exist or that the remote portmap could not be contacted. If Portmapper cannot be contacted, `rpc_createerr` contains the RPC status.

See Also: `getrpcport()` `pmap_getmaps()`, `pmap_rmtcall()`, `pmap_set()`, `pmap_unset()`.

pmap_rmtcall()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

enum clnt_stat
pmap_rmtcall(addr, prognum, versnum, procnum, inproc, in, outproc, out, tout, portp)
struct sockaddr_in *addr;
u_long prognum;
u_long versnum;
u_long procnum;
xdrproc_t inproc;
char *in;
xdrproc_t outproc;
char *out;
struct timeval tout;
u_long *portp;
```

Operand

Description

<i>addr</i>	Points to the internet address of the foreign host.
<i>prognum</i>	Identifies the remote program number.
<i>versnum</i>	Identifies the version number of the remote program.
<i>procnum</i>	Identifies the procedure to be called.
<i>inproc</i>	Identifies the XDR procedure used to encode the arguments of the remote procedure.
<i>in</i>	Points to the arguments of the remote procedure.
<i>outproc</i>	Identifies the XDR procedure used to decode the results of the remote procedure.
<i>out</i>	Points to the results of the remote procedure.
<i>tout</i>	Identifies the time-out period for the remote request.
<i>portp</i>	If the call from the remote portmap service is successful, <i>portp</i> contains the port number of the triple (<i>prognum</i> , <i>versnum</i> , <i>procnum</i>).

Description: The pmap_rmtcall() call instructs Portmapper on the host at *addr* to make an RPC call to a procedure on that host, on your behalf. This procedure should be used only for ping type functions.

Return Values: Returns a *clnt_stat* enumerated type.

See Also: getrpcport(), pmap_getmaps(), pmap_getport(), pmap_set(), pmap_unset().

pmap_set()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

bool_t
pmap_set(prognum, versnum, protocol, port)
u_long prognum;
u_long versnum;
int protocol;
u_short port;
```

Operand

Description

prognum

Identifies the local program number.

versnum

Identifies the version number of the local program.

protocol

Specifies the transport protocol used by the local program.

port

Identifies the port to which the local program is mapped.

Description: The pmap_set() call sets the mapping of the program (specified by *prognum*, *versnum*, and *protocol*) to *port* on the local machine. This procedure is automatically called by the *svc_register()* procedure.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: getrpcport(), pmap_getmaps(), pmap_getport(), pmap_rmtcall(), pmap_unset().

pmap_unset()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

bool_t
pmap_unset(prognum, versnum)
u_long prognum;
u_long versnum;
```

Operand

Description

prognum

Identifies the local program number.

versnum

Identifies the version number of the local program.

pmap_unset()

Description: The `pmap_unset()` call removes the mappings associated with *prognum* and *versnum* on the local machine. All ports for each transport protocol currently mapping the *prognum* and *versnum* are removed from the portmap service.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `getrpcport()`, `pmap_getmaps()`, `pmap_getport()`, `pmap_rmtcall()`, `pmap_set()`.

registerrpc()

```
#include <rpc.h>

int
registerrpc(prognum, versnum, procnum, procname, inproc, outproc)
u_long prognum;
u_long versnum;
u_long procnum;
char *(*procname) ();
xdrproc_t inproc;
xdrproc_t outproc;
```

Operand

Description

prognum

The program number to register.

versnum

Identifies the version number to register.

procnum

Specifies the procedure number to register.

procname

Specifies the procedure that is called when the registered program is requested. *procname* must accept a pointer to its arguments, and return a static pointer to its results.

inproc Specifies the XDR routine used to decode the arguments.

outproc

Specifies the XDR routine that encodes the results.

Description: The `registerrpc()` call registers a procedure (*prognum*, *versnum*, *procnum*) with the local Portmapper, and creates a control structure to remember the server procedure and its XDR routine. The control structure is used by `svc_run()`. When a request arrives for the program (*prognum*, *versnum*, *procnum*), the procedure *procname* is called. Procedures registered using `registerrpc()` are accessed using the UDP transport layer.

Note: `xdr_enum()` cannot be used as an argument to `registerrpc()`. See “`xdr_enum()`” on page 222 for more information.

Return Values: The value 0 indicates success; the value -1 indicates an error.

See Also: `svc_register()`, `svc_run()`.

svc_destroy()

```
#include <rpc.h>

void
svc_destroy(xprt)
SVCXPRT *xprt;
```

Operand

Description

xprt Points to the service transport handle.

Description: The `svc_destroy()` call deletes the RPC service transport handle *xprt*, which becomes undefined after this routine is called.

See Also: `svccraw_create()`, `svctcp_create()`, `svcupdp_create()`.

svc_freeargs()

```
#include <rpc.h>

bool_t
svc_freeargs(xprt, inproc, in)
SVCXPRT *xprt;
xdrproc_t inproc;
char *in;
```

Operand

Description

xprt Points to the service transport handle.
inproc Specifies the XDR routine used to decode the arguments.
in Points to the input arguments.

Description: The `svc_freeargs()` call frees storage allocated to decode the arguments to a service procedure using `svc_getargs()`.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `svc_getargs()`.

svc_getargs()

```
#include <rpc.h>

bool_t
svc_getargs(xprt, inproc, in)
SVCXPRT *xprt;
xdrproc_t inproc;
char *in;
```

Operand

Description

xprt Points to the service transport handle.
inproc Specifies the XDR routine used to decode the arguments.
in Points to the decoded arguments.

svc_getargs()

Description: The `svc_getargs()` call uses the XDR routine `inproc` to decode the arguments of an RPC request associated with the RPC service transport handle `xprt`. The results are placed at address `in`.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `svc_freeargs()`.

svc_getcaller()

```
#include <rpc.h>

struct sockaddr_in *
svc_getcaller(xprt)
SVCXPRT *xprt;
```

Operand

	Description
<code>xprt</code>	Points to the service transport handle.

Description: This macro obtains the network address of the client associated with the service transport handle `xprt`.

Return Values: Returns a pointer to a `sockaddr_in` structure.

See Also: `get_myaddress()`.

svc_getreq()

```
#include <rpc.h>

void
svc_getreq(rdfs)
int rdfs;
```

Operand

	Description
<code>rdfs</code>	Specifies the read descriptor bit mask.

Description: The `svc_getreq()` call is used rather than `svc_run()` to implement asynchronous event processing. The routine returns control to the program when all sockets have been serviced.

Note: `svc_getreq()` limits you to 32 socket descriptors, of which 3 are reserved. Use `svc_getreqset()` if you have more than 29 socket descriptors.

See Also: `svc_run()`.

svc_getreqset()

```
#include <rpc.h>

void
svc_getreqset(rdfs)
fd_set rdfs;
```

Operand**Description**

rdfds Specifies the read descriptor bit set.

Description: The `svc_getreqset()` call is used rather than `svc_run()` to implement asynchronous event processing. The routine returns control to the program when all sockets have been serviced.

A server would use a `select()` call to determine if there are any outstanding RPC requests at any of the sockets created when the programs were registered. The read bit descriptor set returned by `select()` is then used on the call to `svc_getreqset()`.

Note that you should not pass the global bit descriptor set `svc_fdset` on the call to `select()`, because `select()` changes the values. Instead, you should make a copy of `svc_fdset` before you call `select()`.

See Also: `svc_run()`.

svc_register()

```
#include <rpc.h>

bool_t
svc_register(xprt, prognum, versnum, dispatch, protocol)
SVCXPRT *xprt;
u_long prognum;
u_long versnum;
void (*dispatch) ();
int protocol;
```

Operand**Description**

xprt Points to the service transport handle.

prognum Specifies the program number to be registered.

versnum Specifies the version number of the program to be registered.

dispatch Specifies the dispatch routine associated with *prognum* and *versnum*.

Specifies the structure of the dispatch routine is:

```
#include <rpc.h>

dispatch(request, xprt)
struct svc_req *request;
SVCXPRT *xprt;
```

protocol Specifies the protocol used. The value is generally one of the following:

- 0 (zero)
- IPPROTO_UDP
- IPPROTO_TCP

When a value of 0 is used, the service is not registered with Portmapper.

Note: When using a dummy RPC service transport created with `svcrw_create()`, a call to `xprt_register()` must be made immediately after a call to `svc_register()`.

svc_register()

Description: The `svc_register()` call associates the program described by (*prognum*, *versnum*) with the service dispatch routine *dispatch*.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `registerrpc()`, `svc_unregister()`, `xprt_register()`.

svc_run()

The `svc_run()` call has no operands.

```
#include <rpc.h>

void
svc_run()
```

Description: The `svc_run()` call does not return control. It accepts RPC requests and calls the appropriate service using `svc_getreqset()`.

See Also: `svc_getreqset()`.

svc_sendreply()

```
#include <rpc.h>

bool_t
svc_sendreply(xprt, outproc, out)
SVCXPRT *xprt;
xdrproc_t outproc;
char *out;
```

Operand

	Description
<i>xprt</i>	Points to the caller's transport handle.
<i>outproc</i>	Specifies the XDR procedure used to encode the results.
<i>out</i>	Points to the results.

Description: The `svc_sendreply()` call is called by the service dispatch routine to send the results of the call to the caller.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_call()`.

svc_unregister()

```
#include <rpc.h>

void
svc_unregister(prognum, versnum)
u_long prognum;
u_long versnum;
```

Operand

	Description
<i>prognum</i>	Specifies the program number that is removed.

versnum

Specifies the version number of the program that is removed.

Description: The `svc_unregister()` call removes all local mappings of (*prognum*, *versnum*) to dispatch routines and (*prognum*, *versnum*, *) to port numbers.**See Also:** `svc_register()`.

svcerr_auth()

```
#include <rpc.h>

void
svcerr_auth(xprt, why)
SVCXPRT *xprt;
enum auth_stat why;
```

Operand

Description

xprt Points to the service transport handle.
why Specifies the reason the call is refused.

Description: The `svcerr_auth()` call is called by a service dispatch routine that refuses to execute an RPC request because of authentication errors.**See Also:** `svcerr_decode()`, `svcerr_noproc()`, `svcerr_noprogram()`, `svcerr_progvers()`, `svcerr_systemerr()`, `svcerr_weakauth()`.

svcerr_decode()

```
#include <rpc.h>

void
svcerr_decode(xprt)
SVCXPRT *xprt;
```

Operand

Description

xprt Points to the service transport handle.

Description: The `svcerr_decode()` call is called by a service dispatch routine that cannot decode its operands.**See Also:** `svcerr_auth()`, `svcerr_noproc()`, `svcerr_noprogram()`, `svcerr_progvers()`, `svcerr_systemerr()`, `svcerr_weakauth()`.

svcerr_noproc()

```
#include <rpc.h>

void
svcerr_noproc(xprt)
SVCXPRT *xprt;
```

svcerr_noproc()

Operand

Description

xprt Points to the service transport handle.

Description: The `svcerr_noproc()` call is called by a service dispatch routine that does not implement the requested procedure.

See Also: `svcerr_auth()`, `svcerr_decode()`, `svcerr_noprog()`, `svcerr_progvers()`, `svcerr_systemerr()`, `svcerr_weakauth()`.

svcerr_noprog()

```
#include <rpc.h>

void
svcerr_noprog(xprt)
SVCXPRT *xprt;
```

Operand

Description

xprt Points to the service transport handle.

Description: The `svcerr_noprog()` call is used when the desired program is not registered.

See Also: `svcerr_auth()`, `svcerr_decode()`, `svcerr_noproc()`, `svcerr_progvers()`, `svcerr_systemerr()`, `svcerr_weakauth()`.

svcerr_progvers()

```
#include <rpc.h>

void
svcerr_progvers(xprt, low_vers, high_vers)
SVCXPRT *xprt;
u_long low_vers;
u_long high_vers;
```

Operand

Description

xprt Points to the service transport handle.

low_vers

Specifies the low version number that does not match.

high_vers

Specifies the high version number that does not match.

Description: The `svcerr_progvers()` call is called when the version numbers of two RPC programs do not match. The low version number corresponds to the lowest registered version, and the high version corresponds to the highest version registered on the Portmapper.

See Also: `svcerr_auth()`, `svcerr_decode()`, `svcerr_noproc()`, `svcerr_noprog()`, `svcerr_progvers()`, `svcerr_systemerr()`, `svcerr_weakauth()`.

svcerr_systemerr()

```
#include <rpc.h>

void
svcerr_systemerr(xprt)
SVCXPRT *xprt;
```

Operand**Description**

xprt Points to the service transport handle.

Description: The `svcerr_systemerr()` call is called by a service dispatch routine when it detects a system error that is not handled by the protocol.

See Also: `svcerr_auth()`, `svcerr_decode()`, `svcerr_noproc()`, `svcerr_noprogram()`, `svcerr_progvers()`, `svcerr_weakauth()`.

svcerr_weakauth()

```
#include <rpc.h>

void
svcerr_weakauth(xprt)
SVCXPRT *xprt;
```

Operand**Description**

xprt Points to the service transport handle.

Note: This is the equivalent of: `svcerr_auth(xprt, AUTH_TOOWEAK)`.

Description: The `svcerr_weakauth()` call is called by a service dispatch routine that cannot execute an RPC because of correct but weak authentication operands.

See Also: `svcerr_auth()`, `svcerr_decode()`, `svcerr_noproc()`, `svcerr_noprogram()`, `svcerr_progvers()`, `svcerr_systemerr()`.

svcrow_create()

The `svcrow_create()` call has no operands.

```
#include <rpc.h>

SVCXPRT *
svcrow_create()
```

Description: The `svcrow_create()` call creates a local RPC service transport used for timings, to which it returns a pointer. Messages are passed using a buffer within the virtual machine of the local process; so, the client process must also use the same virtual machine. This allows the simulation of RPC programs within one computer. See “`clntraw_create()`” on page 204 for more information.

Return Values: NULL indicates failure.

See Also: `clntraw_create()`, `svc_destroy()`, `svctcp_create()`, `svcudp_create()`.

svctcp_create()

svctcp_create()

```
#include <rpc.h>

SVCXPRT *
svctcp_create(sock, send_buf_size, recv_buf_size)
int sock;
u_int send_buf_size;
u_int recv_buf_size;
```

Operand

Description

sock Specifies the socket descriptor. If *sock* is `RPC_ANYSOCK`, a new socket is created. If the socket is not bound to a local TCP port, it is bound to an arbitrary port.

send_buf_size

Specifies the size of the send buffer. Specify 0 to choose the default.

recv_buf_size

Specifies the size of the receive buffer. Specify 0 to choose the default.

Description: The `svctcp_create()` call creates a TCP-based service transport to which it returns a pointer. `xprt->xp_sock` contains the transport's socket descriptor. `xprt->xp_port` contains the transport's port number.

Return Values: NULL indicates failure.

See Also: `svc_destroy()`, `svccraw_create()`, `svccudp_create()`.

svccudp_create()

```
#include <rpc.h>

SVCXPRT *
svccudp_create(sock, sendsz, recvsz)
int sock;
u_int sendsz;
u_int recvsz;
```

Operand

Description

sock Specifies the socket descriptor. If *sock* is `RPC_ANYSOCK`, a new socket is created. If the socket is not bound to a local UDP port, it is bound to an arbitrary port.

sendsz Specifies the size of the send buffer.

recvsz Specifies the size of the receive buffer.

Description: The `svccudp_create()` call creates a UDP-based service transport to which it returns a pointer. `xprt->xp_sock` contains the transport's socket descriptor. `xprt->xp_port` contains the transport's port number.

Return Values: NULL indicates failure.

See Also: `svc_destroy()`, `svccraw_create()`, `svctcp_create()`.

xdr_accepted_reply()

```
#include <rpc.h>

bool_t
xdr_accepted_reply(xdrs, ar)
XDR *xdrs;
struct accepted_reply *ar;
```

Operand**Description**

xdrs Points to an XDR stream.
ar Points to the reply to be represented.

Description: The `xdr_accepted_reply()` call translates RPC reply messages.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_array()

```
#include <rpc.h>

bool_t
xdr_array(xdrs, arrp, sizep, maxsize, elsize, elproc)
XDR *xdrs;
char **arrp;
u_int *sizep;
u_int maxsize;
u_int elsize;
xdrproc_t elproc;
```

Operand**Description**

xdrs Points to an XDR stream.
arrp Specifies the address of the pointer to the array.
sizep Points to the element count of the array.
maxsize Specifies the maximum number of elements accepted.
elsize Specifies the size of each of the array's elements, found using `sizeof()`.
elproc Specifies the XDR routine that translates an individual array element.

Description: The `xdr_array()` call translates between an array and its external representation.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_authunix_parms()

xdr_authunix_parms()

```
#include <rpc.h>

bool_t
xdr_authunix_parms(xdrs, aupp)
XDR *xdrs;
struct authunix_parms *aupp;
```

Operand

Description

xdrs Points to an XDR stream.
aupp Points to the authentication information.

Description: The `xdr_authunix_parms()` call translates UNIX-based authentication information.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_bool()

```
#include <rpc.h>

bool_t
xdr_bool(xdrs, bp)
XDR *xdrs;
bool_t *bp;
```

Operand

Description

xdrs Points to an XDR stream.
bp Points to the Boolean.

Description: The `xdr_bool()` call translates between Booleans and their external representation.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_bytes()

```
#include <rpc.h>

bool_t
xdr_bytes(xdrs, sp, sizep, maxsize)
XDR *xdrs;
char **sp;
u_int *sizep;
u_int maxsize;
```

Operand

Description

xdrs Points to an XDR stream.
sp Points to a pointer to the byte string.

sizep Points to the byte string size.

maxsize
Specifies the maximum size of the byte string.

Description: The `xdr_bytes()` call translates between byte strings and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_callhdr()

```
#include <rpc.h>

bool_t
xdr_callhdr(xdrs, chdr)
XDR *xdrs;
struct rpc_msg *chdr;
```

Operand

Description

xdrs Points to an XDR stream.

chdr Points to the call header.

Description: The `xdr_callhdr()` call translates an RPC message header into XDR format.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_callmsg()

```
#include <rpc.h>

bool_t
xdr_callmsg(xdrs, cmsg)
XDR *xdrs;
struct rpc_msg *cmsg;
```

Operand

Description

xdrs Points to an XDR stream.

cmsg Points to the call message.

Description: The `xdr_callmsg()` call translates RPC messages (header and authentication, not argument data) to and from the xdr format.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_double()

xdr_double()

```
#include <rpc.h>

bool_t
xdr_double(xdrs, dp)
XDR *xdrs;
double *dp;
```

Operand

Description

xdrs Points to an XDR stream.
dp Points to a double-precision number.

Description: The `xdr_double()` call translates between C double-precision numbers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_enum()

```
#include <rpc.h>

bool_t
xdr_enum(xdrs, ep)
XDR *xdrs;
enum_t *ep;
```

Operand

Description

xdrs Points to an XDR stream.
ep Points to the enumerated number. *enum_t* can be any enumeration type such as `enum colors`, with `colors` declared as `enum colors (black, brown, red)`.

Description: The `xdr_enum()` call translates between C-enumerated groups and their external representation. When calling the procedures `callrpc()` and `registerrpc()`, a stub procedure must be created for both the server and the client before the procedure of the application program using `xdr_enum()`. The following is the format of the stub procedure.

```
#include <rpc.h>

enum colors (black, brown, red)
void
static xdr_enum_t(xdrs, ep)
XDR *xdrs;
enum colors *ep;
{
    xdr_enum(xdrs, ep)
}
```

The `xdr_enum_t` procedure is used as the *inproc* and *outproc* in both the client and server RPCs.

For example, an RPC client would contain the following lines:

```

:
error = callrpc(argv[1],ENUMRCVPROG,VERSION,ENUMRCVPROC,
xdr_enum_t,&innumber,xdr_enum_t,
&outnumber);
:

```

An RPC server would contain the following line:

```

:
registerrpc(ENUMRCVPROG,VERSION,ENUMRCVPROC,
xdr_enum_t,xdr_enum_t);
:

```

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_float()

```

#include <rpc.h>

bool_t
xdr_float(xdrs, fp)
XDR *xdrs;
float *fp;

```

Operand

	Description
<i>xdrs</i>	Points to an XDR stream.
<i>fp</i>	Points to the floating-point number.

Description: The `xdr_float()` call translates between C floating-point numbers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_inline()

xdr_inline()

```
#include <rpc.h>

long *
xdr_inline(xdrs, len)
XDR *xdrs;
u_int len;
```

Operand

Description

xdrs Points to an XDR stream.
len Specifies the byte length of the desired buffer.

Description: The `xdr_inline()` call returns a pointer to a continuous piece of the XDR stream's buffer. The value is `long *` rather than `char *`, because the external data representation of any object is always an integer multiple of 32 bits.

Note: `xdr_inline()` can return `NULL` if there is not sufficient space in the stream buffer to satisfy the request.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_int()

```
#include <rpc.h>

bool_t
xdr_int(xdrs, ip)
XDR *xdrs;
int *ip;
```

Operand

Description

xdrs Points to an XDR stream.
ip Points to the integer.

Description: The `xdr_int()` call translates between C integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_long()

```
#include <rpc.h>

bool_t
xdr_long(xdrs, lp)
XDR *xdrs;
long *lp;
```

Operand

Description

xdrs Points to an XDR stream.
lp Points to the long integer.

Description: The `xdr_long()` call translates between C long integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_opaque()

```
#include <rpc.h>

bool_t
xdr_opaque(xdrs, cp, cnt)
XDR *xdrs;
char *cp;
u_int cnt;
```

Operand

Description

xdrs Points to an XDR stream.
cp Points to the opaque object.
cnt Specifies the size of the opaque object.

Description: The `xdr_opaque()` call translates between fixed-size opaque data and its external representation.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_opaque_auth()

```
#include <rpc.h>

bool_t
xdr_opaque_auth(xdrs, ap)
XDR *xdrs;
struct opaque_auth *ap;
```

Operand

Description

xdrs Points to an XDR stream.
ap Points to the opaque authentication information.

Description: The `xdr_opaque_auth()` call translates RPC message authentications.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_pmap()

xdr_pmap()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

bool_t
xdr_pmap(xdrs, regs)
XDR *xdrs;
struct pmap *regs;
```

Operand

Description

xdrs Points to an XDR stream.
regs Points to the portmap operands.

Description: The `xdr_pmap()` call translates an RPC procedure identification, such as is used in calls to Portmapper.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_pmaplist()

```
#include <rpc.h>
#include <pmap_pro.h>
#include <pmap_cln.h>

bool_t
xdr_pmaplist(xdrs, rp)
XDR *xdrs;
struct pmaplist **rp;
```

Operand

Description

xdrs Points to an XDR stream.
rp Points to a pointer to the portmap data array.

Description: The `xdr_pmaplist()` call translates a variable number of RPC procedure identifications, such as Portmapper creates.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_pointer()

```
#include <rpc.h>

bool_t
xdr_pointer(xdrs, pp, size, proc)
XDR *xdrs;
char **pp;
u_int size;
xdrproc_t proc;
```

Operand**Description**

<i>xdrs</i>	Points to an XDR stream.
<i>pp</i>	Points to a pointer.
<i>size</i>	Specifies the size of the target.
<i>proc</i>	Specifies the XDR procedure that translates an individual element of the type addressed by the pointer.

Description: The `xdr_pointer()` call provides pointer-chasing within structures. This differs from the `xdr_reference()` call in that it can serialize or deserialize trees correctly.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_reference()

```
#include <rpc.h>

bool_t
xdr_reference(xdrs, pp, size, proc)
XDR *xdrs;
u_int size;
xdrproc_t proc;
```

Operand**Description**

<i>xdrs</i>	Points to an XDR stream.
<i>pp</i>	Points to a pointer.
<i>size</i>	Specifies the size of the target.
<i>proc</i>	Specifies the XDR procedure that translates an individual element of the type addressed by the pointer.

Description: The `xdr_reference()` call provides pointer-chasing within structures.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_rejected_reply()

xdr_rejected_reply()

```
#include <rpc.h>

bool_t
xdr_rejected_reply(xdrs, rr)
XDR *xdrs;
struct rejected_reply *rr;
```

Operand

Description

xdrs Points to an XDR stream.
rr Points to the rejected reply.

Description: The `xdr_rejected_reply()` call translates rejected RPC reply messages.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_replymsg()

```
#include <rpc.h>

bool_t
xdr_replymsg(xdrs, rmsg)
XDR *xdrs;
struct rpc_msg *rmsg;
```

Operand

Description

xdrs Points to an XDR stream.
rmsg Points to the reply message.

Description: The `xdr_replymsg()` call translates RPC reply messages.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_short()

```
#include <rpc.h>

bool_t
xdr_short(xdrs, sp)
XDR *xdrs;
short *sp;
```

Operand

Description

xdrs Points to an XDR stream.
sp Points to the short integer.

Description: The `xdr_short()` call translates between C short integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: callrpc(), clnt_broadcast(), clnt_call(), clnt_freeres(), pmap_rmtcall(), registerrpc(), svc_freeargs(), svc_getargs(), svc_sendreply().

xdr_string()

```
#include <rpc.h>

bool_t
xdr_string(xdrs, sp, maxsize)
XDR *xdrs;
char **sp;
u_int maxsize;
```

Operand

Description

xdrs Points to an XDR stream.

sp Points to a pointer to the string.

maxsize

Specifies the maximum size of the string.

Description: The xdr_string() call translates between C strings and their external representations. The xdr_string() call is the only xdr routine to convert ASCII to EBCDIC.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: callrpc(), clnt_broadcast(), clnt_call(), clnt_freeres(), pmap_rmtcall(), registerrpc(), svc_freeargs(), svc_getargs(), svc_sendreply().

xdr_u_int()

```
#include <rpc.h>

bool_t
xdr_u_int(xdrs, up)
XDR *xdrs;
unsigned *up;
```

Operand

Description

xdrs Points to an XDR stream.

up Points to the unsigned integer.

Description: The xdr_u_int() call translates between C unsigned integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: callrpc(), clnt_broadcast(), clnt_call(), clnt_freeres(), pmap_rmtcall(), registerrpc(), svc_freeargs(), svc_getargs(), svc_sendreply().

xdr_u_long()

xdr_u_long()

```
#include <rpc.h>

bool_t
xdr_u_long(xdrs, ulp)
XDR *xdrs;
u_long *ulp;
```

Operand

Description

xdrs Points to an XDR stream.
ulp Points to the unsigned long integer.

Description: The `xdr_u_long()` call translates between C unsigned long integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_u_short()

```
#include <rpc.h>

bool_t
xdr_u_short(xdrs, usp)
XDR *xdrs;
u_short *usp;
```

Operand

Description

xdrs Points to an XDR stream.
usp Points to the unsigned short integer.

Description: The `xdr_u_short()` call translates between C unsigned short integers and their external representations.

Return Values: The value 1 indicates success; the value 0 indicates an error.

xdr_union()

```
#include <rpc.h>

bool_t
xdr_union(xdrs, dscmp, unp, choices, dfault)
XDR *xdrs;
enum_t *dscmp;
char *unp;
struct xdr_discrim *choices;
xdrproc_t dfault;
```

Operand

Description

xdrs Points to an XDR stream.
dscmp Points to the union's discriminant. *enum_t* can be any enumeration type.
unp Points to the union.

choices Points to an array detailing the XDR procedure to use on each arm of the union.

dfault Specifies the default XDR procedure to use.

Description: The `xdr_union()` call translates between a discriminated C union and its external representation.

Return Values: The value 1 indicates success; the value 0 indicates an error.

The following is an example of this call:

```
#include <rpc.h>

enum colors (black, brown, red);

bool_t
xdr_union(xdrs, dscmp, unp, choices, dfault)
XDR *xdrs;
enum colors *dscmp;
char *unp;
struct xdr_discrim *choices;
xdrproc_t dfault;
```

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_vector()

```
#include <rpc.h>

bool_t
xdr_vector(xdrs, basep, nelem, elemsize, xdr_elem)
XDR *xdrs;
char *basep;
u_int nelem;
u_int elemsize;
xdrproc_t xdr_elem;
```

Operand

Description

xdrs Points to an XDR stream.

basep Specifies the base of the array.

nelem Specifies the element count of the array.

elemsize
Specifies the size of each of the array's elements, found using `sizeof()`.

xdr_elem
Specifies the XDR routine that translates an individual array element.

Description: The `xdr_vector()` call translates between a fixed length array and its external representation. Unlike variable-length arrays, the storage of fixed length arrays is static and unfreeable.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_void()

xdr_void()

The `xdr_void()` call has no operands.

```
#include <rpc.h>

bool_t
xdr_void()
```

Description: The `xdr_void()` call is used like a command that does not require any other xdr functions. This call can be placed in the *inproc* or *outproc* operand of the `clnt_call` function when the user does not need to move data.

Return Values: Always a value of 1.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdr_wrapstring()

```
#include <rpc.h>

bool_t
xdr_wrapstring(xdrs, sp)
XDR *xdrs;
char **sp;
```

Operand

Description

xdrs Points to an XDR stream.
sp Points to a pointer to the string.

Description: The `xdr_wrapstring()` call is the same as calling `xdr_string()` with a maximum size of `MAXUNSIGNED`. It is useful because many RPC procedures implicitly invoke two-operand XDR routines, and `xdr_string()` is a three-operand routine.

Return Values: The value 1 indicates success; the value 0 indicates an error.

See Also: `callrpc()`, `clnt_broadcast()`, `clnt_call()`, `clnt_freeres()`, `pmap_rmtcall()`, `registerrpc()`, `svc_freeargs()`, `svc_getargs()`, `svc_sendreply()`.

xdrmem_create()

```
#include <rpc.h>

void
xdrmem_create(xdrs, addr, size, op)
XDR *xdrs;
char *addr;
u_int size;
enum xdr_op op;
```

Operand

Description

xdrs Points to an XDR stream.
addr Points to the memory location.

size Specifies the maximum size of *addr*.

op Determines the direction of the XDR stream (XDR_ENCODE, XDR_DECODE, or XDR_FREE).

Description: The xdrmem_create() call initializes the XDR stream pointed to by *xdrs*. Data is written to, or read from, *addr*.

xdrrec_create()

```
#include <rpc.h>

void
xdrrec_create(xdrs, sendsize, recvsiz, handle, readit, writeit)
XDR *xdrs;
u_int sendsize;
u_int recvsiz;
char *handle;
int (*readit) ();
int (*writeit) ();
```

Operand

Description

xdrs Points to an XDR stream.

sendsize

Indicates the size of the send buffer. Specify 0 to choose the default.

recvsiz

Indicates the size of the receive buffer. Specify 0 to choose the default.

handle Specifies the first operand passed to *readit*() and *writeit*().

readit() Called when a stream's input buffer is empty.

writeit()

Called when a stream's output buffer is full.

Description: The xdrrec_create() call creates a record-oriented stream and initializes the XDR stream pointed to by *xdrs*.

Note:

1. The *x_op* field must be set by the caller.
2. This XDR procedure implements an intermediate record string.
3. Additional bytes in the XDR stream provide record boundary information.

xdrrec_endofrecord()

```
#include <rpc.h>
bool_t
xdrrec_endofrecord(xdrs, sendnow)
XDR *xdrs;
int sendnow;
```

Operand

Description

xdrs Points to an XDR stream.

sendnow

Specifies nonzero to write out data in the output buffer.

xdrrec_endofrecord()

Description: The `xdrrec_endofrecord()` call can be invoked only on streams created by `xdrrec_create()`. Data in the output buffer is marked as a complete record.

Return Values: The value 1 indicates success; the value 0 indicates an error.

xdrrec_eof()

```
#include <rpc.h>

bool_t
xdrrec_eof(xdrs)
XDR *xdrs;
```

Operand

	Description
<i>xdrs</i>	Points to an XDR stream.

Description: The `xdrrec_eof()` call can be invoked only on streams created by `xdrrec_create()`.

Return Values: The value 1 indicates the current record has been consumed; the value 0 indicates continued input on the stream.

xdrrec_skiprecord()

```
#include <rpc.h>

bool_t
xdrrec_skiprecord(xdrs)
XDR *xdrs;
```

Operand

	Description
<i>xdrs</i>	Points to an XDR stream.

Description: The `xdrrec_skiprecord()` call can be invoked only on streams created by `xdrrec_create()`. The XDR implementation is instructed to discard the remaining data in the input buffer.

Return Values: The value 1 indicates success; the value 0 indicates an error.

xdrstdio_create()

```
#include <rpc.h>
#include <stdio.h>

void
xdrstdio_create(xdrs, file, op)
XDR *xdrs;
FILE *file;
enum xdr_op op;
```

Operand

	Description
<i>xdrs</i>	Points to an XDR stream.

file Specifies the file name for the I/O stream.

op Determines the direction of the XDR stream (either XDR_ENCODE, XDR_DECODE, or XDR_FREE).

Description: The xdrstdio_create() call initializes the XDR stream pointed to by *xdrs*. Data is written to, or read from, *file*.

Note: fflush() is the destroy routine associated with this procedure. fclose() is not called.

xprt_register()

```
#include <rpc.h>

void
xprt_register(xprt)
SVCXPRT *xprt;
```

Operand
Description

xprt Points to the service transport handle.

Description: The xprt_register() call registers service transport handles with the RPC service package. This routine also modifies the global variable svc_fds

See Also: svc_register(), svc_fds.

xprt_unregister()

```
#include <rpc.h>

void
xprt_unregister(xprt)
SVCXPRT *xprt;
```

Operand
Description

xprt Points to the service transport handle.

Description: The xprt_unregister() call unregisters an RPC service transport handle. A transport handle should be unregistered with the RPC service package before it is destroyed. This routine also modifies the global variable svc_fds and svc_fdset.

See also: svc_fds, svc_fdset.

Sample RPC Programs

This appendix provides examples of the following programs:

- RPC Genesend client (see “RPC Genesend Client” on page 237)
- RPC Geneserv server (see “RPC Geneserv Server” on page 237)
- RPC Rawex raw data stream (see “RPC Rawex Raw Data Stream” on page 238)

Sample RPC Programs

Refer back to “Compiling, Linking, and Running an RPC Program” on page 192 for examples of how to compile, link, and run RPC programs.

Running the Geneserv server and Genesend client

The Geneserv server and Genesend client are a pair of client-server programs. Typically, the Geneserv server is run in one virtual machine and the Genesend client in another. If a POSIX shell command line is available, both can be run in the same virtual machine by starting the Geneserv server in the background and running the Genesend client in the foreground. The steps for running these programs are as follows:

1. Make sure the TCPIP Client-code disk is accessed (usually TCPMAINT 592).
2. Before the Geneserv server can be started, the Portmapper must be running. To determine if the Portmapper is running, contact the Portmapper with the command `RPCINFO -p`
3. Start the Geneserv server. From the CMS command line issue:

```
openvm run GENESERV
```

To start in the foreground from a POSIX shell command line issue:

```
geneserv
```

To start in the background from a POSIX shell command line issue:

```
geneserv &
```

After starting the Geneserv server you should see output similar to the following:

```
openvm run GENESERV
Intrcv Registration with Port Mapper completed
Floatrcv Registration with Port Mapper completed
integer received: 10
integer being returned: 10
```

4. Start the Genesend client. From the CMS command line issue:

```
openvm run GENESEND hostname some_number
```

To start in the foreground from a POSIX shell command line issue:

```
genesend hostname some_number
```

To start in the background from a POSIX shell command line issue:

```
genesend hostname some_number &
```

The *hostname* argument is the host running the Geneserv server. The *some_number* argument is an integer value that will be sent to the Geneserv server and then returned.

The following is a sample run of the Genesend client:

```
openvm run GENESEND myvmhost 10
value sent: 10 value received: 10
Ready;
```

Running the Rawex program

The rawex program uses the raw RPC interfaces and is a client and server program in the same program. To start Rawex from a CMS command line issue:

```
openvm run RAWEX some_number
```

To start in the foreground from a POSIX shell command line issue:

```
rawex some_number
```

To start in the background from a POSIX shell command line issue:

```
rawex some_number &
```

The following is a sample run of Rawex:

```
openvm run RAWEX 5678
Argument: 5678
Received: 5678
Sent: 5678
Result: 5678
Ready;
```

RPC Genesend Client

The following is an example of an RPC client program.

```
/* GENESEND.C */
/* Send an integer to the remote host and receive the integer back */
/* PORTMAPPER AND REMOTE SERVER MUST BE RUNNING */

#define VM
#include <stdio.h>
#include <rpc.h>
#include <socket.h>

#define intrcvprog ((u_long)150000)
#define version ((u_long)1)
#define intrcvproc ((u_long)1)

main(argc, argv)
    int argc;
    char *argv[];
{
    int innumber;
    int outnumber;
    int error;

    if (argc != 3) {
        fprintf(stderr, "usage: %s hostname integer\n", argv[0]);
        exit (-1);
    } /* endif */
    innumber = atoi(argv[2]);
    /*
     * Send the integer to the server. The server should
     * return the same integer.
     */
    error = callrpc(argv[1], intrcvprog, version, intrcvproc, xdr_int,
                   (char *)&innumber, xdr_int, (char *)&outnumber);

    if (error != 0) {
        fprintf(stderr, "error: callrpc failed: %d \n", error);
        fprintf(stderr, "intrcvprog: %d version: %d intrcvproc: %d",
                intrcvprog, version, intrcvproc);
        exit(1);
    } /* endif */

    printf("value sent: %d   value received: %d\n", innumber, outnumber);
    exit(0);
}
```

RPC Geneserv Server

The following is an example of an RPC server program.

```
/* GENERIC SERVER */
/* RECEIVE AN INTEGER OR FLOAT AND RETURN THEM RESPECTIVELY */
/* PORTMAPPER MUST BE RUNNING */
```

RPC Server

```
#define VM

#include <rpc.h>
#include <stdio.h>

#define intrcvprog ((u_long)150000)
#define fltrcvprog ((u_long)150102)
#define intvers    ((u_long)1)
#define intrcvproc ((u_long)1)
#define fltrcvproc ((u_long)1)
#define fltvers    ((u_long)1)

main()
{
    int *intrcv();
    float *floatrcv();

    /*REGISTER PROG, VERS AND PROC WITH THE PORTMAPPER*/

    /*FIRST PROGRAM*/
    registerrpc(intrcvprog,intvers,intrcvproc,intrcv,xdr_int,xdr_int);
    printf("Intrcv Registration with Port Mapper completed\n");

    /*OR MULTIPLE PROGRAMS*/
    registerrpc(fltrcvprog,fltvers,fltrcvproc,floatrcv,xdr_float,xdr_float);
    printf("Floatrcv Registration with Port Mapper completed\n");

    /*
     * svc_run will handle all requests for programs registered.
     */
    svc_run();
    printf("Error:svc_run returned!\n");
    exit(1);
}

/*
 * Procedure called by the server to receive and return an integer.
 */
int *
intrcv(in)
{
    int *in;
    int *out;

    printf("integer received: %d\n",*in);
    out = in;
    printf("integer being returned: %d\n",*out);
    return (out);
}

/*
 * Procedure called by the server to receive and return a float.
 */

float *
floatrcv(in)
{
    float *in;
    float *out;

    printf("float received: %e\n",*in);
    out=in;
    printf("float being returned: %e\n",*out);
    return(out);
}
```

RPC Rawex Raw Data Stream

The following is an example of an RPC raw data stream program.

```

/*RAWEX                                     */
/* AN EXAMPLE OF THE RAW CLIENT/SERVER USAGE */
/* PORTMAPPER MUST BE RUNNING              */
/*
 * This program does not access an external interface. It provides
 * a test of the raw RPC interface allowing a client and server
 * program to be in the same process.
 */
#define VM
#include <rpc.h>
#include <stdio.h>
#define rawprog ((u_long)150104)
#define rawvers ((u_long)1)
#define rawproc ((u_long)1)

extern enum clnt_stat clntraw_call();
extern void raw2();

main(argc,argv)
int argc;
char *argv[];
{
    SVCXPRT *transp;
    struct hostent *hp;
    struct timeval pertry_timeout, total_timeout;
    struct sockaddr_in server_addr;
    int bout,in;
    register CLIENT *clnt;
    enum clnt_stat cs;
    int addrLen;

    /*
     * The only argument passed to the program is an integer to
     * be transferred from the client to the server and back.
     */
    if(argc!=2) {
        printf("usage: %s integer\n", argv[0]);
        exit(-1);
    }
    in = atoi(argv[1]);

    /*
     * Create the raw transport handle for the server.
     */
    transp = svcraw_create();
    if (transp == NULL) {
        fprintf(stderr, "can't create an RPC server transport\n");
        exit(-1);
    }

    /* In case the program is already registered, deregister it */
    pmap_unset(rawprog, rawvers);

    /* Register the server program with PORTMAPPER */
    if (!svc_register(transp,rawprog,rawvers,raw2, 0)) {
        fprintf(stderr, "can't register service\n");
        exit(-1);
    }
    /*
     * The following registers the transport handle with internal
     * data structures.
     */
    xpvt_register(transp);
    /*
     * Create the client transport handle.
     */
    if ((clnt = clntraw_create(rawprog, rawvers)) == NULL ) {
        clnt_pcreateerror("clntudp_create");
        exit(-1);
    }
    total_timeout.tv_sec = 60;

```

RPC Raw Data Stream

```
total_timeout.tv_usec = 0;
printf("Argument:  %d\n",in);

/*
 * Make the call from the client to the server.
 */
cs=clnt_call(clnt,rawproc,xdr_int,
             (char *)&in,xdr_int,(char *)&bout,total_timeout);

printf("Result:  %d",bout);
if(cs!=0) {
    clnt_perror(clnt,"Client call failed");
    exit(1);
}
exit(0);
}

/*
 * Service procedure called by the server when it receives the client
 * request.
 */
void raw2(rqstp,transp)
struct svc_req *rqstp;
SVCXPRT *transp;
{
    int in,out;
    if (rqstp->rq_proc=rawproc) {
        /*
         * Unpack the integer passed by the client.
         */
        svc_getargs(transp,xdr_int,&in);
        printf("Received:  %d\n",in);
        /*
         * Send the integer back to the client.
         */
        out=in;
        printf("Sent:  %d\n",out);
        if (!svc_sendreply(transp, xdr_int,&out)) {
            printf("Can't reply to RPC call.\n");
            exit(1);
        }
    }
}
}
```

Chapter 6. X Window System Interface

This chapter contains information specific to the VM implementation of the X Window System. The X Window System application program interface (API) allows you to write applications in the VM/CMS environment that can be displayed on X11 servers on a TCP/IP-based network. This API provides the application with graphics capabilities as defined by the X Window System protocol. For more information about the X protocol and application program interface, see the X Window System publications listed in “Bibliography” on page 433.

What Is Provided

The X Window System support provided with TCP/IP includes support for the following API from the X Window System Version 11, Release 4:

- X11LIB TXTLIB (Xlib, Xmu, Xext, and Xau routines)
- OLDXLIB TXTLIB (X Release 10 compatibility routines)
- XTLIB TXTLIB (X Intrinsics)
- XAWLIB TXTLIB (Athena widget set)
- Header files needed for compiling X clients

In addition, it also includes support for the following API based on Release 1.1 of the OSF/Motif-based widget set:

- XMLIB TXTLIB (OSF/Motif-based widget set)
- Header files needed for compiling clients using the OSF/Motif-based widget set.

Software Requirements

Application programs using the X Window System API are written in C and require the following:

- IBM C for VM/ESA Compiler, Version 3 Release 1 Program (Program Number 5654-033).
- IBM Language Environment for MVS™ & VM, Version 1 Release 5 Program (Program Number 5688-198).

Using the X Window System Interface in the VM Environment

The X Window System is a network-transparent protocol that supports windowing and graphics. The protocol is communicated between a client or application and an X server over a reliable bidirectional byte stream. This byte stream is provided by the TCP/IP communication protocol.

In the VM/CMS environment, X Window System support consists of a set of application calls that create the X protocol, as requested by the application. This application program interface allows an application to be created, which uses the X Window System protocol to be displayed on an X server.

In an X Window System environment, the X server distributes user input to and accepts requests from various client programs located either on the same system or elsewhere on a network. The X client code uses sockets to communicate with the X server.

X Window System Interface

Figure 37 shows a high-level abstraction of how the X Window System works in a VM environment. As an application writer, you need to be concerned only with the client API in writing your application.

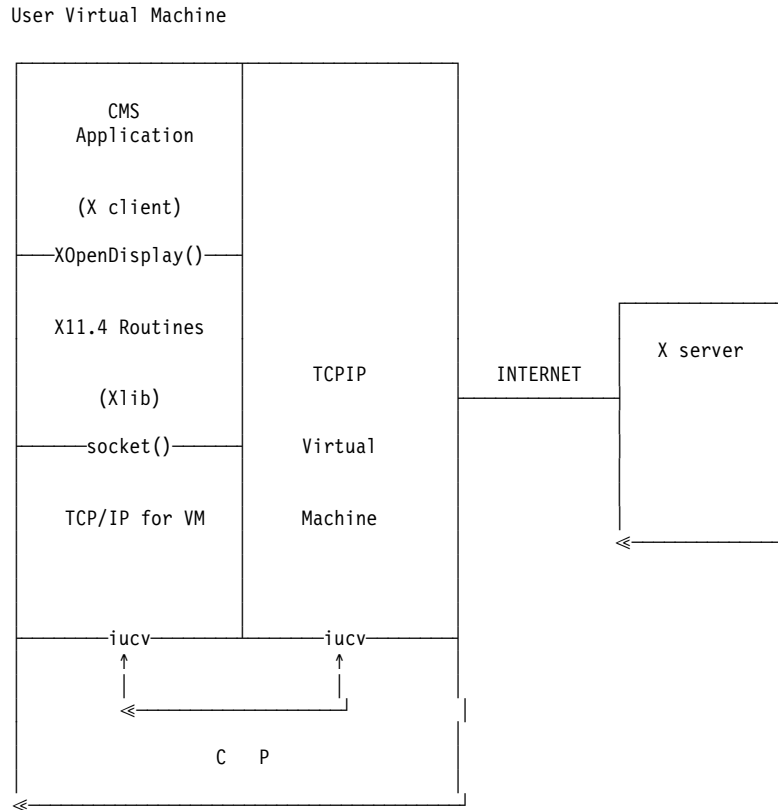


Figure 37. VM X Window System Application to Server

The communication path from the VM X Window System application to the server involves the client code and TCP/IP. The application program that you create is the client part of a client-server relationship. The X server provides access to the resources that are shared among many X applications, such as the screen, keyboard, mouse, fonts, and graphics contexts. A single X server can control more than one physical screen.

Each client can interact with multiple servers, and each server can interact with multiple clients.

If your application is written to the Xlib interface, it calls `XOpenDisplay()` to start communication with an X server on a workstation. The Xlib code opens a communication path called a socket to the X server, and sends the appropriate X protocol to initiate client-server communication.

The X protocol generated by the Window System client code uses an ISO Latin-1 encoding for character strings, while the VM/CMS encoding for character strings is EBCDIC. The X Window System client code in the VM/CMS environment automatically transforms character strings from EBCDIC to ISO Latin-1 or from ISO Latin-1 to EBCDIC, as needed using internal translate tables.

When programming using the C/VM Compiler, CMS file identifiers are specified as *filename filetype filemode*. In the following sections a file specified as *filename.filetype* refers to the CMS file, file name file type.

In the VM/CMS environment, external names must be eight characters or less. Many of the X Window System application program interface names exceed this limit. To support the X API in CMS, all X names longer than eight characters are remapped to unique names using the C compiler preprocessor. This name remapping is found in a header file called X11GLUE.H, which is automatically included in your program when you include the standard X header file called XLIB.H. In debugging your application, it may be helpful to reference the X11GLUE.H header file to find the remapped names of the X API routines.

Application Resource File

The X Window System allows you to modify certain characteristics of an application at run time by means of application resources. Typically, application resources are set to tailor the appearance and possibly the behavior of an application. The application resources may specify information about an application's window sizes, placement, coloring, font usage, and other functional details.

On a UNIX system, this information can be found in the user's home directory in a file called `.Xdefaults`. In the VM/CMS environment, this file is called `X DEFAULTS`. Each line of this file represents resource information for an application. Figure 38 shows an example of a set of resources specified for a typical X Window System application.

```
XClock*geometry:      500x60+5-5
XClock*font:          -bitstream--bold-r--33-240-*
XClock*foreground:    orange
XClock*background:    skyblue
XClock*borderWidth:   4
XClock*borderColor:   blue
XClock*analog:        false
```

Figure 38. Resources Specified for a Typical X Window System Application

In this example, the Xclock application automatically creates a window in the lower left corner of the screen with a digital display in orange letters on a skyblue background.

These resources can also be set on the `RESOURCE_MANAGER` property of the X server, which allows a single, central place where resources are found, which control all applications that are displayed on an X server. You can use the `xrdb` program to control the X server resource database in the resource property.

The `xrdb` program is an X client that you can use either to get or to set the contents of the `RESOURCE_MANAGER` property on the root window of screen 0. This property is then used by all applications at startup to control the application resource.

Identifying the Target Display

A CMS global command is used by the X Window System to identify the internet address of the target display.

The following is the format of the CMS global command.

XLIB.H header file as the first included X Window System header file, you do not have to define the IBMCPP preprocessor symbol, because it is automatically defined by this header file.

For applications written using the X Window System Toolkit, including the INTRINSIC.H header file as the first X Window System header file also defines the preprocessor symbol for you. You do not have to define it again when you invoke the compiler.

3. Generate the executable module by entering the CMOD command:

```
CMOD myxprog
```

You should now have the file, *myxprog* MODULE, on your A disk. Verify that you have set the LOADLIB and TXTLIB search order. To run this module, do the following:

4. Specify the IP address of the X server on which you wish to display the application output by setting the DISPLAY global variable in the CENV (C Environment) group of global variables:

```
GLOBALV SELECT CENV SET DISPLAY charm.cambridge.ibm.com:0.0
```

or

```
GLOBALV SELECT CENV SET DISPLAY 129.42.3.105:0.0
```

Note: charm.cambridge.ibm.com:0.0 and 129.42.3.105:0.0 are example addresses.

5. Allow the host application access to the X server.

On the workstation where you wish to display the application output, you must grant permission for the VM host to access the X server. To do this enter the xhost command:

```
xhost cambvm3
```

Note: cambvm3 is an example host name.

6. Run the application by entering the following command:

```
myxprog
```

Typically, an X application uses the global variable DISPLAY in the CENV group as the X server address on which it is to display. Some applications also allow you to specify this information as a command line option. You should refer to the documentation for the application you are attempting to run for these and other options that are available to you.

In the preceding example, the application is displayed on the X server at the internet address associated with the name charm.cambridge.ibm.com. The application is displayed on the X server on screen 0 on this system.

In the preceding example, the GLOBAL TXTLIB command specified the X11LIB and COMMTXT TXTLIBs in the TXTLIB search order. Depending on the facilities of X that your application makes use of, additional libraries may have to be specified to generate your application. For example, to generate an application that is written to the OSF/Motif interface, specify the following command:

```
GLOBAL TXTLIB XMLIB XTLIB X11LIB COMMTXT CMSLIB
```

Table 24 on page 246 describes the various TXTLIBs associated with the X Window System support in the VM/CMS environment.

X Window System Interface

Table 24. *TXTLIBs Associated with X Window System Support*

TXTLIB	Routine(s)
X11LIB	X11.4 X Window System client routines and X11.4 Miscellaneous Utility routines
OLDXLIB	X10 Compatibility routines
XTLIB	X11.4 Intrinsic routines
XAWLIB	Athena widget routines
XMLIB	OSF/Motif-based widget routines

X Window System Subroutines

This section provides information about X Window System in tabular form for quick reference.

The following tables list the subroutines supported by TCP/IP for z/VM.

The subroutines are grouped according to the type of function provided.

Opening and Closing a Display

Table 25 provides the subroutines for opening and closing a display.

Table 25. *Opening and Closing Display*

Subroutine	Description
XCloseDisplay()	Closes a display.
XFree()	Frees in-memory data created by Xlib function.
XNoOp()	Executes a NoOperation protocol request.
XOpenDisplay()	Opens a display.

Creating and Destroying Windows

Table 26 provides the subroutines for creating and destroying windows.

Table 26. *Creating and Destroying Windows*

Subroutine	Description
XConfigureWindow()	Configures the specified window.
XCreateSimpleWindow()	Creates unmapped InputOutput subwindow.
XCreateWindow()	Creates unmapped subwindow.
XDestroySubwindows()	Destroys all subwindows of specified window.
XDestroyWindow()	Unmaps and destroys window and all subwindows.

Manipulating Windows

Table 27 provides the subroutines for manipulating windows.

Table 27. Manipulating Windows

Subroutine	Description
<code>XCirculateSubwindows()</code>	Circulates a subwindow up or down.
<code>XCirculateSubwindowsUp()</code>	Raises the lowest mapped child of the window.
<code>XCirculateSubwindowsDown()</code>	Lowers the highest mapped child of the window.
<code>XIconifyWindow()</code>	Sends a <code>WM_CHANGE_STATE</code> ClientMessage to the root window of the specified screen.
<code>XLowerWindow()</code>	Lowers the specified window.
<code>XMapRaised()</code>	Maps and raises the specified window.
<code>XMapSubwindows()</code>	Maps all subwindows of the specified window.
<code>XMapWindow()</code>	Maps the specified window.
<code>XMoveResizeWindow()</code>	Changes the specified window's size and location.
<code>XMoveWindow()</code>	Moves the specified window.
<code>XRaiseWindow()</code>	Raises the specified window.
<code>XReconfigureWMWindow()</code>	Issues a <code>ConfigureWindow</code> request on the specified top-level window.
<code>XResizeWindow()</code>	Changes the specified window's size.
<code>XRestackWindows()</code>	Restacks a set of windows from top to bottom.
<code>XSetWindowBorderWidth()</code>	Changes the border width of the window.
<code>XUnmapSubwindows()</code>	Unmaps all subwindows of the specified window.
<code>XUnmapWindow()</code>	Unmaps the specified window.
<code>XWithdrawWindow()</code>	Unmaps the specified window and sends a synthetic <code>UnmapNotify</code> event to the root window of the specified screen.

Changing Window Attributes

Table 28 provides the subroutines for changing window attributes.

Table 28. Changing Window Attributes

Subroutine	Description
<code>XChangeWindowAttributes()</code>	Changes one or more window attributes.
<code>XSetWindowBackground()</code>	Sets the window's background to a specified pixel.
<code>XSetWindowBackgroundPixmap()</code>	Sets the window's background to a specified pixmap.
<code>XSetWindowBorder()</code>	Changes the window's border to a specified pixel.

X Window System Interface

Table 28. Changing Window Attributes (continued)

Subroutine	Description
XSetWindowBorderPixmap()	Changes the window's border tile.
XTranslateCoordinates()	Transforms coordinates between windows.

Obtaining Window Information

Table 29 provides the subroutines for obtaining window information.

Table 29. Obtaining Window Information

Subroutine	Description
XGetGeometry()	Gets the current geometry of the specified drawable.
XGetWindowAttributes()	Gets the current attributes for the specified window.
XQueryPointer()	Gets the pointer coordinates and the root window.
XQueryTree()	Obtains the IDs of the children and parent windows.

Obtaining Properties and Atoms

Table 30 provides the subroutines for obtaining properties and atoms.

Table 30. Properties and Atoms

Subroutine	Description
XGetAtomName()	Gets a name for the specified atom ID.
XInternAtom()	Gets an atom for the specified name.

Manipulating Window Properties

Table 31 provides the subroutines for manipulating the properties of windows.

Table 31. Manipulating Window Properties

Subroutine	Description
XChangeProperty()	Changes the property for the specified window.
XDeleteProperty()	Deletes a property for the specified window.
XGetWindowProperty()	Gets the atom type and property format for the window.
XListProperties()	Gets the specified window's property list.
XRotateWindowProperties()	Rotates the properties in a property array.

Setting Window Selections

Table 32 provides the subroutines for setting window selections.

Table 32. Setting Window Selections

Subroutine	Description
XConvertSelection()	Converts a selection.

Table 32. Setting Window Selections (continued)

Subroutine	Description
XGetSelectionOwner()	Gets the selection owner.
XSetSelectionOwner()	Sets the selection owner.

Manipulating Colormaps

Table 33 provides the subroutines for manipulating color maps.

Table 33. Manipulating Colormaps

Subroutine	Description
XAllocStandardColormap()	Allocates an XStandardColormap structure.
XCopyColormapAndFree()	Creates a new colormap from a specified colormap.
XCreateColormap()	Creates a colormap.
XFreeColormap()	Frees the specified colormap.
XQueryColor()	Queries the RGB value for a specified pixel.
XQueryColors()	Queries the RGB values for an array of pixels.
XSetWindowColormap()	Sets the colormap of the specified window.

Manipulating Color Cells

Table 34 provides the subroutines for manipulating color cells.

Table 34. Manipulating Color Cells

Subroutine	Description
XAllocColor()	Allocates a read-only color cell.
XAllocColorCells()	Allocates read/write color cells.
XAllocColorPlanes()	Allocates read/write color resources.
XAllocNamedColor()	Allocates a read-only color cell by name.
XFreeColors()	Frees colormap cells.
XLookupColor()	Looks up a colorname.
XStoreColor()	Stores an RGB value into a single colormap cell.
XStoreColors()	Stores RGB values into colormap cells.
XStoreNamedColor()	Sets a pixel color to the named color.

Creating and Freeing Pixmaps

Table 35 provides the subroutines for creating and freeing pixmaps.

Table 35. Creating and Freeing Pixmaps

Subroutine	Description
XCreatePixmap()	Creates a pixmap of a specified size.
XFreePixmap()	Frees all storage associated with specified pixmap.

Manipulating Graphics Contexts

Table 36 provides the subroutines for manipulating graphics contexts.

Table 36. Manipulating Graphics Contexts

Subroutine	Description
XChangeGC()	Changes the components in the specified Graphics Context (GC).
XCopyGC()	Copies the components from a source GC to a destination GC.
XCreateGC()	Creates a new GC.
XFreeGC()	Frees the specified GC.
XGetGCValues()	Returns the GC values in the specified structure.
XGContextFromGC()	Obtains the GContext resource ID for GC.
XQueryBestTile()	Gets the best fill tile shape.
XQueryBestSize()	Gets the best size tile, stipple, or cursor.
XQueryBestStipple()	Gets the best stipple shape.
XSetArcMode()	Sets the arc mode of the specified GC.
XSetBackground()	Sets the background of the specified GC.
XSetClipmask()	Sets the clip_mask of the specified GC to a specified pixmap.
XSetClipOrigin()	Sets the clip origin of the specified GC.
XSetClipRectangles()	Sets the clip_mask of GC to a list of rectangles.
XSetDashes()	Sets the dashed line style components of a specified GC.
XSetFillRule()	Sets the fill rule of the specified GC.
XSetFillStyle()	Sets the fill style of the specified GC.
XSetFont()	Sets the current font of the specified GC.
XSetForeground()	Sets the foreground of the specified GC.
XSetFunction()	Sets display function in the specified GC.
XSetGraphicsExposures()	Sets the graphics-exposure flag of the specified GC.
XSetLineAttributes()	Sets the line-drawing components of the GC.
XSetPlaneMask()	Sets the plane mask of the specified GC.
XSetState()	Sets the foreground, background, plane mask, and function in GC.
XSetStipple()	Sets the stipple of the specified GC.
XSetSubwindowMode()	Sets the subwindow mode of the specified GC.
XSetTile()	Sets the fill tile of the specified GC.
XSetTSTOrigin()	Sets the tile or stipple origin of the specified GC.

Clearing and Copying Areas

Table 37 provides the subroutines for clearing and copying areas.

Table 37. *Clearing and Copying Areas*

Subroutine	Description
XClearArea()	Clears a rectangular area of window.
XClearWindow()	Clears the entire window.
XCopyArea()	Copies the drawable area between drawables of the same root and the same depth.
XCopyPlane()	Copies single bit-plane of the drawable.

Drawing Lines

Table 38 provides the subroutines for drawing lines.

Table 38. *Drawing Lines*

Subroutine	Description
XDraw()	Draws an arbitrary polygon or curve that is defined by the specified list of Vertices as specified in <i>vlist</i> .
XDrawArc()	Draws a single arc in the drawable.
XDrawArcs()	Draws multiple arcs in a specified drawable.
XDrawFilled()	Draws arbitrary polygons or curves and then fills them.
XDrawLine()	Draws a single line between two points in a drawable.
XDrawLines()	Draws multiple lines in the specified drawable.
XDrawPoint()	Draws a single point in the specified drawable.
XDrawPoints()	Draws multiple points in the specified drawable.
XDrawRectangle()	Draws an outline of a single rectangle in the drawable.
XDrawRectangles()	Draws an outline of multiple rectangles in the drawable.
XDrawSegments()	Draws multiple line segments in the specified drawable.

Filling Areas

Table 39 provides the subroutines for filling areas.

Table 39. *Filling Areas*

Subroutine	Description
XFillArc()	Fills a single arc in drawable.
XFillArcs()	Fills multiple arcs in drawable.
XFillPolygon()	Fills a polygon area in the drawable.

X Window System Interface

Table 39. Filling Areas (continued)

Subroutine	Description
XFillRectangle()	Fills a single rectangular area in the drawable.
XFillRectangles()	Fills multiple rectangular areas in the drawable.

Loading and Freeing Fonts

Table 40 provides the subroutines for loading and freeing fonts.

Table 40. Loading and Freeing Fonts

Subroutine	Description
XFreeFont()	Unloads the font and frees the storage used by the font.
XFreeFontInfo()	Frees the font information array.
XFreeFontNames()	Frees a font name array.
XFreeFontPath()	Frees data returned by XGetFontPath.
XGetFontPath()	Gets the current font search path.
XGetFontProperty()	Gets the specified font property.
XListFontsWithInfo()	Gets names and information about loaded fonts.
XLoadFont()	Loads a font.
XLoadQueryFont()	Loads and queries font in one operation.
XListFonts()	Gets a list of available font names.
XQueryFont()	Gets information about a loaded font.
XSetFontPath()	Sets the font search path.
XUnloadFont()	Unloads the specified font.

Querying Character String Sizes

Table 41 provides the subroutines for querying the character size of a string.

Table 41. Querying Character String Sizes

Subroutine	Description
XFreeStringList()	Frees the in-memory data associated with the specified string list.
XQueryTextExtents()	Gets a 1-byte character string bounding box from the server.
XQueryTextExtents16()	Gets a 2-byte character string bounding box from the server.
XTextExtents()	Gets a bounding box of a 1-byte character string.
XTextExtents16()	Gets a bounding box of a 2-byte character string.
XTextPropertyToStringList()	Returns a list of strings representing the elements of the specified XTextProperty structure.

Table 41. Querying Character String Sizes (continued)

Subroutine	Description
XTextWidth()	Gets the width of an 8-bit character string.
XTextWidth16()	Gets the width of a 2-byte character string.

Drawing Text

Table 42 provides the subroutines for drawing text.

Table 42. Drawing Text

Subroutine	Description
XDrawImageString()	Draws 8-bit image text in the specified drawable.
XDrawImageString16()	Draws 2-byte image text in the specified drawable.
XDrawString()	Draws 8-bit text in the specified drawable.
XDrawString16()	Draws 2-byte text in the specified drawable.
XDrawText()	Draws 8-bit complex text in the specified drawable.
XDrawText16()	Draws 2-byte complex text in the specified drawable.

Transferring Images

Table 43 provides the subroutines for transferring images.

Table 43. Transferring Images

Subroutine	Description
XGetImage()	Gets the image from the rectangle in the drawable.
XGetSubImage()	Copies the rectangle on the display to image.
XPutImage()	Puts the image from memory into the rectangle in the drawable.

Manipulating Cursors

Table 44 provides the subroutines for manipulating cursors.

Table 44. Manipulating Cursors

Subroutine	Description
XCreateFontCursor()	Creates a cursor from a standard font.
XCreateGlyphCursor()	Creates a cursor from font glyphs.
XDefineCursor()	Defines a cursor for a window.
XFreeCursor()	Frees a cursor.
XQueryBestCursor()	Gets useful cursor sizes.
XRecolorCursor()	Changes the color of a cursor.
XUndefineCursor()	Undefines a cursor for a window.

Handling Window Manager Functions

Table 45 provides the subroutines for handling the window manager functions.

Table 45. Handling Window Manager Functions

Subroutine	Description
XAddToSaveSet()	Adds a window to the client's save-set.
XAllowEvents()	Allows events to be processed after a device is frozen.
XChangeActivePointerGrab()	Changes the active pointer grab.
XChangePointerControl()	Changes the interactive feel of the pointer device.
XChangeSaveSet()	Adds or removes a window from the client's save-set.
XGetInputFocus()	Gets the current input focus.
XGetPointerControl()	Gets the current pointer parameters.
XGrabButton()	Grabs a mouse button.
XGrabKey()	Grabs a single key of the keyboard.
XGrabKeyboard()	Grabs the keyboard.
XGrabPointer()	Grabs the pointer.
XGrabServer()	Grabs the server.
XInstallColormap()	Installs a colormap.
XKillClient()	Removes a client.
XListInstalledColormaps()	Gets a list of currently installed colormaps.
XRemoveFromSaveSet()	Removes a window from the client's save-set.
XReparentWindow()	Changes the parent of a window.
XSetCloseDownMode()	Changes the close down mode.
XSetInputFocus()	Sets the input focus.
XUngrabButton()	Ungrabs a mouse button.
XUngrabKey()	Ungrabs a key.
XUngrabKeyboard()	Ungrabs the keyboard.
XUngrabPointer()	Ungrabs the pointer.
XUngrabServer()	Ungrabs the server.
XUninstallColormap()	Uninstalls a colormap.
XWarpPointer()	Moves the pointer to arbitrary point on the screen.

Manipulating Keyboard Settings

Table 46 provides the subroutines for manipulating keyboard settings.

Table 46. Manipulating Keyboard Settings

Subroutine	Description
XAutoRepeatOff()	Turns off the keyboard auto-repeat.
XAutoRepeatOn()	Turns on the keyboard auto-repeat.
XBell()	Sets the volume of the bell.

Table 46. Manipulating Keyboard Settings (continued)

Subroutine	Description
XChangeKeyboardControl()	Changes the keyboard settings.
XChangeKeyboardMapping()	Changes the mapping of symbols to keycodes.
XDeleteModifiermapEntry()	Deletes an entry from the XModifierKeymap structure.
XFreeModifiermap()	Frees XModifierKeymap structure.
XGetKeyboardControl()	Gets the current keyboard settings.
XGetKeyboardMapping()	Gets the mapping of symbols to keycodes.
XGetModifierMapping()	Gets keycodes to be modifiers.
XGetPointerMapping()	Gets the mapping of buttons on the pointer.
XInsertModifiermapEntry()	Adds an entry to the XModifierKeymap structure.
XNewModifiermap()	Creates the XModifierKeymap structure.
XQueryKeymap()	Gets the state of the keyboard keys.
XSetPointerMapping()	Sets the mapping of buttons on the pointer.
XSetModifierMapping()	Sets keycodes to be modifiers.

Controlling the Screen Saver

Table 47 provides the subroutines for controlling the screen saver.

Table 47. Controlling the Screen Saver

Subroutine	Description
XActivateScreenSaver()	Activates the screen saver.
XForceScreenSaver()	Turns the screen saver on or off.
XGetScreenSaver()	Gets the current screen saver settings.
XResetScreenSaver()	Resets the screen saver.
XSetScreenSaver()	Sets the screen saver.

Manipulating Hosts and Access Control

Table 48 provides the subroutines for manipulating hosts and toggling the access control.

Table 48. Manipulating Hosts and Access Control

Subroutine	Description
XDisableAccessControl()	Disables access control.
XEnableAccessControl()	Enables access control.
XListHosts()	Gets the list of hosts.
XSetAccessControl()	Changes access control.

Handling Events

Table 49 provides the subroutines for handling events.

Table 49. Handling Events

Subroutine	Description
XCheckIfEvent()	Checks event queue for the specified event without blocking.
XCheckMaskEvent()	Removes the next event that matches a specified mask without blocking.
XCheckTypedEvent()	Gets the next event that matches event type.
XCheckTypedWindowEvent()	Gets the next event for the specified window.
XCheckWindowEvent()	Removes the next event that matches the specified window and mask without blocking.
XEventsQueued()	Checks the number of events in the event queue.
XFlush()	Flushes the output buffer.
XGetMotionEvents()	Gets the motion history for the specified window.
XIfEvent()	Checks the event queue for the specified event and removes it.
XMaskEvent()	Removes the next event that matches a specified mask.
XNextEvent()	Gets the next event and removes it from the queue.
XPeekEvent()	Peeks at the event queue.
XPeekIfEvent()	Checks the event queue for the specified event.
XPending()	Returns the number of events that are pending.
XPutBackEvent()	Pushes the event back to the top of the event queue.
XSelectInput()	Selects events to be reported to the client.
XSendEvent()	Sends an event to a specified window.
XSync()	Flushes the output buffer and waits until all requests are completed.
XWindowEvent()	Removes the next event that matches the specified window and mask.

Enabling and Disabling Synchronization

Table 50 provides the subroutines for toggling synchronization.

Table 50. Enabling and Disabling Synchronization

Subroutine	Description
XSetAfterFunction()	Sets the previous after function.
XSynchronize()	Enables or disables synchronization.

Using Default Error Handling

Table 51 provides the subroutines for using the default error handling.

Table 51. Using Default Error Handling

Subroutine	Description
XDisplayName()	Gets the name of the display currently being used.
XGetErrorText()	Gets the error text for the specified error code.
XGetErrorDatabaseText()	Gets the error text from the error database.
XSetErrorHandler()	Sets the error handler.
XSetIOErrorHandler()	Sets the error handler for unrecoverable I/O errors.

Communicating with Window Managers

Table 52 provides the subroutines for communicating with window managers.

Table 52. Communicating with Window Managers

Subroutine	Description
XAllocClassHints()	Allocates storage for an XClassHint structure.
XAllocIconSize()	Allocates storage for an XIconSize structure.
XAllocSizeHints()	Allocates storage for an XSizeHints structure.
XAllocWMHints()	Allocates storage for an XWMHints structure.
XGetClassHint()	Gets the class of a window.
XFetchName()	Gets the name of a window.
XGetCommand()	Gets a window's WM_COMMAND property.
XGetIconName()	Gets the name of an icon window.
XGetIconSizes()	Gets the values of icon size atom.
XGetNormalHints()	Gets size hints for window in normal state.
XGetRGBColormaps()	Gets colormap associated with specified atom.
XGetSizeHints()	Gets the values of type WM_SIZE_HINTS properties.
XGetStandardColormap()	Gets colormap associated with specified atom.
XGetTextProperty()	Gets a window's property of type TEXT.
XGetTransientForHint()	Gets WM_TRANSIENT_FOR property for window.
XGetWMClientMachine()	Gets the value of a window's WM_CLIENT_MACHINE property.
XGetWMColormapWindows()	Gets the value of a window's WM_COLORMAP_WINDOWS property.
XGetWMHints()	Gets the value of the window manager's hints atom.
XGetWMName()	Gets the value of the WM_NAME property.
XGetWMIconName()	Gets the value of the WM_ICON_NAME property.

X Window System Interface

Table 52. Communicating with Window Managers (continued)

Subroutine	Description
XGetWMNormalHints()	Gets the value of the window manager's hints atom.
XGetWMProtocols()	Gets the value of a window's WM_PROTOCOLS property.
XGetWMSizeHints()	Gets the values of type WM_SIZE_HINTS properties.
XGetZoomHints()	Gets values of the zoom hints atom.
XSetCommand()	Sets the value of the command atom.
XSetClassHint()	Sets the class of a window.
XSetIconName()	Assigns a name to an icon window.
XSetIconSizes()	Sets the values of icon size atom.
XSetNormalHints()	Sets size hints for a window in normal state.
XSetRGBColormaps()	Sets the colormap associated with the specified atom.
XSetSizeHints()	Sets the values of the type WM_SIZE_HINTS properties.
XSetStandardColormap()	Sets the colormap associated with the specified atom.
XSetStandardProperties()	Specifies a minimum set of properties.
XSetTextProperty()	Sets a window's properties of type TEXT.
XSetTransientForHint()	Sets WM_TRANSIENT_FOR property for window.
XSetWMClientMachine()	Sets a window's WM_CLIENT_MACHINE property.
XSetWMColormapWindows()	Sets a window's WM_COLORMAP_WINDOWS property.
XSetWMHints()	Sets the value of the window manager's hints atom.
XSetWMIconName()	Sets the value of the WM_ICON_NAME property.
XSetWMName()	Sets the value of the WM_NAME property.
XSetWMNormalHints()	Sets the value of the window manager's hints atom.
XSetWMProperties()	Sets the values of properties for a window manager.
XSetWMProtocols()	Sets the value of the WM_PROTOCOLS property.
XSetWMSizeHints()	Sets the values of type WM_SIZE_HINTS properties.
XSetZoomHints()	Sets the values of the zoom hints atom.
XStoreName()	Assigns a name to a window.

Manipulating Keyboard Event Functions

Table 53 on page 259 provides the subroutines for manipulating the functions of keyboard events.

Table 53. Keyboard Event Functions

Subroutine	Description
XKeyCodeToKeysym()	Converts a keycode to a keysym value.
XKeysymToKeyCode()	Converts a keysym value to keycode.
XKeysymToString()	Converts a keysym value to keysym name.
XLookupKeysym()	Translates a keyboard event into a keysym value.
XLookupMapping()	Gets the mapping of a keyboard event from a keymap file.
XLookupString()	Translates the keyboard event into a character string.
XRebindCode()	Changes the keyboard mapping in the keymap file.
XRebindKeysym()	Maps the character string to a specified keysym and modifiers.
XRefreshKeyboardMapping()	Refreshes the stored modifier and keymap information.
XStringToKeysym()	Converts the keysym name to the keysym value.
XUseKeymap()	Changes the keymap files.
XGeometry()	Parses window geometry given padding and font values.
XGetDefault()	Gets the default window options.
XParseColor()	Obtains RGB values from color name.
XParseGeometry()	Parses standard window geometry options.
XWMGeometry()	Obtains a window's geometry information.

Manipulating Regions

Table 54 provides the subroutines for manipulating regions.

Table 54. Manipulating Regions

Subroutine	Description
XClipBox()	Generates the smallest enclosing rectangle in the region.
XCreateRegion()	Creates a new empty region.
XEmptyRegion()	Determines whether a specified region is empty.
XEqualRegion()	Determines whether two regions are the same.
XIntersectRegion()	Computes the intersection of two regions.
XDestroyRegion()	Frees storage associated with the specified region.
XOffsetRegion()	Moves the specified region by the specified amount.
XPointInRegion()	Determines if a point lies in the specified region.
XPolygonRegion()	Generates a region from points.

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Table 54. Manipulating Regions (continued)

Subroutine	Description
XRectInRegion()	Determines if a rectangle lies in the specified region.
XSetRegion()	Sets the GC to the specified region.
XShrinkRegion()	Reduces the specified region by a specified amount.
XSubtractRegion()	Subtracts two regions.
XUnionRegion()	Computes the union of two regions.
XUnionRectWithRegion()	Creates a union of source region and rectangle.
XXorRegion()	Gets the difference between the union and intersection of regions.

Using Cut and Paste Buffers

Table 55 provides the subroutines for using cut and paste buffers.

Table 55. Using Cut and Paste Buffers

Subroutine	Description
XFetchBuffer()	Gets data from a specified cut buffer.
XFetchBytes()	Gets data from the first cut buffer.
XRotateBuffers()	Rotates the cut buffers.
XStoreBuffer()	Stores data in a specified cut buffer.
XStoreBytes()	Stores data in first cut buffer.

Querying Visual Types

Table 56 provides the subroutines for querying visual types.

Table 56. Querying Visual Types

Subroutine	Description
XGetVisualInfo()	Gets a list of visual information structures.
XListDepths()	Determines the number of depths that are available on a given screen.
XListPixmapFormats()	Gets the pixmap format information for a given display.
XMatchVisualInfo()	Gets visual information matching screen depth and class.
XPixmapFormatValues()	Gets the pixmap format information for a given display.

Manipulating Images

Table 57 provides the subroutines for manipulating images.

Table 57. Manipulating Images

Subroutine	Description
XAddPixel()	Increases each pixel in a pixmap by a constant value.
XCreateImage()	Allocates memory for the XImage structure.
XDestroyImage()	Frees memory for the XImage structure.
XGetPixel()	Gets a pixel value in an image.
XPutPixel()	Sets a pixel value in an image.
XSubImage()	Creates an image that is a subsection of a specified image.

Manipulating Bitmaps

Table 58 provides the subroutines for manipulating bitmaps.

Table 58. Manipulating Bitmaps

Subroutine	Description
XCreateBitmapFromData()	Includes a bitmap in the C program.
XCreatePixmapFromBitmapData()	Creates a pixmap using bitmap data.
XDeleteContext()	Deletes data associated with the window and context type.
XFindContext()	Gets data associated with the window and context type.
XReadBitmapFile()	Reads in a bitmap from a file.
XSaveContext()	Stores data associated with the window and context type.
XUniqueContext()	Allocates a new context.
XWriteBitmapFile()	Writes out a bitmap to a file.

Using the Resource Manager

Table 59 provides the subroutines for using the resource manager.

Table 59. Using the Resource Manager

Subroutine	Description
Xpermalloc()	Allocates memory that is never freed.
XrmDestroyDatabase()	Destroys a resource database and frees its allocated memory.
XrmGetFileDatabase()	Creates a database from a specified file.
XrmGetResource()	Retrieves a resource from a database.
XrmGetStringDatabase()	Creates a database from a specified string.
XrmInitialize()	Initializes the resource manager.
XrmMergeDatabases()	Merges two databases.
XrmParseCommand()	Stores command options in a database.
XrmPutFileDatabase()	Copies the database into a specified file.

X Window System Interface

Table 59. Using the Resource Manager (continued)

Subroutine	Description
XrmPutLineResource()	Stores a single resource entry in a database.
XrmPutResource()	Stores a resource in a database.
XrmPutStringResource()	Stores string resource in a database.
XrmQGetResource()	Retrieves a quark from a database.
XrmQGetSearchList()	Gets a resource search list of database levels.
XrmQGetSearchResource()	Gets a quark search list of database levels.
XrmQPutResource()	Stores binding and quarks in a database.
XrmQPutStringResource()	Stores string binding and quarks in a database.
XrmQuarkToString()	Converts a quark to a character string.
XrmStringToQuark()	Converts a character string to a quark.
XrmStringToQuarkList()	Converts character strings to a quark list.
XrmStringToBindingQuarkList()	Converts strings to bindings and quarks.
XrmUniqueQuark()	Allocates a new quark.

Manipulating Display Functions

Table 60 provides the subroutines for manipulating the display functions.

Table 60. Display Functions

Subroutine	Description
AllPlanes() XAllPlanes()	Returns all bits suitable for use in plane argument.
BitMapBitOrder() XBitMapOrder()	Returns either the most or least significant bit in each bitmap unit.
BitMapPad() XBitMapPad()	Returns the multiple of bits padding each scanline.
BitMapUnit() XBitMapUnit()	Returns the size of a bitmap's unit in bits.
BlackPixel() XBlackPixel()	Returns the black pixel value of the screen specified.
BlackPixelOfScreen() XBlackPixelOfScreen()	Returns the black pixel value of the screen specified.
CellsOfScreen() XCellsOfScreen()	Returns the number of colormap cells.
ConnectionNumber() XConnectionNumber()	Returns the file descriptor of the connection.
CreatePixmapCursor() XCreatePixmapCursor()	Creates a pixmap of a specified size.
CreateWindow() XCreateWindow()	Creates an unmapped subwindow for a specified parent window.
DefaultColormap() XDefaultColormap()	Returns a default colormap ID for allocation on the screen specified.
DefaultColormapOfScreen() XDefaultColormapOfScreen	Returns the default colormap ID of the screen specified.
DefaultDepth() XDefaultDepth()	Returns the depth of the default root window.

Table 60. Display Functions (continued)

Subroutine	Description
DefaultDepthOfScreen() XDefaultDepthOfScreen()	Returns the default depth of the screen specified.
DefaultGC() XDefaultGC()	Returns the default GC of the default root window.
DefaultGCOfScreen() XDefaultGCOfScreen()	Returns the default GC of the screen specified.
DefaultScreen() XDefaultScreen()	Obtains the default screen referenced in the XOpenDisplay routine.
DefaultScreenofDisplay() XDefaultScreenofDisplay()	Returns the default screen of the display specified.
DefaultRootWindow() XDefaultRootWindow()	Obtains the root window for the default screen specified.
DefaultVisual() XDefaultVisual()	Returns the default visual type of the screen specified.
DefaultVisualOfScreen() XDefaultVisualOfScreen()	Returns the default visual type of the screen specified.
DisplayCells() XDisplayCells()	Displays the number of entries in the default colormap.
DisplayHeight() XDisplayHeight()	Displays the height of the screen in pixels.
DisplayHeightMM() XDisplayHeightMM()	Displays the height of the screen in millimeters.
DisplayOfScreen() XDisplayOfScreen()	Displays the type of screen specified.
DisplayPlanes() XDisplayPlanes()	Displays the depth (number of planes) of the root window of the screen specified.
DisplayString() XDisplayString()	Displays the string passed to XOpenDisplay when the current display was opened.
DisplayWidth() XDisplayWidth()	Displays the width of the specified screen in pixels.
DisplayWidthMM() XDisplayWidthMM()	Displays the width of the specified screen in millimeters.
DoesBackingStore() XDoesBackingStore()	Indicates whether the specified screen supports backing stores.
DoesSaveUnders() XDoesSaveUnders()	Indicates whether the specified screen supports save unders.
EventMaskOfScreen() XEventMaskOfScreen()	Returns the initial root event mask for a specified screen.
HeightMMOfScreen() XHeightMMOfScreen()	Returns the height of a specified screen in millimeters.
HeightOfScreen() XHeightOfScreen()	Returns the height of a specified screen in pixels.
ImageByteOrder() XImageByteOrder()	Specifies the required byte order for each scanline unit of an image.
IsCursorKey()	Returns TRUE if keysym is on cursor key.
IsFunctionKey()	Returns TRUE if keysym is on function keys.
IsKeypadKey()	Returns TRUE if keysym is on keypad.

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Table 60. Display Functions (continued)

Subroutine	Description
IsMiscFunctionKey()	Returns TRUE if keysym is on miscellaneous function keys.
IsModifierKey()	Returns TRUE if keysym is on modifier keys.
IsPFKey()	Returns TRUE if keysym is on PF keys.
LastKnownRequestProcessed() XLastKnownRequestProcessed()	Extracts the full serial number of the last known request processed by the X server.
MaxCmapsOfScreen() XMaxCmapsOfScreen()	Returns the maximum number of colormaps supported by the specified screen.
MinCmapsOfScreen() XMinCmapsOfScreen()	Returns the minimum number of colormaps supported by the specified screen.
NextRequest() XNextRequest()	Extracts the full serial number to be used for the next request to be processed by the X Server.
PlanesOfScreen() XPlanesOfScreen()	Returns the depth (number of planes) in a specified screen.
ProtocolRevision() XProtocolRevision()	Returns the minor protocol revision number (zero) of the X server associated with the display.
ProtocolVersion() XProtocolVersion()	Returns the major version number (11) of the protocol associated with the display.
QLength() XQLength()	Returns the length of the event queue for the display.
RootWindow() XRootWindow()	Returns the root window of the current screen.
RootWindowOfScreen() XRootWindowOfScreen()	Returns the root window of the specified screen.
ScreenCount() XScreenCount()	Returns the number of screens available.
XScreenNumberOfScreen()	Returns the screen index number of the specified screen.
ScreenOfDisplay() XScreenOfDisplay()	Returns the pointer to the screen of the display specified.
ServerVendor() XServerVendor()	Returns the pointer to a null-determined string that identifies the owner of the X server implementation.
VendorRelease() XVendorRelease()	Returns the number related to the vendor's release of the X server.
WhitePixel() XWhitePixel()	Returns the white pixel value for the current screen.
WhitePixelOfScreen() XWhitePixelOfScreen()	Returns the white pixel value of the specified screen.
WidthMMOfScreen() XWidthMMOfScreen()	Returns the width of the specified screen in millimeters.
WidthOfScreen() XWidthOfScreen()	Returns the width of the specified screen in pixels.

Extension Routines

Table 61 lists the X Window System Extension Subroutines.

Table 61. Extension Routines

Subroutine	Description
XAllocID()	Returns a resource ID that can be used when creating new resources.
XESetCloseDisplay()	Defines a procedure to call when XCloseDisplay is called.
XESetCopyGC()	Defines a procedure to call when a GC is copied.
XESetCreateFont()	Defines a procedure to call when XLoadQueryFont is called.
XESetCreateGC()	Defines a procedure to call when a new GC is created.
XESetError()	Suppresses the call to an external error handling routine and defines an alternative routine for error handling.
XESetErrorString()	Defines a procedure to call when an I/O error is detected.
XESetEventToWire()	Defines a procedure to call when an event must be converted from the host to wire format.
XESetFreeFont()	Defines a procedure to call when XFreeFont is called.
XESetFreeGC()	Defines a procedure to call when a GC is freed.
XESetWireToEvent()	Defines a procedure to call when an event is converted from the wire to the host format.
XFreeExtensionList()	Frees memory allocated by XListExtensions.
XListExtensions()	Returns a list of all extensions supported by the server.
XQueryExtension()	Indicates whether named extension is present.

MIT Extensions to X

Table 62 lists the routines that allow an application to use these extensions:

Table 62. MIT Extensions to X

Subroutine	Description
XShapeQueryExtension	Queries to see if the server supports the SHAPE extension.
XShapeQueryVersion	Checks the version number of the server SHAPE extension.
XShapeCombineRegion	Converts the specified region into a list of rectangles and calls XShapeRectangles.
XShapeCombineRectangles	Performs a CombineRectangles operation.

X Window System Interface

Table 62. MIT Extensions to X (continued)

Subroutine	Description
XShapeCombineMask	Performs a CombineMask operation.
XShapeCombineShape	Performs a CombineShape operation.
XShapeOffsetShape	Performs an OffsetShape operation.
XShapeQueryExtents	Sets the extents of the bounding and clip shapes.
XShapeSelectInput	Selects Input Events.
XShapeInputSelected	Returns the current input mask for extension events on the specified window.
XShapeGetRectangles	Gets a list of rectangles describing the region specified.
XMITMiscQueryExtension	Queries to see if the server supports the MITMISC extension.
XMITMiscSetBugMode	Sets the compatibility mode switch.
XMITMiscGetBugMode	Queries the compatibility mode switch.
XmbufQueryExtension	Queries to see if the server supports the MULTIBUF extension.
XmbufGetVersion	Gets the version number of the extension.
XmbufCreateBuffers	Requests that multiple buffers be created.
XmbufDestroyBuffers	Requests that the buffers be destroyed.
XmbufDisplayBuffers	Displays the indicated buffers.
XmbufGetWindowAttributes	Gets the multibuffering attributes.
XmbufChangeWindowAttributes	Sets the multibuffering attributes.
XmbufGetBufferAttributes	Gets the attributes for the indicated buffer.
XmbufChangeBufferAttributes	Sets the attributes for the indicated buffer.
XmbufGetScreenInfo	Gets the parameters controlling how mono and stereo windows may be created on the indicated screen.
XmbufCreateStereoWindow	Creates a stereo window.

Associate Table Functions

Table 63 lists the Associate Table functions.

Table 63. Associate Table Functions

Subroutine	Description
XCreateAssocTable()	Returns a pointer to the newly created associate table.
XDeleteAssoc()	Deletes an entry from the specified associate table.
XDestroyAssocTable()	Frees memory allocated to the specified associate table.
XLookUpAssoc()	Obtains data from the specified associate table.
XMakeAssoc()	Creates an entry in the specified associate table.

Miscellaneous Utility Routines

Table 64 lists the Miscellaneous Utility routines.

Table 64. Miscellaneous Utility Routines

Subroutine	Description
XctCreate()	Creates an XctData structure for parsing a Compound Text string.
XctFree()	Frees all data associated with the XctData structure.
XctNextItem()	Parses the next <i>item</i> from the Compound Text string.
XctReset()	Resets the XctData structure to reparse the Compound Text string.
XmuAddCloseDisplayHook()	Adds a callback for the given display.
XmuAddInitializer()	Registers a procedure, to be invoked the first time XmuCallInitializers is called on a given application context.
XmuAllStandardColormaps()	Creates all of the appropriate standard colormaps.
XmuCallInitializers()	Calls each of the procedures that have been registered with XmuAddInitializer.
XmuClientWindow()	Finds a window, at or below the specified window.
XmuCompareISOLatin1()	Compares two strings, ignoring case differences.
XmuConvertStandardSelection()	Converts many standard selections.
XmuCopyISOLatin1Lowered()	Copies a string, changing all Latin-1 uppercase letters to lowercase.
XmuCopyISOLatin1Uppered()	Copies a string, changing all Latin-1 lowercase letters to uppercase.
XmuCreateColormap()	Creates a colormap.
XmuCreatePixmapFromBitmap()	Creates a pixmap of the specified width, height, and depth.
XmuCreateStippledPixmap()	Creates a two pixel by one pixel stippled pixmap of specified depth on the specified screen.
XmuCursorNameToIndex()	Returns the index in the standard cursor font for the name of a standard cursor.
XmuCvtFunctionToCallback()	Converts a callback procedure to a callback list containing that procedure.
XmuCvtStringToBackingStore()	Converts a string to a backing-store integer.
XmuCvtStringToBitmap()	Creates a bitmap suitable for window manager icons.
XmuCvtStringToCursor()	Converts a string to a Cursor.
XmuCvtStringToJustify()	Converts a string to an XtJustify enumeration value.
XmuCvtStringToLong()	Converts a string to an integer of type long.

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Table 64. Miscellaneous Utility Routines (continued)

Subroutine	Description
XmuCvtStringToOrientation()	Converts a string to an XtOrientation enumeration value.
XmuCvtStringToShapeStyle()	Converts a string to an integer shape style.
XmuCvtStringToWidget()	Converts a string to an immediate child widget of the parent widget passed as an argument.
XmuDeleteStandardColormap()	Removes the specified property from the specified screen.
XmuDQAddDisplay()	Adds the specified display to the queue.
XmuDQCreate()	Creates and returns an empty XmuDisplayQueue.
XmuDQDestroy()	Releases all memory associated with the specified queue.
XmuDQLookupDisplay()	Returns the queue entry for the specified display.
XmuDQNDisplays()	Returns the number of displays in the specified queue.
XmuDQRemoveDisplay()	Removes the specified display from the specified queue.
XmuDrawLogo()	Draws the <i>official</i> X Window System logo.
XmuDrawRoundedRectangle()	Draws a rounded rectangle.
XmuFillRoundedRectangle()	Draws a filled rounded rectangle.
XmuGetAtomName()	Returns the name of an Atom.
XmuGetColormapAllocation()	Determines the best allocation of reds, greens, and blues in a standard colormap.
XmuGetHostname()	Returns the host name.
XmuInternAtom()	Caches the Atom value for one or more displays.
XmuInternStrings()	Converts a list of atom names into Atom values.
XmuLocateBitmapFile()	Reads a file in standard bitmap file format.
XmuLookupAPL()	Maps a key event to an APL string. This function is similar to XLookupString.
XmuLookupArabic()	Maps a key event to a Latin/Arabic (ISO 8859-6) string. This function is similar to XLookupString.
XmuLookupCloseDisplayHook()	Determines if a callback is installed.
XmuLookupCyrillic()	Maps a key event to a Latin/Cyrillic (ISO 8859-5) string. This function is similar to XLookupString, except that it maps a
XmuLookupGreek()	Maps a key event to a Latin/Greek (ISO 8859-7) string. This function is similar to XLookupString.
XmuLookupHebrew()	Maps a key event to a Latin/Hebrew (ISO 8859-8) string. This function is similar to XLookupString.

Table 64. Miscellaneous Utility Routines (continued)

Subroutine	Description
XmuLookupJISX0201()	Maps a key event to a string in the JIS X0201-1976 encoding. This function is similar to XLookupString.
XmuLookupKana()	Maps a key event to a string in the JIS X0201-1976 encoding. This function is similar to XLookupString.
XmuLookupLatin1()	This function is identical to XLookupString.
XmuLookupLatin2()	Maps a key event to a Latin-2 (ISO 8859-2) string. This function is similar to XLookupString.
XmuLookupLatin3()	Maps a key event to a Latin-3 (ISO 8859-3) string. This function is similar to XLookupString.
XmuLookupLatin4()	Maps a key event to a Latin-4 (ISO 8859-4) string. This function is similar to XLookupString.
XmuLookupStandardColormap()	Creates or replaces a standard colormap if one does not currently exist.
XmuLookupString()	Maps a key event into a specific key symbol set.
XmuMakeAtom()	Creates and initializes an opaque object.
XmuNameOfAtom()	Returns the name of an AtomPtr.
XmuPrintDefaultErrorMessage()	Prints an error message, equivalent to Xlib's default error message.
XmuReadBitmapData()	Reads a standard bitmap file description.
XmuReadBitmapDataFromFile()	Reads a standard bitmap file description from the specified file.
XmuReleaseStippledPixmap()	Frees a pixmap created with XmuCreateStippledPixmap.
XmuRemoveCloseDisplayHook()	Deletes a callback that has been added with XmuAddCloseDisplayHook.
XmuReshapeWidget()	Reshapes the specified widget, using the Shape extension.
XmuScreenOfWindow()	Returns the screen on which the specified window was created.
XmuSimpleErrorHandler()	A simple error handler for Xlib error conditions.
XmuStandardColormap()	Creates a standard colormap for the given screen.
XmuUpdateMapHints()	Clears the PPosition and PSize flags and sets the USPosition and USSize flags.
XmuVisualStandardColormaps()	Creates all of the appropriate standard colormaps for a given visual.

X Authorization Routines

Table 65 lists the X Authorization routines.

Table 65. Authorization Data Routines

Subroutine	Description
XauFileName()	Generates the default authorization file name.
XauReadAuth()	Reads the next entry from the authfile.
XuWriteAuth()	Writes an authorization entry to the authfile.
XauGetAuthByAddr()	Searches for an authorization entry.
XauLockAuth()	Does the work necessary to synchronously update an authorization file.
XauUnlockAuth()	Undoes the work of XauLockAuth.
XauDisposeAuth()	Frees storage allocated to hold an authorization entry.

X Intrinsic Routines

Table 66 provides the X Intrinsic Routines.

Table 66. X Intrinsic Routines

Routine	Description
CompositeClassPartInitialize	Initializes the CompositeClassPart of a Composite Widget.
CompositeDeleteChild	Deletes a child widget from a Composite Widget.
CompositeDestroy	Destroys a composite widget.
CompositeInitialize	Initializes a Composite Widget structure.
CompositeInsertChild	Inserts a child widget in a Composite Widget.
RemoveCallback	Removes a callback procedure from a callback list.
XrmCompileResourceList	Compiles an XtResourceList into an XrmResourceList.
XtAddActions	Declares an action table and registers it with the translation manager
XtAddCallback	Adds a callback procedure to the callback list of the specified widget.
XtAddCallbacks	Adds a list of callback procedures to the callback list of specified widget.
XtAddConverter	Adds a new converter.
XtAddEventHandler	Registers an event handler procedure with the dispatch mechanism when an event matching the mask occurs on the specified widget.
XtAddExposureToRegion	Computes the union of the rectangle defined by the specified exposure event and region.
XtAddGrab	Redirects user input to a model widget.

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtAddInput	Registers a new source of events.
XtAddRawEventHandler	Registers an event handler procedure with the dispatch mechanism without causing the server to select for that event.
XtAddTimeout	Creates a timeout value in the default application context and returns an identifier for it.
XtAddWorkProc	Registers a work procedure in the default application context.
XtAppAddActionHook	Adds an actionhook procedure to an application context.
XtAppAddActions	Declares an action table and registers it with the translation manager.
XtAppAddConverter	Registers a new converter.
XtAppAddInput	Registers a new file as an input source for a specified application.
XtAppAddTimeout	Creates a timeout value and returns an identifier for it.
XtAppAddWorkProc	Registers a work procedure for a specified procedure.
XtAppCreateShell	Creates a top-level widget that is the root of a widget tree.
XtAppError	Calls the installed fatal error procedure.
XtAppErrorMsg	Calls the high-level error handler.
XtAppGetErrorDatabase	Obtains the error database and merges it with an application or widget-specified database.
XtAppGetErrorDatabaseText	Obtains the error database text for an error or warning for an error message handler.
XtAppGetSelectionTimeout	Gets and returns the current selection timeout (ms) value.
XtAppInitialize	A convenience routine for initializing the toolkit.
XtAppMainLoop	Processes input by calling XtAppNextEvent and XtDispatchEvent.
XtAppNextEvent	Returns the value from the top of a specified application input queue.
XtAppPeekEvent	Returns the value from the top of a specified application input queue without removing input from queue.
XtAppPending	Determines if the input queue has any events for a specified application.
XtAppProcessEvent	Processes applications that require direct control of the processing for different types of input.
XtAppReleaseCacheRefs	Decrements the reference count for the conversion entries identified by the refs argument.

X Window System Interface

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtAppSetErrorHandler	Registers a procedure to call on fatal error conditions. The default error handler prints the message to standard error.
XtAppSetErrorMsgHandler	Registers a procedure to call on fatal error conditions. The default error handler constructs a string from the error resource database.
XtAppSetFallbackResources	Sets the fallback resource list that will be loaded at display initialization time.
XtAppSetSelectionTimeout	Sets the Intrinsic selection time-out value.
XtAppSetTypeConverter	Registers the specified type converter and destructor in all application contexts created by the calling process.
XtAppSetWarningHandler	Registers a procedure to call on nonfatal error conditions. The default warning handler prints the message to standard error.
XtAppSetWarningMsgHandler	Registers a procedure to call on nonfatal error conditions. The default warning handler constructs a string from error resource database.
XtAppWarning	Calls the installed nonfatal error procedure.
XtAppWarningMsg	Calls the installed high-level warning handler.
XtAugmentTranslations	Merges new translations into an existing widget translation table.
XtBuildEventMask	Retrieves the event mask for a specified widget.
XtCallAcceptFocus	Calls the <code>accept_focus</code> procedure for the specified widget.
XtCallActionProc	Searches for the named action routine and, if found, calls it.
XtCallbackExclusive	Calls customized code for callbacks to create pop-up shell.
XtCallbackNone	Calls customized code for callbacks to create pop-up shell.
XtCallbackNonexclusive	Calls customized code for callbacks to create pop-up shell.
XtCallbackPopdown	Pops down a shell that was mapped by callback functions.
XtCallbackReleaseCacheRef	A callback that can be added to a callback list to release a previously returned XtCacheRef value.
XtCallbackReleaseCacheRefList	A callback that can be added to a callback list to release a list of previously returned XtCacheRef value.
XtCallCallbackList	Calls all callbacks on a callback list.
XtCallCallbacks	Executes the callback procedures in a widget callback list.

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtCallConverter	Looks up the specified type converter in the application context and invokes the conversion routine.
XtCalloc	Allocates and initializes an array.
XtClass	Obtains the class of a widget and returns a pointer to the widget class structure.
XtCloseDisplay	Closes a display and removes it from an application context.
XtConfigureWidget	Moves and resizes the sibling widget of the child making the geometry request.
XtConvert	Invokes resource conversions.
XtConvertAndStore	Looks up the type converter registered to convert from_type to to_type and then calls XtCallConverter.
XtConvertCase	Determines upper and lowercase equivalents for a KeySym.
XtCopyAncestorSensitive	Copies the sensitive value from a widget record.
XtCopyDefaultColormap	Copies the default colormap from a widget record.
XtCopyDefaultDepth	Copies the default depth from a widget record.
XtCopyFromParent	Copies the parent from a widget record.
XtCopyScreen	Copies the screen from a widget record.
XtCreateApplicationContext	Creates an opaque type application context.
XtCreateApplicationShell	Creates an application shell widget by calling XtAppCreateShell.
XtCreateManagedWidget	Creates and manages a child widget in a single procedure.
XtCreatePopupShell	Creates a pop-up shell.
XtCreateWidget	Creates an instance of a widget.
XtCreateWindow	Calls XcreateWindow with the widget structure and parameter.
XtDatabase	Obtains the resource database for a particular display.
XtDestroyApplicationContext	Destroys an application context.
XtDestroyGC	Deallocates graphics context when it is no longer needed.
XtDestroyWidget	Destroys a widget instance.
XtDirectConvert	Invokes resource conversion.
XtDisownSelection	Informs the Intrinsic selection mechanism that the specified widget is to lose ownership of the selection.
XtDispatchEvent	Receives X events and calls appropriate event handlers.

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Table 66. X Intrinsic Routines (continued)

Routine	Description
XtDisplay	Returns the display pointer for the specified widget.
XtDisplayInitialize	Initializes a display and adds it to an application context.
XtDisplayOfObject	Returns the display pointer for the specified widget.
XtDisplayStringConversionWarning	Issues a warning message for conversion routines.
XtDisplayToApplicationContext	Retrieves the application context associated with a Display.
XtError	Calls the installed fatal error procedure.
XtErrorMsg	A low-level error and warning handler procedure type.
XtFindFile	Searches for a file using substitutions in a path list.
XtFree	Frees an allocated block of storage.
XtGetActionKeysym	Retrieves the KeySym and modifiers that matched the final event specification in a translation table entry.
XtGetApplicationNameAndClass	Returns the application name and class as passed to XtDisplayInitialize
XtGetApplicationResources	Retrieves resources that are not specific to a widget, but apply to the overall application.
XtGetConstraintResourceList	Returns the constraint resource list for a particular widget.
XtGetErrorDatabase	Obtains the error database and returns the address of the error database.
XtGetErrorDatabaseText	Obtains the error database text for an error or warning.
XtGetGC	Returns a read-only sharable GC.
XtGetKeysymTable	Returns a pointer to the KeySym to KeyCode mapping table for a particular display.
XtGetMultiClickTime	Returns the multi-click time setting.
XtGetResourceList	Obtains the resource list structure for a particular class.
XtGetSelectionRequest	Retrieves the SelectionRequest event which triggered the convert_selection procedure.
XtGetSelectionTimeout	Obtains the current selection timeout.
XtGetSelectionValue	Obtains the selection value in a single, logical unit.
XtGetSelectionValueIncremental	Obtains the selection value using incremental transfers.
XtGetSelectionValues	Takes a list of target types and client data and obtains the current value of the selection converted to each of the targets.

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtGetSelectionValuesIncremental	A function similar to XtGetSelectionValueIncremental except that it takes a list of targets and client_data.
XtGetSubresources	Obtains resources other than widgets.
XtGetSubvalues	Retrieves the current value of a non-widget resource data associated with a widget instance.
XtGetValues	Retrieves the current value of a resource associated with a widget instance.
XtGrabButton	Passively grabs a single pointer button.
XtGrabKey	Passively grabs a single key of the keyboard.
XtGrabKeyboard	Actively grabs the keyboard.
XtGrabPointer	Actively grabs the pointer.
XtHasCallbacks	Finds the status of a specified widget callback list.
XtInitialize	Initializes the toolkit, application, and shell.
XtInitializeWidgetClass	Initializes a widget class without creating any widgets.
XtInsertEventHandler	Registers an event handler procedure that receives events before or after all previously registered event handler.
XtInsertRawEventHandler	Registers an event handler procedure that receives events before or after all previously registered event handler without selecting for the events.
XtInstallAccelerators	Installs accelerators from a source widget to destination widget.
XtInstallAllAccelerators	Installs all the accelerators from a widget and all the descendants of the widget onto one destination widget.
XtIsApplicationShell	Determines whether a specified widget is a subclass of an Application Shell widget.
XtIsComposite	Determines whether a specified widget is a subclass of a Composite widget.
XtIsConstraint	Determines whether a specified widget is a subclass of a Constraint widget.
XtIsManaged	Determines the managed state of a specified child widget.
XtIsObject	Determines whether a specified widget is a subclass of an Object widget.
XtIsOverrideShell	Determines whether a specified widget is a subclass of an Override Shell widget.
XtIsRealized	Determines if a widget has been realized.
XtIsRectObj	Determines whether a specified widget is a subclass of a RectObj widget.
XtIsSensitive	Determines the current sensitivity state of a widget.

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Table 66. X Intrinsic Routines (continued)

Routine	Description
XtIsShell	Determines whether a specified widget is a subclass of a Shell widget.
XtIsSubclass	Determines whether a specified widget is in a specific subclass.
XtIsTopLevelShell	Determines whether a specified widget is a subclass of a TopLevelShell widget.
XtIsTransientShell	Determines whether a specified widget is a subclass of a TransientShell widget.
XtIsVendorShell	Determines whether a specified widget is a subclass of a VendorShell widget.
XtIsWidget	Determines whether a specified widget is a subclass of a Widget widget.
XtIsWMShell	Determines whether a specified widget is a subclass of a WMShell widget.
XtKeysymToKeycodeList	Returns the list of KeyCodes that map to a particular KeySym.
XtLastTimestampProcessed	Retrieves the timestamp from the most recent call to XtDispatchEvent.
XtMainLoop	An infinite loop which processes input.
XtMakeGeometryRequest	A request from the child widget to a parent widget for a geometry change.
XtMakeResizeRequest	Makes a resize request from a widget.
XtMalloc	Allocates storage.
XtManageChild	Adds a single child to a parent widget list of managed children.
XtManageChildren	Adds a list of widgets to the geometry-managed, displayable, subset of its composite parent widget.
XtMapWidget	Maps a widget explicitly.
XtMenuPopupAction	Pops up a menu when a pointer button is pressed or when the pointer is moved into the widget.
XtMergeArgLists	Merges two ArgList structures.
XtMoveWidget	Moves a sibling widget of the child making the geometry request.
XtName	Returns a pointer to the instance name of the specified object.
XtNameToWidget	Translates a widget name to a widget instance.
XtNewString	Copies an instance of a string.
XtNextEvent	Returns the value from the header of the input queue.
XtOpenDisplay	Opens, initializes, and adds a display to an application context.
XtOverrideTranslations	Overwrites existing translations with new translations.

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtOwnSelection	Sets the selection owner when using atomic transfer.
XtOwnSelectionIncremental	Sets the selection owner when using incremental transfers.
XtParent	Returns the parent widget for the specified widget.
XtParseAcceleratorTable	Parses an accelerator table into the opaque internal representation.
XtParseTranslationTable	Compiles a translation table into the opaque internal representation of type XtTranslations.
XtPeekEvent	Returns the value from the front of the input queue without removing it from the queue.
XtPending	Determines if the input queue has events pending.
XtPopdown	Unmaps a pop-up from within an application.
XtPopup	Maps a pop-up from within an application.
XtPopupSpringLoaded	Maps a spring-loaded pop-up from within an application.
XtProcessEvent	Processes one input event, timeout, or alternate input source.
XtQueryGeometry	Queries the preferred geometry of a child widget.
XtRealizeWidget	Realizes a widget instances.
XtRealloc	Changes the size of an allocated block of storage, sometimes moving it.
XtRegisterCaseConverter	Registers a specified case converter.
XtRegisterGrabAction	Registers button and key grabs for a widget's window according to the event bindings in the widget's translation table.
XtReleaseGC	Deallocates a shared GC when it is no longer needed.
XtRemoveActionHook	Removes an action hook procedure without destroying the application context.
XtRemoveAllCallbacks	Deletes all callback procedures from a specified widget callback list.
XtRemoveCallback	Deletes a callback procedure from a specified widget callback list only if both the procedure and the client data match.
XtRemoveCallbacks	Deletes a list of callback procedures from a specified widget callback list.
XtRemoveEventHandler	Removes a previously registered event handler.
XtRemoveGrab	Removes the redirection of user input to a modal widget.

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Table 66. X Intrinsic Routines (continued)

Routine	Description
XtRemoveInput	Discontinues a source of input by causing the Intrinsic read routine to stop watching for input from the input source.
XtRemoveRawEventHandler	Removes previously registered raw event handler.
XtRemoveTimeOut	Clears a timeout value by removing the timeout.
XtRemoveWorkProc	Removes the specified background work procedure.
XtResizeWidget	Resizes a sibling widget of the child making the geometry request.
XtResizeWindow	Resizes a child widget that already has the values for its width, height, and border width.
XtResolvePathname	Searches for a file using standard substitutions in a path list.
XtScreen	Returns the screen pointer for the specified widget.
XtScreenOfObject	Returns the screen pointer for the nearest ancestor of object that is of class Widget.
XtSetErrorHandler	Registers a procedure to call under fatal error conditions.
XtSetErrorMsgHandler	Registers a procedure to call under fatal error conditions.
XtSetKeyboardFocus	Redirects keyboard input to a child of a composite widget without calling XSetInputFocus.
XtSetKeyTranslator	Registers a key translator.
XtSetMappedWhenManaged	Changes the widget map_when_managed field.
XtSetMultiClickTime	Sets the multi-click time for an application.
XtSetSelectionTimeout	Sets the Intrinsic selection timeout.
XtSetSensitive	Sets the sensitivity state of a widget.
XtSetSubvalues	Sets the current value of a non-widget resource associated with an instance.
XtSetTypeConverter	Registers a type converter for all application contexts in a process.
XtSetValues	Modifies the current value of a resource associated with widget instance.
XtSetWarningHandler	Registers a procedure to be called on non-fatal error conditions.
XtSetWarningMsgHandler	Registers a procedure to be called on non-fatal error conditions.
XtSetWMColormapWindows	Sets the value of the WM_COLORMAP_WINDOWS property on a widget's window.

Table 66. X Intrinsic Routines (continued)

Routine	Description
XtStringConversionWarning	A convenience routine for old-format resource converters that convert from strings.
XtSuperclass	Obtains the superclass of a widget by returning a pointer to the superclass structure of the widget.
XtToolkitInitialize	Initializes the X Toolkit internals.
XtTranslateCoords	Translates an [x,y] coordinate pair from widget coordinates to root coordinates.
XtTranslateKey	The default key translator routine.
XtTranslateKeyCode	Registers a key translator.
XtUngrabButton	Cancels a passive button grab.
XtUngrabKey	Cancels a passive key grab.
XtUngrabKeyboard	Cancels an active keyboard grab.
XtUngrabPointer	Cancels an active pointer grab.
XtUninstallTranslations	Causes the entire translation table for widget to be removed.
XtUnmanageChild	Removes a single child from the managed set of its parent.
XtUnmanageChildren	Removes a list of children from the managed list of the parent, but does not destroy the children widgets.
XtUnmapWidget	Unmaps a widget explicitly.
XtUnrealizeWidget	Destroys the associated with a widget and its descendants.
XtVaAppCreateShell	Creates a top-level widget that is the root of a widget tree using varargs lists.
XtVaAppInitialize	Initializes the Xtk internals, creates an application context, opens and initializes a display and creates the initial application shell instance using varargs lists.
XtVaCreateArgsList	Dynamically allocates a varargs list for use with XtVaNestedList in multiple calls.
XtVaCreateManagedWidget	Creates and manages a child widget in a single procedure using varargs lists.
XtVaCreatePopupShell	Creates a pop-up shell using varargs lists.
XtVaCreateWidget	Creates an instance of a widget using varargs lists.
XtVaGetApplicationResources	Retrieves resources for the overall application using varargs list.
XtVaGetSubresources	Fetches resources for widget sub-parts using varargs list.
XtVaGetSubvalues	Retrieves the current values of non-widget resources associated with a widget instance using varargs lists.
XtVaGetValues	Retrieves the current values of resources associated with a widget instance using varargs lists.

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Table 66. X Intrinsic Routines (continued)

Routine	Description
XtVaSetSubvalues	Sets the current values of non-widget resources associated with a widget instance using varargs lists.
XtVaSetValues	Modifies the current values of resources associated with a widget instance using varargs lists.
XtWarning	Calls the installed non-fatal error procedure.
XtWarningMsg	Calls the installed high-level warning handler.
XtWidgetToApplicationContext	Gets the application context for given widget.
XtWindow	Returns the window of the specified widget.
XtWindowOfObject	Returns the window for the nearest ancestor of object that is of class Widget.
XtWindowToWidget	Translates a window and display pointer into a widget instance.

Athena Widget Support

Table 67 provides the Athena widget routines.

Table 67. Athena Widget Routines

Routine	Description
XawAsciiSave	Saves the changes made in the current text source into a file.
XawAsciiSaveAsFile	Saves the contents of the current text buffer into a named file.
XawAsciiSourceChanged	Determines if the text buffer in an AsciiSrc object has changed.
XawAsciiSourceFreeString	Frees the storage associated with the string from an AsciiSrc widget requested with a call to XtGetValues.
XawDialogAddButton	Adds a new button to a Dialog widget.
XawDialogGetValueString	Returns the character string in the text field of a Dialog Widget.
XawDiskSourceCreate	Creates a disk source.
XawFormDoLayout	Forces or defers a re-layout of the form.
XawInitializeWidgetSet	Forces a reference to vendor shell so that the one in this widget is installed.
XawListChange	Changes the list that is displayed.
XawListHighlight	Highlights an item in the list.
XawListShowCurrent	Retrieves the list element that is currently set.
XawListUnhighlight	Unhighlights an item in the list.
XawPanedAllowResize	Enables or disables a child's request for pane resizing.
XawPanedGetMinMax	Retrieves the minimum and maximum height settings for a pane.

Table 67. Athena Widget Routines (continued)

Routine	Description
XawPanedGetNumSub	Retrieves the number of panes in a paned widget.
XawPanedSetMinMax	Sets the minimum and maximum height settings for a pane.
XawPanedSetRefigureMode	Enables or disables automatic recalculation of pane sizes and positions
XawScrollbarSetThumb	Sets the position and length of a Scrollbar thumb.
XawSimpleMenuAddGlobalActions	Registers an XawPositionSimpleMenu global action routine.
XawSimpleMenuClearActiveEntry	Clears the SimpleMenu widget's internal information about the currently highlighted menu entry.
XawSimpleMenuGetActiveEntry	Gets the currently highlighted menu entry.
XawStringSourceCreate	Creates a string source.
XawTextDisableRedisplay	Disables redisplay while making several changes to a Text Widget.
XawTextDisplay	Displays batched updates.
XawTextDisplayCaret	Enables and disables the insert point.
XawTextEnableRedisplay	Enables redisplay.
XawTextGetInsertionPoint	Returns the current position of the insert point.
XawTextGetSelectionPos	Retrieves the text that has been selected by this text widget.
XawTextGetSource	Retrieves the current text source for the specified widget.
XawTextInvalidate	Redisplays a range of characters.
XawTextReplace	Modifies the text in an editable Text widget.
XawTextSearch	Searches for a string in a Text widget.
XawTextSetInsertionPoint	Moves the insert point to the specified source position.
XawTextSetLastPos	Sets the last position data in an AsciiSource Object.
XawTextSetSelection	Selects a piece of text.
XawTextSetSelectionArray	Assigns a new selection array to a text widget.
XawTextSetSource	Replaces the text source in the specified widget.
XawTextSinkClearToBackground	Clears a region of the sink to the background color
XawTextSinkDisplayText	Stub function that in subclasses will display text.
XawTextSinkFindDistance	Finds the Pixel Distance between two text Positions.
XawTextSinkFindPosition	Finds a position in the text.

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Table 67. Athena Widget Routines (continued)

Routine	Description
XawTextSinkGetCursorBounds	Finds the bounding box for the insert cursor.
XawTextSinkInsertCursor	Places the InsertCursor.
XawTextSinkMaxHeight	Finds the Minimum height that will contain a given number of lines.
XawTextSinkMaxLines	Finds the Maximum number of lines that will fit in a given height.
XawTextSinkResolve	Resolves a location to a position.
XawTextSinkSetTabs	Sets the Tab stops.
XawTextSourceConvertSelection	Dummy selection converter.
XawTextSourceRead	Reads the source into a buffer.
XawTextSourceReplace	Replaces a block of text with new text.
XawTextSourceScan	Scans the text source for the number and type of item specified.
XawTextSourceSearch	Searches the text source for the text block passed.
XawTextSourceSetSelection	Allows special setting of the selection.
XawTextTopPosition	Returns the character position of the left-most character on the first line displayed in the widget.
XawTextUnsetSelection	Unhighlights previously highlighted text in a widget.
XawToggleChangeRadioGroup	Allows a toggle widget to change radio groups.
XawToggleGetCurrent	Returns the RadioData associated with the toggle widget that is currently active in a toggle group.
XawToggleSetCurrent	Sets the Toggle widget associated with the radio_data specified.
XawToggleUnsetCurrent	Unsets all Toggles in the radio_group specified.

Extension Routines

X Window System Extension Routines allow you to create extensions to the core Xlib functions with the same performance characteristics. The following are the protocol requests for X Window System extensions:

- XQueryExtension
- XListExtensions
- XFreeExtensionList

For a table that lists these extension routines and provides a description of each extension routine, see Table 61 on page 265.

MIT Extensions to X

The AIX[®] extensions described in the *IBM AIX X-Windows Programmer's Reference* are not supported by the X Window System API provided by the TCP/IP library routines.

The following MIT extensions are supported by TCP/IP for z/VM:

- SHAPE
- MITMISC
- MULTIBUF

See Table 62 on page 265.

Associate Table Functions

When you need to associate arbitrary information with resource IDs, the XAssocTable allows you to associate your own data structures with X resources, such as bitmaps, pixmaps, fonts, and windows.

An XAssocTable can be used to *type* X resources. For example, to create three or four types of windows with different properties, each window ID is associated with a pointer to a user-defined window property data structure. (A generic type, called XID, is defined in XLIB.H.)

Follow these guidelines when using an XAssocTable:

- Ensure the correct display is active before initiating an XAssocTable function, because all XIDs are relative to a specified display.
- Restrict the size of the table (number of buckets in the hashing system) to a power of two, and assign no more than eight XIDs for each bucket to maximize the efficiency of the table.

There is no restriction on the number of XIDs for each table or display, or the number of displays for each table. For a table that lists these associate table functions and provides a description of each function, see Table 63 on page 266.

Miscellaneous Utility Routines

Included in the X11LIB TXTLIB are the MIT X Miscellaneous Utility routines. These routines are a set of common utility functions that have been useful to application writers. For a table that lists these utility routines and provides a description of each utility routine, see Table 64 on page 267.

X Authorization Routines

Included in the X11LIB TXTLIB are the MIT X Authorization routines. These routines are used to deal with X authorization data in X clients. For a table that lists these subroutines and provides a description of each authorization routine, see Table 65 on page 270.

X Window System Toolkit

An X Window System Toolkit is a set of library functions layered on top of the X Window System Xlib functions that allows you to simplify the design of applications by providing an underlying set of common user interface functions. Included are mechanisms for defining and expanding interclient and

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intracomponent interaction independently, masking implementation details from both the application and component implementor.

An X Window System Toolkit consists of the following:

- A set of programming mechanisms, called Intrinsic, used to build widgets.
- An architectural model to help programmers design new widgets, with enough flexibility to accommodate different application interface layers.
- A consistent interface, in the form of a coordinated set of widgets and composition policies, some of which are application domain-specific, while others are common across several application domains.

The fundamental data type of the X Window System Toolkit is the widget. A widget is allocated dynamically and contains state information. Every widget belongs to one widget class that is allocated statically and initialized. The widget class contains the operations allowed on widgets of that class.

An X Window System Toolkit manages the following functions:

- Toolkit initialization
- Widgets and widget geometry
- Memory
- Window, file, and timer events
- Input focus
- Selections
- Resources and resource conversion
- Translation of events
- Graphics contexts
- Pixmap
- Errors and warnings.

In the VM/CMS environment, you must remap many of the X Widget and X Intrinsic routine names. This remapping is done in a file called `XT_REMAP.H`. This file is automatically included by the `INTRINSIC.H` header file. In debugging your application, it may be helpful to reference the `XT_REMAP.H` file to find the remapped names of the X Toolkit routines.

Some of the X Window System header files have been renamed from their original distribution names, because of the file-naming conventions in the VM/CMS environment. Such name changes are generally restricted to those header files used internally by the actual widget code, rather than the application header files, to minimize the number of changes required for an application to be ported to the VM/CMS environment.

In porting applications to the VM/CMS environment, you may have to make file name changes as shown in Table 68.

Table 68. X Intrinsic Header File Names

MIT Distribution Name	TCP/IP Name
<code>CompositeI.h</code>	<code>ComposiI.h</code>
<code>CompositeP.h</code>	<code>ComposiP.h</code>
<code>ConstrainP.h</code>	<code>ConstraP.h</code>
<code>IntrinsicI.h</code>	<code>IntriniI.h</code>
<code>IntrinsicP.h</code>	<code>IntriniP.h</code>
<code>PassivGraI.h</code>	<code>PassivGr.h</code>

Table 68. X Intrinsic Header File Names (continued)

MIT Distribution Name	TCP/IP Name
ProtocolsP.h	ProtocoP.h
SelectionI.h	SelectiI.h
WindowObjP.h	WindowOP.h

Application Resources

X applications can be modified at run time by a set of resources. Applications that make use of an X Window System toolkit can be modified by additional sets of application resources. These resources are searched until a resource specification is found. The X Intrinsics determine the actual search order used for determining a resource value.

The search order used in the CMS environment in descending order of preference is:

1. Command Line

Standard arguments include:

- a. Command switches (-display, -fg, -foreground, +rv, and so forth)
- b. Resource manager directives (-name, -xrm)
- c. Natural language directive (-xnlanguage)

2. User Environment File

Use the first source found from:

- a. The file named by the XENVIRONMENT environment variable, which can be set with the CMS command:

```
GLOBALV SELECT CENV SET XENVIRONMENT filename.filetype
```

- b. XDEFAULT.*host* file

In this case, *host* is the string returned by the gethostname() call.

3. Server and User Preference Resources

Use the first source found from:

- a. RESOURCE_MANAGER property on the root window (screen())
- b. X.DEFAULTS file

4. Application User Resources

Use the first source found from:

- a. The file named by the XUSERFILESEARCHPATH environment variable that can be set with the CMS command:

```
GLOBALV SELECT CENV SET XUSERFILESEARCHPATH filename.filetype
```

- b. The file, which is called XAPDF.*classname.xapplresdir*, if the XAPPLRESDIR environment variable has been set. In this case, XAPDF is the file name; and *classname* is the file type. The environment variable, *xapplresdir*, contains the value of the file mode.

The XAPPLRESDIR environment variable can be set with the CMS command:

```
GLOBALV SELECT CENV SET XAPPLRESDIR filemode
```

The CMS file name XAPDF is modified if a natural language directive is specified to be XAPDF *xnlanguage*, where *xnlanguage* is the string specified by the natural language directive.

5. Application Class Resources

Use the first source found from:

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- a. The file named by the XFILESEARCHPATH environment variable, which can be set with the CMS command:
GLOBALV SELECT CENV SET XFILESEARCHPATH *filename.filetype*
- b. The default application resource file named XAPDF.*classname*, where *classname* is the application-specified class name.
The CMS file name XAPDF is modified if a natural language directive is specified as *xnllanguage*XAPDF, where *xnllanguage* is the string specified by the natural language directive.
- c. Fallback resources defined by XtAppSetFallbackResources within the application.

Athena Widget Set

The X Window System Support with TCP/IP includes the widget set developed at MIT, which is generally known as the Athena widget set.

The Athena widget set supports the following widgets:

AsciiSink	Paned
AsciiSrc	Scrollbar
AsciiText	Simple
Box	SimpleMenu
Clock	Sme (Simple Menu Entry)
Command	SmeBSB (BSB Menu Entry)
Dialog	Smeline
Form	StripChart
Grip	Text
Label	TextSink
List	TextSrc
Logo	Toggle
Mailbox	VPaned
MenuButton	Viewport

For a complete list of the widgets supported by the Athena widget set, see “Athena Widget Support” on page 280.

Some of the header files have been renamed from their original distribution names, because of the file-naming conventions in the VM/CMS environment. In addition, some of the header file names were changed to eliminate duplicate file names with the OSF/Motif-based Widget support. If your application uses these header files, it will have to be modified to use the new header file name, see Table 69.

Table 69. Athena Header File Names

MIT Distribution Name	TCP/IP Name
AsciiSinkP.h	AscSinkP.h
AsciiSrcP.h	AscSrcP.h
AsciiTextP.h	AscTextP.h

Table 69. Athena Header File Names (continued)

MIT Distribution Name	TCP/IP Name
Command.h	ACommand.h
CommandP.h	ACommanP.h
Form.h	AForm.h
FormP.h	AFormP.h
Label.h	ALabel.h
LabelP.h	ALabelP.h
List.h	AList.h
ListP.h	AListP.h
MenuButtoP.h	MenuButP.h
Scrollbar.h	AScrollb.h
ScrollbarP.h	AScrollP.h
SimpleMenP.h	SimpleMP.h
StripCharP.h	StripChP.h
TemplateP.h	TemplatP.h
Text.h	AText.h
TextSinkP.h	TextSinP.h
TextP.h	ATextP.h
TextSrcP.h	ATextSrP.h
ViewportP.h	ViewporP.h

OSF/Motif-Based Widget Support

The X Window System support with TCP/IP includes the OSF/Motif-based widget set (Release 1.1).

The OSF/Motif-based Widget set supports the following gadgets and widgets:

ArrowButton	MenuShell
ArrowGadget	MessageBox
ArrowButtonGadget	PanedWindow
BulletinBoard	PushButton
CascadeButton	PushButtonGadget
CascadeButtonGadget	RowColumn
Command	Sash
DialogShell	Scale
DrawingArea	ScrollBar
DrawnButton	ScrolledWindow
FileSelectionBox	SelectionBox
FileSelectionDialog	SelectionDialog
Form	Separator
Frame	SeparatorGadget

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Label	Text
LabelGadget	ToggleButton
List	ToggleButtonGadget
MainWindow	

Some of the header files have been renamed from their original distribution names, because of the file-naming conventions in the CMS environment. Such name changes are generally restricted to those header files used internally by the actual widget code, rather than the application header files, to minimize the number of changes required for an application to be ported to the VM/CMS environment.

In porting applications to the CMS environment, you may have to make header file name changes as shown in Table 68 on page 284. In porting applications to the CMS environment, the header file name changes shown in Table 70 may have to be made.

Table 70. OSF/Motif Header File Names

OSF/Motif Distribution Name	TCP/IP Name
BulletinBP.h	BulletBP.h
CascadeBG.h	CascadBG.h
CascadeBGP.h	CascaBGP.h
CascadeBP.h	CascadBP.h
CutPasteP.h	CutPastP.h
MenuShellP.h	MenuSheP.h
MessageBP.h	MessageBP.h
RowColumnP.h	RowColuP.h
ScrollBarP.h	ScrollBP.h
ScrolledWP.h	ScrollWP.h
SelectioB.h	SelectiB.h
SelectioBP.h	SelectBP.h
SeparatoG.h	SeparatG.h
SeparatoGP.h	SeparatGP.h
SeparatorP.h	SeparatP.h
ToggleBGP.h	ToggleBGP.h
ToggleBP.h	ToggleBP.h

Sample X Window System Applications

This section contains the following sample programs:

- A simple program that uses Xlib calls (see “Xlib Sample Program” on page 289)
- A simple program that uses the Athena widget set (see “Athena Widget Sample Program” on page 290)
- A simple program that uses the OSF/Motif-based widget set (see “OSF/Motif-Based Widget Sample Program” on page 291).

Xlib Sample Program

The following is an X Window System program that uses basic Xlib functions to create a window, map the window to the screen, wait 60 seconds, destroy the window, and end.

```

/*
 * This is an X window program using X11 API,
 * that opens the display and creates a window, waits
 * 60 seconds, then destroys the window before ending.
 */
#include <Xlib.h>
#include <types.h>
#include <stdio.h>

main(argc, argv)
int argc;
char *argv[];
{
    Display *dp;
    Window w;
/*
 * X will lookup the value of the DISPLAY global variable in
 * the ENV group when passed a NULL pointer in XOpenDisplay.
 */

    dp = XOpenDisplay(NULL);

/*
 * Create a 200X200 window at xy(40,40) with black border and name.
 */

    w = XCreateSimpleWindow(dp, RootWindow(dp, 0),
        40, 40, 200, 200, 2, BlackPixel(dp, 0),
        WhitePixel(dp, 0));
    XStoreName(dp, w, "VM/CMS X Sample");
    XSetIconName(dp, w, "X Sample");

/*
 * Map the window to the display.
 * This will cause the window to become visible on the screen.
 */

    XMapWindow(dp, w);

/*
 * Force X to write buffered requests.
 */

    XFlush(dp);

    fprintf(stderr, "Going to sleep now.... 60 seconds...\n");
    system("CP SLEEP 60 SEC");
    fprintf(stderr, "Okay, back!\n");

/*
 * Destroy the window and end the connection to the X Server.
 */

    XDestroyWindow(dp, w);
    XCloseDisplay(dp);
}

```

Athena Widget Sample Program

The following is a simple X Window System program that uses the Athena Label widget to create a window with the string *Hello, World* centered in the middle of a window.

```
/*
 * This an example of how "Hello, World" could be written using
 * The X Toolkit and the Athena widget set.
 *
 * November 14, 1989 - Chris D. Peterson
 */

/*
 * $XConsortium: xhw.c,v 1.7 89/12/11 15:31:33 kit Exp $
 *
 * Copyright 1989 Massachusetts Institute of Technology
 *
 * Permission to use, copy, modify, distribute, and sell this
 * software and its documentation for any purpose is hereby
 * granted without fee, provided that the above copyright notice
 * appear in all copies and that both that copyright notice and
 * this permission notice appear in supporting documentation, and
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 * OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING
 * FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION
 * OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT
 * OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.
 */

#include <stdio.h>
#include <X11/Intrinsic.h> /* Include standard Toolkit Header file.
                          We do not need "StringDefs.h" */
#ifdef IBMCPP
#include <X11/Xaw/ALabel.h> /* Include the Label widget's header file. */
#else
#include <X11/Xaw/Label.h> /* Include the Label widget's header file. */
#endif
#include <X11/Xaw/Cardinals.h> /* Definition of ZERO. */

/*
 * These resources will be loaded only if there is no app-defaults
 * file for this application. Since this is such a simple application
 * I am just loading the resources here. For more complex applications
 * It is best to install an app-defaults file.
 */

String fallback_resources[] = { "*Label.Label: Hello, World", NULL };

main(argc, argv)
int argc;
char **argv;
{
    XtAppContext app_con;
    Widget toplevel;

    /*
```

Athena Widget Sample Program

```
    * Initialize the Toolkit, set the fallback resources, and get
    * the application context associated with this application.
    */

    toplevel = XtAppInitialize(&app_con, "Xhw", NULL, ZERO, &argc, argv,
                              fallback_resources, NULL, ZERO);

    /*
    * Create a Widget to display the string. The label is picked up
    * from the resource database.
    */

    (void) XtCreateManagedWidget("label", labelWidgetClass, toplevel,
                                  NULL, ZERO);

    /*
    * Create the windows, and set their attributes according
    * to the Widget data.
    */

    XtRealizeWidget(toplevel);
    /*
    * Now process the events.
    */

    XtAppMainLoop(app_con);
}
```

OSF/Motif-Based Widget Sample Program

The following is a simple X Window System program that uses the OSF/Motif-based PushButton widget to pop up a window with the string *Press here* in it. It exits when you press the button.

```
#include <stdio.h>
#include <X11/Intrinsic.h>
#include <Xm/Shell.h>
#include <Xm/PushB.h>
static void CloseApp();
Widget      Shell;
Widget      Button;
void main(argc, argv)
int  argc;
char *argv[];
{
    Arg      args[10];
    int      n;
    XmString xst;
    Display  *display;
    XtAppContext app_context;

    XtToolkitInitialize();
    app_context = XtCreateApplicationContext();
    display = XtOpenDisplay(app_context, NULL, argv[0], "Xsamp3",
                           NULL, 0, &argc, argv);

    if (display == NULL) {
        fprintf(stderr, "%s: Can't open display\n", argv[0]);
        exit(1);
    }

    n = 0;
    XtSetArg(args[n], XmNwidth, 100); n++;
    XtSetArg(args[n], XmNheight, 75); n++;
    XtSetArg(args[n], XmNallowShellResize, True); n++;
    Shell = XtAppCreateShell(argv[0], NULL, applicationShellWidgetClass,
                             display, args, n);
}
```

OSF/Motif-Based Widget Sample Program

```
XtRealizeWidget(Shell);
n = 0;
Button = XmCreatePushButton(Shell, "Press here", args, n);
XtManageChild(Button);
XtAddCallback (Button, XmNactivateCallback, CloseApp, NULL);

XtAppMainLoop(app_context);
}

/*****
/*                               CloseApp()                               */
*****/
static
void CloseApp(w, client_data, call_data)
Widget w;
caddr_t client_data;
caddr_t call_data;
{
    exit(0);
}
```

Chapter 7. SNMP Agent Distributed Programming Interface

The Simple Network Management Protocol (SNMP) agent distributed programming interface (DPI) permits end users to dynamically add, delete, or replace management variables in the local Management Information Base (MIB) without requiring you to recompile the SNMP agent.

SNMP Agents and Subagents

SNMP defines an architecture that consists of network management stations (SNMP clients), network elements (hosts and gateways), and network management agents and subagents. The network management agents perform information management functions, such as gathering and maintaining network performance information and formatting and passing this data to clients when requested. This information is collectively called the Management Information Base (MIB). For more information about clients, agents, and the MIB, see the *z/VM: TCP/IP User's Guide*.

A subagent provides an extension to the functionality provided by the SNMP agent. The subagent allows you to define your own MIB variables, which are useful in your environment, and register them with the SNMP agent. When requests for these variables are received by the SNMP agent, the agent passes the request to the subagent. The subagent then returns a response to the agent. The SNMP agent creates an SNMP response packet and sends the response to the remote network management station that initiated the request. The existence of the subagent is transparent to the network management station.

To allow the subagents to perform these functions, the SNMP agent binds to an arbitrarily chosen TCP port and listens for connection requests. A well-known port is not used. Every invocation of the SNMP agent potentially results in a different TCP port being used.

A subagent of the SNMP agent determines the port number by sending a GET request for the MIB variable, which represents the value of the TCP port. The subagent is not required to create and parse SNMP packets, because the DPI C language application program interface (API) has a library routine `query_DPI_port()`. This routine handles the GET request and response called Protocol Data Units (PDUs) necessary to obtain the port number of the TCP port used by the agent for DPI requests. After the subagent obtains the value of the DPI TCP port, it should make a TCP connection to the appropriate port. After a successful `connect()`, the subagent registers the set of variables it supports with the SNMP agent. When all variable classes are registered, the subagent waits for requests from the SNMP agent.

Processing DPI Requests

The SNMP agent can initiate three DPI requests: GET, SET, and GET-NEXT. These requests correspond to the three SNMP requests that a network management station can make. The subagent responds to a request with a response packet. The response packet can be created using the `mkDPIresponse()` library routine, which is part of the DPI API library.

SNMP Agent Distributed Program Interface

The SNMP subagent can initiate only two requests: REGISTER and TRAP. For an overview of the SNMP DPI, see Figure 39.

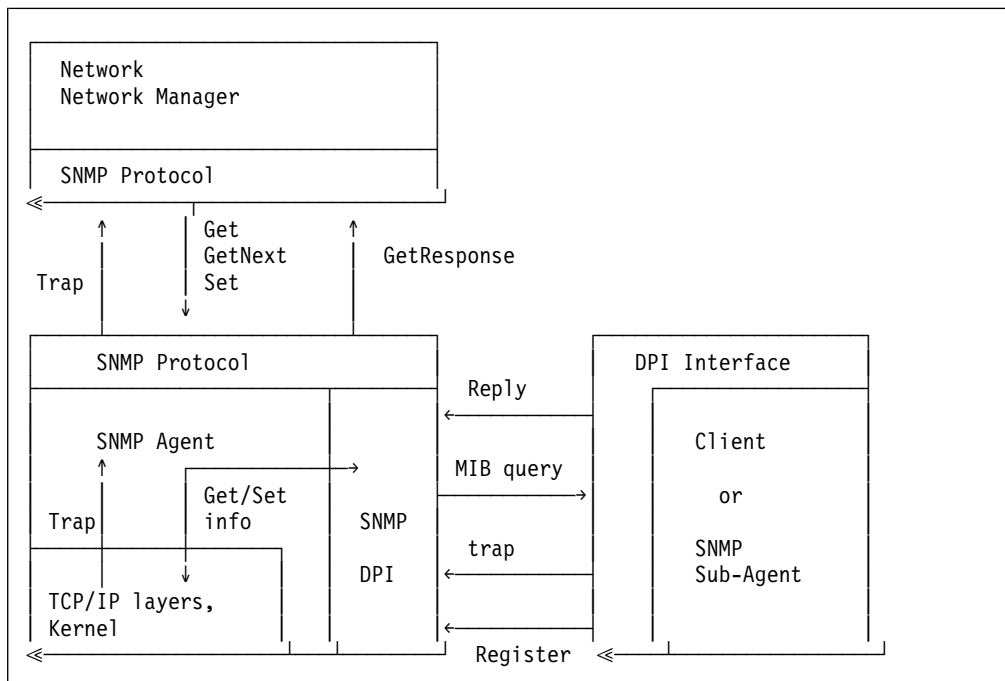


Figure 39. SNMP DPI overview

Note:

1. The SNMP agent communicates with the SNMP manager by the standard SNMP protocol.
2. The SNMP agent communicates with the TCP/IP layers and kernel (operating system) in an implementation-dependent manner. It implements the standard MIB II view.
3. An SNMP Subagent, running as a separate process (potentially even on another machine), can register objects with the SNMP agent.
4. The SNMP agent decodes SNMP Packets. If such a packet contains a Get, GetNext or Set request for an object registered by a subagent, it sends the request to the subagent by a query packet.
5. The SNMP subagent sends responses back by a reply packet.
6. The SNMP agent then encodes the reply into an SNMP packet and sends it back to the requesting SNMP manager.
7. If the subagent wants to report an important state change, it sends a trap packet to the SNMP agent, which encodes it into an SNMP trap packet and sends it to the manager(s).

Processing a GET Request

The DPI packet is parsed, using the `pDPIpacket()` routine, to get the object ID of the requested variable. If the specified object ID of the requested variable is not supported by the subagent, the subagent returns an error indication of `SNMP_NO_SUCH_NAME`. Name, type, or value information is not returned. For example:

```
unsigned char *cp;

cp = mkDPIresponse(SNMP_NO_SUCH_NAME,0);
```

If the object ID of the variable is supported, an error is not returned and the name, type, and value of the object ID are returned using the `mkDPISet()` and `mkDPISetResponse()` routines. The following is an example of an object ID, whose type is string, being returned.

```
char *obj_id;

unsigned char *cp;
struct dpi_set_packet *ret_value;
char *data;

/* obj_id = object ID of variable, like 1.3.6.1.2.1.1.1 */
/* should be identical to object ID sent in GET request */
data = a string to be returned;
ret_value = mkDPISet(obj_id,SNMP_TYPE_STRING,
                    strlen(data)+1,data);
cp = mkDPISetResponse(0,ret_value);
```

Processing a SET Request

Processing a SET request is similar to processing a GET request, but you must pass additional information to the subagent. This additional information consists of the type, length, and value to be set.

If the object ID of the variable is not supported, the subagent returns an error indication of `SNMP_NO_SUCH_NAME`. If the object ID of the variable is supported, but cannot be set, an error indication of `SNMP_READ_ONLY` is returned. If the object ID of the variable is supported, and is successfully set, the message `SNMP_NO_ERROR` is returned.

Processing a GET_NEXT Request

Parsing a GET_NEXT request yields two operands: the object ID of the requested variable and the reason for this request. This allows the subagent to return the name, type, and value of the next supported variable, whose name lexicographically follows that of the passed object ID.

Subagents can support several different groups of the MIB tree. However, the subagent cannot jump from one group to another. You must first determine the reason for the request to then determine the path to traverse in the MIB tree. The second operand contains this reason and is the group prefix of the MIB tree that is supported by the subagent.

If the object ID of the next variable supported by the subagent does not match this group prefix, the subagent must return `SNMP_NO_SUCH_NAME`. If required, the SNMP agent will call on the subagent again and pass a different group prefix.

For example, if you have two subagents, the first subagent registers two group prefixes, A and C, and supports variables A.1, A.2, and C.1. The second subagent registers the group prefix B, and supports variable B.1.

When a remote management station begins dumping the MIB, starting from A, the following sequence of queries is performed.

Subagent 1 is called:

```
get_next(A,A) == A.1
get_next(A.1,A) == A.2
get_next(A.2,A) == error(no such name)
```

Subagent 2 is then called:

SNMP Agent Distributed Program Interface

```
get_next(A.2,B) == B.1  
get_next(B.1,B) == error(no such name)
```

Subagent 1 is then called:

```
get_next(B.1,C) == C.1  
get_next(C.1,C) == error(no such name)
```

Processing a REGISTER Request

A subagent must register the variables that it supports with the SNMP agent. Packets can be created using the `mkDPIregister()` routine.

For example:

```
unsigned char *cp;  
  
cp = mkDPIregister('1.3.6.1.2.1.1.2.');
```

Note: Object IDs are registered with a trailing dot (“.”). Although DPI 1.0 level did accept an Object ID without a trailing dot, the new level (DPI 1.1) does not.

Processing a TRAP Request

A subagent can request that the SNMP agent generate a TRAP for it. The subagent must provide the desired values for the generic and specific operands of the TRAP. The subagent can optionally provide a name, type, and value operand. The DPI API library routine `mkDPItrap()` can be used to generate the TRAP packet.

Compiling and Linking

To compile your program, you must include the `SNMP_DPI.H` header file.

To compile and link your applications, use the following procedures:

1. To set up the C environment, enter the following commands:

```
SET LDRTBLS nn  
GLOBAL LOADLIB SCEERUN  
GLOBAL TXTLIB SCEELKED
```
2. To compile your program, enter one of the following commands:
 - Place compile options on the `CC` command:

```
CC filename (def(VM))
```
 - Place `#define VM` in the first line of all user's C source files:

```
CC filename
```
3. To generate an executable module, enter the following command:

```
TCPLOAD load_list control_file c (TXTLIB DPILIB)
```

Note:

1. Make sure you have access to the IBM C for VM/ESA Compiler and to the TCPMAINT 592 minidisk.
2. For the syntax of the `TCPLOAD EXEC`, see Appendix A, “`TCPLOAD EXEC`,” on page 403 and for the syntax of the `SET LDRTBLS` command, see the *z/VM: CMS Commands and Utilities Reference*.

SNMP DPI Reference

The following table provides a reference for SNMP DPI. Table 71 describes each SNMP DPI routine supported by TCP/IP, and identifies the page in the book where you can find more information.

Table 71. SNMP DPI Reference

SNMP DPI Routine	Description	Location
DPIdebug()	Used to turn some DPI internal tracing on or off.	"DPIdebug()"
fDPIparse()	Frees a parse tree previously created by a call to pDPIpacket().	"fDPIparse()"
mkDPIlist()	Creates the portion of the parse tree that represents a list of name and value pairs.	"mkDPIlist()" on page 298
mkDPIregister()	Creates a register request packet and returns a pointer to a static buffer.	"mkDPIregister()" on page 299
mkDPIresponse()	Creates a response packet.	"mkDPIresponse()" on page 299
mkDPIset()	Creates a representation of a parse tree name and value pair.	"mkDPIset()" on page 300
mkDPItrap()	Creates a trap request packet.	"mkDPItrap()" on page 301
mkDPItrape()	Creates an extended trap. Basically the same as the mkDPItrap() routine but allows you to pass a list of variables and an enterprise object ID.	"mkDPItrape()" on page 302
pDPIpacket()	Parses a DPI packet and returns a parse tree representation.	"pDPIpacket()" on page 303
query_DPI_port()	Determines what TCP port is associated with DPI.	"query_DPI_port()" on page 305

DPI Library Routines

This section provides the syntax, operands, and other appropriate information for each DPI routine supported by TCP/IP for z/VM.

DPIdebug()

```
#include <snmp_dpi.h>
#include <types.h>

void DPIdebug(onoff)
int *onoff;
```

Operand

Description

onoff Specifies an integer. A value of 0 turns tracing off and a value of 1 (or nonzero) turns tracing on.

Description: The DPIdebug() routine can be used to turn DPI internal tracing on or off.

fDPIparse()

fDPIparse()

```
#include <snmp_dpi.h>
#include <types.h>

void fDPIparse(hdr)
struct snmp_dpi_hdr *hdr;
```

Operand

	Description
<i>hdr</i>	Specifies a parse tree.

Description: The fDPIparse() routine frees a parse tree that was previously created by a call to pDPIpacket(). After calling fDPIparse(), no further references to the parse tree can be made.

mkDPIlist()

```
#include <snmp_dpi.h>
#include <types.h>

struct dpi_set_packet *mkDPIlist(packet, oid_name, type, len, value)
struct dpi_set_packet *packet;
char *oid_name;
int type;
int len;
char *value;
```

Operand

	Description
packet	Specifies a pointer to a structure dpi_set_packet.
oid_name	Specifies the object identifier of the variable.
type	Specifies the type of the value.
len	Specifies the length of the value.
value	Specifies a pointer to the value.

Description: The mkDPIlist() routine can be used to create the portion of the parse tree that represents a list of name and value pairs. Each entry in the list represents a name and value pair (as would normally be returned in a response packet). If the pointer *packet* is NULL, then a new dpi_set_packet structure is dynamically allocated and the pointer to that structure is returned. The structure contains the new name and value pair. If the pointer *packet* is not NULL, then a new dpi_set_packet structure is dynamically allocated and chained to the list. The new structure contains the new name and value pair. The pointer *packet* is returned to the caller. If an error is detected, a NULL pointer is returned.

The value of *type* can be the same as for mkDPIset(). These values are defined in the *snmp_dpi.h* header file.

As a result, the structure dpi_set_packet has changed and now has a next pointer (zero in case of a mkDPIset() call and also zero upon the first mkDPIlist() call). The following is the format of dpi_set_packet:

```

struct dpi_set_packet {
    char            *object_id;
    unsigned char   type;
    unsigned short  value_len;
    char            *value;
    struct dpi_set_packet *next;
};

```

A subagent writer would normally look only at the `dpi_set_packet` structure when receiving a `SNMP_DPI_SET` request and after having issued a `pDPIpacket()` call.

mkDPIregister()

```

#include <snmp_dpi.h>
#include <types.h>

unsigned char *mkDPIregister(oid_name)
char *oid_name;

```

Operand Description

oid_name

Specifies the object identifier of the variable to be registered. Object identifiers are registered with a trailing dot (".").

Description: The `mkDPIregister()` routine creates a register request packet and returns a pointer to a static buffer, which holds the packet contents. The length of the remaining packet is stored in the first two bytes of the packet.

Return Values: If successful, returns a pointer to a static buffer containing the packet contents. A NULL pointer is returned if an error is detected during the creation of the packet.

Example: The following is an example of the `mkDPIregister()` routine.

```

unsigned char *packet;
int len;

/* register sysDescr variable */
packet = mkDPIregister("1.3.6.1.2.1.1.1.");

len = *packet * 256 + *(packet + 1);
len += 2; /* include length bytes */

```

mkDPIresponse()

```

#include <snmp_dpi.h>
#include <types.h>

unsigned char *mkDPIresponse(ret_code, value_list)
int ret_code;
struct dpi_set_packet *value_list;

```

Operand Description

ret_code

Determines the error code to be returned.

mkDPIresponse()

value_list

Points to a parse tree containing the name, type, and value information to be returned.

Description: The `mkDPIresponse()` routine creates a response packet. The first operand, *ret_code*, is the error code to be returned. Zero indicates no error. Possible errors include the following:

- `SNMP_NO_ERROR`
- `SNMP_TOO_BIG`
- `SNMP_NO_SUCH_NAME`
- `SNMP_BAD_VALUE`
- `SNMP_READ_ONLY`
- `SNMP_GEN_ERR`

See the `SNMP_DPI.H` header file for a description of these messages.

If *ret_code* does not indicate an error, then the second operand is a pointer to a parse tree created by `mkDPIset()`, which represents the name, type, and value information being returned. If an error is indicated, the second operand is passed as a `NULL` pointer.

The length of the remaining packet is stored in the first two bytes of the packet.

Note: `mkDPIresponse()` always frees the passed parse tree.

Return Values: If successful, `mkDPIresponse()` returns a pointer to a static buffer containing the packet contents. This is the same buffer used by `mkDPIregister()`. A `NULL` pointer is returned if an error is detected during the creation of the packet.

Example: The following is an example of the `mkDPIresponse()` routine.

```
unsigned char *packet;

int error_code;
struct dpi_set_packet *ret_value;

packet = mkDPIresponse(error_code, ret_value);

len = *packet * 256 + *(packet + 1);
len += 2; /* include length bytes */
```

mkDPIset()

```
#include <snmp_dpi.h>
#include <types.h>

struct dpi_set_packet *mkDPIset(oid_name, type, len, value)
char *oid_name;
int type;
int len;
char *value;
```

Operand

Description

oid_name

Specifies the object identifier of the variable.

type

Specifies the type of the object identifier.

len

Indicates the length of the value.

value

Points to the first byte of the value of the object identifier.

Description: The mkDPIset() routine can be used to create the portion of a parse tree that represents a name and value pair (as would normally be returned in a response packet). It returns a pointer to a dynamically allocated parse tree representing the name, type, and value information. If there is an error detected while creating the parse tree, a NULL pointer is returned.

The value of *type* can be one of the following (which are defined in the SNMP_DPI.H header file):

- SNMP_TYPE_NUMBER
- SNMP_TYPE_STRING
- SNMP_TYPE_OBJECT
- SNMP_TYPE_INTERNET
- SNMP_TYPE_COUNTER
- SNMP_TYPE_GAUGE
- SNMP_TYPE_TICKS

The *value* operand is always a pointer to the first byte of the object ID's value.

Note: The parse tree is dynamically allocated, and copies are made of the passed operands. After a successful call to mkDPIset(), the application can dispose of the passed operands without affecting the contents of the parse tree.

Return Values: Returns a pointer to a parse tree containing the name, type, and value information.

mkDPItrap()

```
#include <snmp_dpi.h>
#include <types.h>

unsigned char *mkDPItrap(generic, specific, value_list)
int generic;
int specific;
struct dpi_set_packet *value_list;
```

Operand

Description

generic Specifies the generic field in the SNMP TRAP packet.

specific Identifies the specific field in the SNMP TRAP packet.

value_list

Passes the name and value pair to be placed into the SNMP packet.

Description: The mkDPItrap() routine creates a TRAP request packet. The information contained in *value_list* is passed as the set_packet portion of the parse tree.

The length of the remaining packet is stored in the first two bytes of the packet.

Note: mkDPItrap() always frees the passed parse tree.

Return Values: If the packet can be created, a pointer to a static buffer containing the packet contents is returned. This is the same buffer that is used by mkDPIregister(). If an error is encountered while creating the packet, a NULL pointer is returned.

mkDPItrap()

Example: The following is an example of the mkDPItrap() routine.

```
struct dpi_set_packet *if_index_value;
unsigned long data;
unsigned char *packet;
int len;

data = 3; /* interface number = 3 */
if_index_value = mkDPIset("1.3.6.1.2.1.2.2.1.1", SNMP_TYPE_NUMBER,
    sizeof(unsigned long), &data);
packet = mkDPItrap(2, 0, if_index_value);
len = *packet * 256 + *(packet + 1);
len += 2; /* include length bytes */
write(fd,packet,len);
```

mkDPItrape()

```
#include <snmp_dpi.h>
#include <types.h>

unsigned char *mkDPItrape(generic, specific, value_list, enterprise_oid)
long int generic; /* 4 octet integer */
long int specific;
struct dpi_set_packet *value_list;
char *enterprise_oid;
```

Operand

Description

generic

Specifies the generic field for the SNMP TRAP packet.

specific

Specifies the specific field for the SNMP TRAP packet.

value_list

Specifies a pointer to a structure dpi_set_packet, which contains one or more variables to be sent with the SNMP TRAP packet. Or NULL if no variables are to be send.

enterprise_oid

Specifies a pointer to a character string representing the enterprise object ID (in ASN.1 notation, for example, 1.3.6.1.4.1.2.2.1.4). Specifies NULL if you want the SNMP agent to use its own enterprise object ID.

Description: The mkDPItrape() routine can be used to create an *extended* trap. An extended trap resembles the mkDPItrap() routine, but it allows you to pass a list of variables and an enterprise-object ID.

The structure for dpi_trap_packet has changed, but this structure is not exposed to subagent writers.

Example of an Extended Trap

The following is a piece of sample code to send an extended trap. No error checking is done.

```
struct dpi_set_packet *set;
int len;
long int num = 15; /* 4 octet integer */
unsigned long int ctr = 1234;
char str[] = "a string";
unsigned char *packet;
```

```

set = 0;
set = mkDPIList(set,"1.3.6.1.4.1.2.2.1.4.1",SNMP_TYPE_NUMBER,sizeof(num),&num);
set = mkDPIList(set,"1.3.6.1.4.1.2.2.1.4.2",SNMP_TYPE_STRING,strlen(str),str);
set = mkDPIList(set,"1.3.6.1.4.1.2.2.1.4.6",SNMP_TYPE_COUNTER,sizeof(ctr),&ctr);

packet = mkDPITrape(6L, 37L, set, "1.3.6.1.4.1.2.2.1.4");

len = *packet * 256 + *(packet+1);
len += 2;

write(fd, packet, len) /* use send on OS/2 */

```

You can use a `mkDPISet()` call to create an initial `dpi_set_packet` for the first name and value pair. So the following sample is equivalent to the one above.

```

struct dpi_set_packet *set;
int len;
long int num = 15; /* 4 octet integer */
unsigned long int ctr = 1234;
char str[] = "a string";
unsigned char *packet;

set = mkDPISet("1.3.6.1.4.1.2.2.1.4.1",SNMP_TYPE_NUMBER,sizeof(num),&num);
set = mkDPIList(set,"1.3.6.1.4.1.2.2.1.4.2",SNMP_TYPE_STRING,strlen(str),str);
set = mkDPIList(set,"1.3.6.1.4.1.2.2.1.4.6",SNMP_TYPE_COUNTER,sizeof(ctr),&ctr);

packet = mkDPITrape(6L, 37L, set, "1.3.6.1.4.1.2.2.1.4");

len = *packet * 256 + *(packet+1);
len += 2;

write(fd, packet, len) /* use send on OS/2 */

```

If the high order bit must be on for the specific trap type, then a negative integer must be passed.

pDPIPacket()

```

#include <snmp_dpi.h>
#include <types.h>

struct snmp_dpi_hdr *pDPIPacket(packet)
unsigned char *packet;

```

Operand

Description

packet Specifies the DPI packet to be parsed.

Description: The `pDPIPacket()` routine parses a DPI packet and returns a parse tree representing its contents. The parse tree is dynamically allocated and contains copies of the information within the DPI packet. After a successful call to `pDPIPacket()`, the packet can be disposed of in any manner the application chooses, without affecting the contents of the parse tree.

Return Values: If `pDPIPacket()` is successful, a parse tree is returned. If an error is encountered during the parse, a NULL pointer is returned.

Note: The parse tree structures are defined in the `SNMP_DPI.H` header file.

Example: The following is an example of the `mkDPITrap()` routine. The root of the parse tree is represented by an `snmp_dpi_hdr` structure.

pDPIpacket()

```
struct snmp_dpi_hdr {
    unsigned char proto_major;
    unsigned char proto_minor;
    unsigned char proto_release;

    unsigned char packet_type;
    union {
        struct dpi_get_packet    *dpi_get;
        struct dpi_next_packet   *dpi_next;
        struct dpi_set_packet    *dpi_set;
        struct dpi_resp_packet   *dpi_response;
        struct dpi_trap_packet   *dpi_trap;
    } packet_body;
};
```

The *packet_type* field can have one of the following values, which are defined in the SNMP_DPI.H header file:

- SNMP_DPI_GET
- SNMP_DPI_GET_NEXT
- SNMP_DPI_SET

The *packet_type* field indicates the request that is made of the DPI client. For each of these requests, the remainder of the *packet_body* is different. If a GET request is indicated, the object ID of the desired variable is passed in a *dpi_get_packet* structure.

```
struct dpi_get_packet {
    char *object_id;
};
```

A GET-NEXT request is similar, but the *dpi_next_packet* structure also contains the object ID prefix of the group that is currently being traversed.

```
struct dpi_next_packet {
    char *object_id;
    char *group_id;
};
```

If the next object, whose object ID lexicographically follows the object ID indicated by *object_id*, does not begin with the suffix indicated by the *group_id*, the DPI client must return an error indication of SNMP_NO_SUCH_NAME.

A SET request has the most data associated with it, and this is contained in a *dpi_set_packet* structure.

```
struct dpi_set_packet {
    char *object_id;
    unsigned char type;
    unsigned short value_len;
    char *value;
};
```

The object ID of the variable to be modified is indicated by *object_id*. The type of the variable is provided in *type* and can have one of the following values:

- SNMP_TYPE_NUMBER
- SNMP_TYPE_STRING
- SNMP_TYPE_OBJECT
- SNMP_TYPE_EMPTY
- SNMP_TYPE_INTERNET
- SNMP_TYPE_COUNTER
- SNMP_TYPE_GAUGE
- SNMP_TYPE_TICKS

The length of the value to be set is stored in *value_len* and *value* contains a pointer to the value.

Note: The storage pointed to by *value* is reclaimed when the parse tree is freed. The DPI client must make provision for copying the value contents.

query_DPI_port()

```
#include <snmp_dpi.h>

int query_DPI_port (host_name, community_name)
char *host_name;
char *community_name;
```

Operand

Description

host_name

Points to the SNMP agent's host name or internet address.

community_name

Points to the community name to be used when making a request.

Description: The `query_DPI_port()` routine is used by a DPI client to determine the TCP port number that is associated with the DPI. This port number is needed to connect() to the SNMP agent. The port number is obtained through an SNMP GET request. *community_name* and *host_name* are the arguments that are passed to the `query_DPI_port()` routine.

Return Values: An integer representing the TCP port number is returned if successful; a -1 is returned if the port cannot be determined.

Sample SNMP DPI Client Program

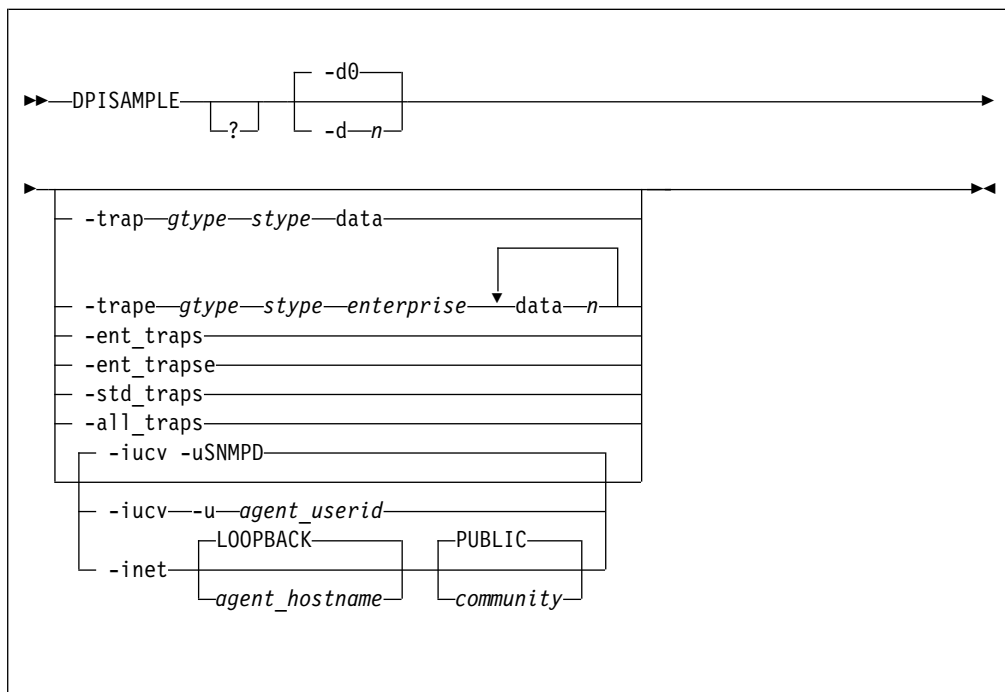
This section provides an example of an SNMP DPI agent program. You can run the `dpisample` program against the SNMP agents that support the SNMP-DPI interface, as described in RFC 1228.

The sample can be used to test agent DPI implementations because it provides variables of all types and also allows you to generate traps of all types.

The `DPISAMPLE` program implements a set of variables in the `DPISAMPLE` table which consists of a set of objects in the IBM Research tree (1.4.1.2.2.1.4). See Figure 40 on page 307 for the object type and objectID.

The DPISAMPLE Program (Sample DPI Subagent)

The DPISAMPLE program accepts the following arguments:



Operand

Description

- ?** Invokes output with an explanation about how the *dpisample* command is used. This option should be used in a C-shell environment.
- d n** Sets the debug level. The level, *n*, has a range from 0 - 4, 0 is silent and 4 is most verbose. The default level is 0.
- trap** Generates a trap with the following options:
 - gtype* Specifies the type as generic. The available ranges are 0 - 6.
 - stype* Specifies the type as specific.
 - data** Passes data as an additional value for the variable *dpiSample.stype.0*. Data is interpreted depending on *stype*. The following list describes the available values for the *stype* operand and their data descriptions:
 - 1** number
 - 2** octet string
 - 3** object id
 - 4** empty (ignored)
 - 5** internet address
 - 6** counter
 - 7** gauge
 - 8** time ticks
 - 9** display string
 - other** octet string
- trape** Generates an extended trap (available with DPI 1.1 level) with the following defined options:

The DPISAMPLE Program (Sample DPI Subagent)

gtype Specifies the trap as generic. The available ranges are 0 - 6.

stype Specifies the type as specific.

enterprise

Provides the object ID for the extended trap.

data Passes data values for additional variables. Data is passed as octet strings. Instances of data can be 1-n.

-ent_traps

Generates nine enterprise-specific traps with *stype* values of 1 - 9, using the internal dpiSample variables as data.

-ent_trapse

Generates nine enterprise-specific traps with *stype* values of 11 - 19, using the internal dpiSample variables as data.

-std_traps

Generates and simulates the standard five SNMP traps (generic types 1 - 5) including the link-down trap.

-all_traps

Generates both the standard traps (-std_traps) and the enterprise-specific traps with *stype* of 1 - 9 (-ent_traps).

-iucv Specifies that an AF_IUCV socket is to be used to connect to the SNMP agent. The *-iucv* operand is the default.

-u agent_userid

Specifies the user ID where the SNMP agent (SNMPD) is running. The default is SNMPD.

-inet

Specifies that an AF_INET socket is to be used to connect to the SNMP agent.

agent_hostname

Specifies the host name of the system where an SNMP-DPI capable agent is running. The default, if *-inet* is specified, is LOOPBACK.

community_name

Specifies the community name to get the dpiPort. The default is PUBLIC.

DPISAMPLE TABLE

```
# DPISAMPLE.C supports these variables as an SNMP DPI sample sub-agent
# it also generates enterprise specific traps via DPI with these objects.
DPISample 1.3.6.1.4.1.2.2.1.4. table 0
DPISampleNumber 1.3.6.1.4.1.2.2.1.4.1. number 10
# next one is to be able to send a badValue with a SET request
DPISampleNumberString 1.3.6.1.4.1.2.2.1.4.1.1. string 10
DPISampleOctetString 1.3.6.1.4.1.2.2.1.4.2. string 10
DPISampleObjectID 1.3.6.1.4.1.2.2.1.4.3. object 10
# XGMON/SQESERV does not allow to specify empty (so use empty string)
DPISampleEmpty 1.3.6.1.4.1.2.2.1.4.4. string 10
DPISampleInetAddress 1.3.6.1.4.1.2.2.1.4.5. internet 10
DPISampleCounter 1.3.6.1.4.1.2.2.1.4.6. counter 10
DPISampleGauge 1.3.6.1.4.1.2.2.1.4.7. gauge 10
DPISampleTimeTicks 1.3.6.1.4.1.2.2.1.4.8. ticks 10
DPISampleDisplayString 1.3.6.1.4.1.2.2.1.4.9. display 10
DPISampleCommand 1.3.6.1.4.1.2.2.1.4.10. display 1
```

Figure 40. DPISAMPLE Table MIB descriptions

Client Sample Program

The following is an example of a SNMP-DPI subagent program.

```

/*****/
/*
/* SNMP-DPI - SNMP Distributed Programming Interface
/*
/* May 1991 - Version 1.0 - SNMP-DPI Version 1.0 (RFC1228)
/* Created by IBM Research.
/* Feb 1992 - Version 1.1 - Allow enterpriseID to be passed with
/* a (enterprise specific) trap
/* - allow multiple variables to be passed
/* - Use 4 octets (INTEGER from RFC1157)
/* for generic and specific type.
/* Jun 1992 - Make it run on OS/2 as well
/* Note: dpisample = dpisamp1 on OS/2
/*
/* Copyright None
/*
/* dpisample.c - a sample SNMP-DPI subagent
/* - can be used to test agent DPI implementations.
/*
/* For testing with XGMON and/or SQESERV (SNMP Query Engine)
/* it is best to keep the following define for OID in sync
/* with the dpiSample objectID in the MIB description file
/* (mib_desc for XGMON, MIB_DESC DATA for SQESERV on VM and
/* MIB@DESC.DATA for SQESERV on MVS, MIB2TBL on OS/2).
/*
/*****/

#define OID "1.3.6.1.4.1.2.2.1.4."
#define ENTERPRISE_OID "1.3.6.1.4.1.2.2.1.4" /* dpiSample */
#define ifIndex "1.3.6.1.2.1.2.2.1.1.0"
#define egpNeighAddr "1.3.6.1.2.8.5.1.2.0"
#define PUBLIC_COMMUNITY_NAME "public"

#if defined(VM) || defined(MVS)

#define SNMPAGENTUSERID "SNMPD"
#define SNMPIUCVNAME "SNMP_DPI"
#pragma csect(CODE, "$DPISAMP")
#pragma csect(STATIC, "#DPISAMP")
#include <manifest.h> /* VM specific things */
#include "snmpnms.h" /* short external names for VM/MVS */
#include "snmp_vm.h" /* more of those short names */
#include <saiucv.h>
#include <bsdtime.h>
#include <bsdtypes.h>
#include <socket.h>
#include <in.h>
#include <netdb.h>
#include <inet.h>
extern char ebcdicto[, asciitoe][;
#pragma linkage(cmxmlate,OS)
#define DO_ETOA(a) cmxmlate((a),ebcdictoascii,strlen((a)))
#define DO_ATOE(a) cmxmlate((a),asciitoebcdic,strlen((a)))
#define DO_ERROR(a) tcperror((a))
#define LOOPBACK "loopback"
#define IUCV TRUE
#define max(a,b) (((a) > (b)) ? (a) : (b))
#define min(a,b) (((a) < (b)) ? (a) : (b))

#else /* we are not on VM or MVS */

#ifdef OS2
#define INCL_DOSPROCESS

```

```

#include <stdlib.h>
#include <types.h>
#include <doscalls.h> /* GKS */
#include <os2.h> /* GKS */
#ifdef sleep
#define sleep(a) DosSleep(1000L * (a)) /*GKS*/
#endif
#define close soclose
/*char * malloc(); */
/*unsigned long strtoul(); */
#endif

#include <sys/time.h> /* GKS */
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <arpa/inet.h>
#define DO_ETOA(a) ; /* no need for this */
#define DO_ATOE(a) ; /* no need for this */
#define DO_ERROR(a) perror((a))
#define LOOPBACK "localhost"
#define IUCV FALSE
#ifdef AIX221
#define isdigit(c) (((c) >= '0') && ((c) <= '9'))
#else
#include <sys/select.h>
#endif /* AIX221 */

#endif /* defined(VM) || defined(MVS) */

#include <stdio.h>
#ifdef OS2
#include <dpi/snmp_dpi.h>
#else
#include "snmp_dpi.h"
#endif

#define WAIT_FOR_AGENT 3 /* time to wait before closing agent fd */

#ifdef TRUE
#define TRUE 1
#define FALSE 0
#endif

#ifdef _NO_PROTO /* for classic K&R C */
static void check_arguments();
static void send_packet();
static void print_val();
static void usage();
static void init_connection();
static void init_variables();
static void wait_and_read_packet();
static void handle_packet();
static void do_get();
static void do_set();
static void issue_traps();
static void issue_one_trap();
static void issue_one_trap();
static void issue_std_traps();
static void issue_ent_traps();
static void issue_ent_trap();
static void do_register();
static void dump_bfr();
static struct dpi_set_packet *addto();
/extern unsigned long lookup_host();

```

Client Sample Program

```
#else /* _NO_PROTO */                               /* for ANSI-C compiler */

static void check_arguments(const int argc, char *argv)[];
static void send_packet(const char * packet);
static void print_val(const int index);
static void usage(const char *progname, const int exit_rc);
static void init_connection(void);
static void init_variables(void);
static void await_and_read_packet(void);
static void handle_packet(void);
static void do_get(void);
static void do_set(void);
static void issue_traps(void);
static void issue_one_trap(void);
static void issue_one_trapc(void);
static void issue_std_traps(void);
static void issue_ent_traps(void);
static void issue_ent_trapc(void);
static void do_register(void);
static void dump_bfr(const char *buf, const int len);
static struct dpi_set_packet *addtoset(struct dpi_set_packet *data,
                                      int stype);

static unsigned long lookup_host(const char *hostname);

#endif /* _NO_PROTO */

#define OSTRING          "hex01-04:"
#define DSTRING          "Initial Display String"
#define COMMAND          "None"
#define BUFSIZE          4096
#define TIMEOUT          3
#define PACKET_LEN(packet) (((unsigned char)*(packet)) * 256 + \
                             ((unsigned char)*((packet) + 1)) + 2)

/* We have the following instances for OID.x variables */
/* 0 - table */
static long number = 0; /* 1 - a number */
static unsigned char *ostring = 0; /* 2 - octet string */
static int ostring_len = 0; /* and its length */
static unsigned char *objectID = 0; /* 3 - objectID */
static int objectID_len = 0; /* and its length */
/* 4 - some empty variable */
static unsigned long ipaddr = 0; /* 5 - ipaddress */
static unsigned long counter = 1; /* 6 - a counter */
static unsigned long gauge = 1; /* 7 - a gauge */
static unsigned long ticks = 1; /* 8 - time ticks */
static unsigned char *dstring = 0; /* 9 - display string */
static unsigned char *command = 0; /* 10 - command */

static char *DPI_var[] = {
    "dpiSample",
    "dpiSampleNumber",
    "dpiSampleOctetString",
    "dpiSampleObjectID",
    "dpiSampleEmpty",
    "dpiSampleInetAddress",
    "dpiSampleCounter",
    "dpiSampleGauge",
    "dpiSampleTimeTicks",
    "dpiSampleDisplayString",
    "dpiSampleCommand"
};

static short int valid_types[] = { /* SNMP_TYPES accepted on SET */
    -1, /* 0 do not check type */
    SNMP_TYPE_NUMBER, /* 1 number */
    SNMP_TYPE_STRING, /* 2 octet string */
};
```

```

        SNMP_TYPE_OBJECT,          /* 3 object identifier */
        -1, /* SNMP_TYPE_EMPTY */ /* 4 do not check type */
        SNMP_TYPE_INTERNET,       /* 5 internet address */
        SNMP_TYPE_COUNTER,        /* 6 counter */
        SNMP_TYPE_GAUGE,          /* 7 gauge */
        SNMP_TYPE_TICKS,          /* 8 time ticks */
        SNMP_TYPE_STRING,         /* 9 display string */
        SNMP_TYPE_STRING          /* 10 command (display string) */
#define OID_COUNT_FOR_TRAPS      9
#define OID_COUNT                10
};

static char      *packet = NULL; /* ptr to send packet. */
static char      inbuf]BUFSIZE[]; /* buffer for receive packets */
static int       dpi_fd;         /* fd for socket to DPI agent */
static short int dpi_port;       /* DPI_port at agent */
static unsigned long dpi_ipaddress; /* IP address of DPI agent */
static char      *dpi_hostname;  /* hostname of DPI agent */
static char      *dpi_userid;    /* userid of DPI agent VM/MVS */
static char      *var_gid;       /* groupID received */
static char      *var_oid;       /* objectID received */
static int       var_index;      /* OID variable index */
static unsigned char var_type;    /* SET value type */
static char      *var_value;     /* SET value */
static short int var_value_len;  /* SET value length */
static int       debug_lvl = 0;  /* current debug level */
static int       use_iucv = IUCV; /* optional use of AF_IUCV */
static int       do_quit = FALSE; /* Quit in await loop */
static int       trap_gtype = 0; /* trap generic type */
static int       trap_stype = 0; /* trap specific type */
static char      *trap_data = NULL; /* trap data */
static int       do_trap = 0;    /* switch for traps */
#define ONE_TRAP      1
#define ONE_TRAPE     2
#define STD_TRAPS     3
#define ENT_TRAPS     4
#define ENT_TRAPSE    5
#define ALL_TRAPS     6
#define MAX_TRAPE_DATA 10        /* data for extended trap */
static long      trape_gtype = 6; /* trap generic type */
static long      trape_stype = 11; /* trap specific type */
static char      *trape_eprise = NULL; /* enterprise id */
static char      *trape_data]MAX_TRAPE_DATA[]; /* pointers to data values */
static int       trape_datacnt;   /* actual number of values */

#ifdef _NO_PROTO                /* for classic K&R C */
main(argc, argv)                /* main line */
int  argc;
char *argv[];
#else /* _NO_PROTO */          /* for ANSI-C compiler */
main(const int argc, char *argv[]) /* main line */
#endif /* _NO_PROTO */
{
    check_arguments(argc, argv); /* check callers arguments */
    dpi_ipaddress = lookup_host(dpi_hostname); /* get ip address */
    init_connection();           /* connect to specified agent */
    init_variables();            /* initialize our variables */
    if (do_trap) {               /* we just need to do traps */
        issue_traps();           /* issue the trap(s) */
        sleep(WAIT_FOR_AGENT);   /* sleep a bit, so agent can */
        close(dpi_fd);           /* read data before we close */
        exit(0);                 /* and that's it */
    }                             /* end if (do_trap) */
    do_register();               /* register our objectIDs */
    printf("%s ready and awaiting queries from agent\n", argv[0]);
    while (do_quit == FALSE) {   /* forever until quit or error */
        await_and_read_packet(); /* wait for next packet */
    }
}

```

Client Sample Program

```
        handle_packet();           /* handle it */
        if (do_trap) issue_traps(); /* request to issue traps */
    }                               /* while loop */
    sleep(WAIT_FOR_AGENT);         /* allow agent to read response */
    printf("Quitting, %s set to: quit\n",DPI_var]10[]);
    exit(2);                       /* sampleDisplayString == quit */
}

#ifdef _NO_PROTO                   /* for classic K&R C */
static void issue_traps()
#else /* _NO_PROTO */              /* for ANSI-C compiler */
static void issue_traps(void)
#endif /* _NO_PROTO */
{
    switch (do_trap) {             /* let's see which one(s) */
    case ONE_TRAP:                 /* only need to issue one trap */
        issue_one_trap();         /* go issue the one trap */
        break;
    case ONE_TRAPE:                /* only need to issue one trape */
        issue_one_trap();         /* go issue the one trape */
        break;
    case STD_TRAPS:                /* only need to issue std traps */
        issue_std_traps();        /* standard traps gtypes 0-5 */
        break;
    case ENT_TRAPS:                /* only need to issue ent traps */
        issue_ent_traps();        /* enterprise specific traps */
        break;
    case ENT_TRAPSE:              /* only need to issue ent trapse */
        issue_ent_trapse();       /* enterprise specific trapse */
        break;
    case ALL_TRAPS:                /* only need to issue std traps */
        issue_std_traps();        /* standard traps gtypes 0-5 */
        issue_ent_traps();        /* enterprise specific traps */
        issue_ent_trapse();       /* enterprise specific trapse */
        break;
    default:                       /* end switch (do_trap) */
        break;                   /* reset do_trap switch */
    }
    do_trap = 0;
}

#ifdef _NO_PROTO                   /* for classic K&R C */
static void await_and_read_packet() /* await packet from DPI agent */
#else /* _NO_PROTO */              /* for ANSI-C compiler */
static void await_and_read_packet(void)/* await packet from DPI agent */
#endif /* _NO_PROTO */
{
    int len, rc, bytes_to_read, bytes_read = 0;
#ifdef OS2
    int socks]5[];
#else
    fd_set read_mask;
#endif
    struct timeval timeout;

#ifdef OS2
    socks]0[ = dpi_fd;
    rc = select(socks, 1, 0, 0, -1L);
#else
    FD_ZERO(&read_mask);
    FD_SET(dpi_fd, &read_mask);    /* wait for data */
    rc = select(dpi_fd+1, &read_mask, NULL, NULL, NULL);
#endif
    if (rc != 1) {                 /* exit on error */
        DO_ERROR("await_and_read_packet: select");
        close(dpi_fd);
        exit(1);
    }
}
```

```

}
#ifdef OS2
    len = recv(dpi_fd, inbuf, 2, 0);          /* read 2 bytes first */
#else
    len = read(dpi_fd, inbuf, 2);           /* read 2 bytes first */
#endif
if (len <= 0) {                             /* exit on error or EOF */
    if (len < 0) DO_ERROR("await_and_read_packet: read");
    else printf("Quitting, EOF received from DPI-agent\n");
    close(dpi_fd);
    exit(1);
}
bytes_to_read = (inbuf[0] << 8) + inbuf[1]; /* bytes to follow */
if (BUFSIZE < (bytes_to_read + 2)) {        /* exit if too much */
    printf("Quitting, packet larger than %d byte buffer\n",BUFSIZE);
    close(dpi_fd);
    exit(1);
}
while (bytes_to_read > 0) {                  /* while bytes to read */
#ifdef OS2
    socks[0] = dpi_fd;
    len = select(socks, 1, 0, 0, 3000L);
#else
    timeout.tv_sec = 3;                     /* wait max 3 seconds */
    timeout.tv_usec = 0;
    FD_SET(dpi_fd, &read_mask);            /* check for data */
    len = select(dpi_fd+1, &read_mask, NULL, NULL, &timeout);
#endif
    if (len == 1) {                         /* select returned OK */
#ifdef OS2
        len = recv(dpi_fd, &inbuf[2] + bytes_read, bytes_to_read, 0);
#else
        len = read(dpi_fd, &inbuf[2] + bytes_read, bytes_to_read);
#endif
    } /* end if (len == 1) */
    if (len <= 0) {                         /* exit on error or EOF */
        if (len < 0) DO_ERROR("await_and_read_packet: read");
        printf("Can't read remainder of packet\n");
        close(dpi_fd);
        exit(1);
    } else {                                /* count bytes_read */
        bytes_read += len;
        bytes_to_read -= len;
    }
} /* while (bytes_to_read > 0) */
}

#ifdef _NO_PROTO                             /* for classic K&R C */
static void handle_packet() /* handle DPI packet from agent */
#else /* _NO_PROTO */          /* for ANSI-C compiler */
static void handle_packet(void) /* handle DPI packet from agent */
#endif /* _NO_PROTO */
{
    struct snmp_dpi_hdr *hdr;

    if (debug_lvl > 2) {
        printf("Received following SNMP-DPI packet:\n");
        dump_bfr(inbuf, PACKET_LEN(inbuf));
    }
    hdr = pDPIpacket(inbuf);                /* parse received packet */
    if (hdr == 0) {                         /* ignore if can't parse */
        printf("Ignore received packet, could not parse it!\n");
        return;
    }
    packet = NULL;
    var_type = 0;
    var_oid = "";
}

```

Client Sample Program

```
var_oid = "";
switch (hdr->packet_type) {
    /* extract pointers and/or data from specific packet types, */
    /* such that we can use them independent of packet type. */
    case SNMP_DPI_GET:
        if (debug_lvl > 0) printf("SNMP_DPI_GET for ");
        var_oid = hdr->packet_body.dpi_get->object_id;
        break;
    case SNMP_DPI_GET_NEXT:
        if (debug_lvl > 0) printf("SNMP_DPI_GET_NEXT for ");
        var_oid = hdr->packet_body.dpi_next->object_id;
        var_oid = hdr->packet_body.dpi_next->group_id;
        break;
    case SNMP_DPI_SET:
        if (debug_lvl > 0) printf("SNMP_DPI_SET for ");
        var_value_len = hdr->packet_body.dpi_set->value_len;
        var_value = hdr->packet_body.dpi_set->value;
        var_oid = hdr->packet_body.dpi_set->object_id;
        var_type = hdr->packet_body.dpi_set->type;
        break;
    default: /* Return a GEN_ERROR */
        if (debug_lvl > 0) printf("Unexpected packet_type %d, genErr\n",
            hdr->packet_type);
        packet = mkDPIresponse(SNMP_GEN_ERR, NULL);
        fDPIparse(hdr); /* return storage allocated by pDPIpacket() */
        send_packet(packet);
        return;
        break;
} /* end switch(hdr->packet_type) */
if (debug_lvl > 0) printf("objectID: %s \n",var_oid);

if (strlen(var_oid) <= strlen(OID)) { /* not in our tree */
    if (hdr->packet_type == SNMP_DPI_GET_NEXT) var_index = 0; /* OK */
    else { /* cannot handle */
        if (debug_lvl>0) printf("...Ignored %s, noSuchName\n",var_oid);
        packet = mkDPIresponse(SNMP_NO_SUCH_NAME, NULL);
        fDPIparse(hdr); /* return storage allocated by pDPIpacket() */
        send_packet(packet);
        return;
    }
} else { /* Extract our variable index (from OID.index.instance) */
    /* We handle any instance the same (we only have one instance) */
    var_index = atoi(&var_oid[strlen(OID)]);
}
if (debug_lvl > 1) {
    printf("...The groupID=%s\n",var_oid);
    printf("...Handle as if objectID=%s%d\n",OID,var_index);
}
switch (hdr->packet_type) {
    case SNMP_DPI_GET:
        do_get(); /* do a get to return response */
        break;
    case SNMP_DPI_GET_NEXT:
        { char toid]256[; /* space for temporary objectID */
          var_index++; /* do a get for the next variable */
          sprintf(toid,"%s%d",OID,var_index); /* construct objectID */
          var_oid = toid; /* point to it */
          do_get(); /* do a get to return response */
        } break;
    case SNMP_DPI_SET:
        if (debug_lvl > 1) printf("...value_type=%d\n",var_type);
        do_set(); /* set new value first */
        if (packet) break; /* some error response was generated */
        do_get(); /* do a get to return response */
        break;
}
fDPIparse(hdr); /* return storage allocated by pDPIpacket() */
```

```

}

#ifdef _NO_PROTO /* for classic K&R C */
static void do_get() /* handle SNMP_GET request */
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void do_get(void) /* handle SNMP_GET request */
#endif /* _NO_PROTO */
{
    struct dpi_set_packet *data = NULL;

    switch (var_index) {
    case 0: /* table, cannot be queried by itself */
        printf("...Should not issue GET for table %s.0\n", OID);
        break;
    case 1: /* a number */
        data = mkDPISet(var_oid,SNMP_TYPE_NUMBER,sizeof(number),&number);
        break;
    case 2: /* an octet_string (can have binary data) */
        data = mkDPISet(var_oid,SNMP_TYPE_STRING,ostring_len,ostring);
        break;
    case 3: /* object id */
        data = mkDPISet(var_oid,SNMP_TYPE_OBJECT,objectID_len,objectID);
        break;
    case 4: /* some empty variable */
        data = mkDPISet(var_oid,SNMP_TYPE_EMPTY,0,NULL);
        break;
    case 5: /* internet address */
        data = mkDPISet(var_oid,SNMP_TYPE_INTERNET,sizeof(ipaddr),&ipaddr);
        break;
    case 6: /* counter (unsigned) */
        data =mkDPISet(var_oid,SNMP_TYPE_COUNTER,sizeof(counter),&counter);
        break;
    case 7: /* gauge (unsigned) */
        data = mkDPISet(var_oid,SNMP_TYPE_GAUGE,sizeof(gauge),&gauge);
        break;
    case 8: /* time ticks (unsigned) */
        data = mkDPISet(var_oid,SNMP_TYPE_TICKS,sizeof(ticks),&ticks);
        break;
    case 9: /* a display_string (printable ascii only) */
        DO_ETOA(dstring);
        data = mkDPISet(var_oid,SNMP_TYPE_STRING,strlen(dstring),dstring);
        DO_ATOE(dstring);
        break;
    case 10: /* a command request (command is a display string) */
        DO_ETOA(command);
        data = mkDPISet(var_oid,SNMP_TYPE_STRING,strlen(command),command);
        DO_ATOE(command);
        break;
    default: /* Return a NoSuchName */
        if (debug_lvl > 1)
            printf("...GET]NEXT[ for %s, not found\n", var_oid);
        break;
    } /* end switch (var_index) */

    if (data) {
        if (debug_lvl > 0) {
            printf("...Sending response oid: %s type: %d\n",
                var_oid, data->type);
            printf(".....Current value: ");
            print_val(var_index); /* prints \n at end */
        }
        packet = mkDPISet(SNMP_NO_ERROR,data);
    } else { /* Could have been an error in mkDPISet though */
        if (debug_lvl > 0) printf("...Sending response noSuchName\n");
        packet = mkDPISet(SNMP_NO_SUCH_NAME,NULL);
    } /* end if (data) */
    if (packet) send_packet(packet);
}

```

Client Sample Program

```
}

#ifdef _NO_PROTO /* for classic K&R C */
static void do_set() /* handle SNMP_SET request */
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void do_set(void) /* handle SNMP_SET request */
#endif /* _NO_PROTO */
{
    unsigned long *ulp;
    long *lp;

    if (valid_types[var_index] != var_type &&
        valid_types[var_index] != -1) {
        printf("...Ignored set request with type %d, expect type %d,",
            var_type, valid_types[var_index]);
        printf(" Returning badValue\n");
        packet = mkDPIresponse(SNMP_BAD_VALUE, NULL);
        if (packet) send_packet(packet);
        return;
    }
    switch (var_index) {
    case 0: /* table, cannot set table. */
        if (debug_lvl > 0) printf("...Ignored set TABLE, noSuchName\n");
        packet = mkDPIresponse(SNMP_NO_SUCH_NAME, NULL);
        break;
    case 1: /* a number */
        lp = (long *)var_value;
        number = *lp;
        break;
    case 2: /* an octet_string (can have binary data) */
        free(ostring);
        ostring = (char *)malloc(var_value_len + 1);
        bcopy(var_value, ostring, var_value_len);
        ostring_len = var_value_len;
        ostring[var_value_len] = '\0'; /* so we can use it as a string */
        break;
    case 3: /* object id */
        free(objectID);
        objectID = (char *)malloc(var_value_len + 1);
        bcopy(var_value, objectID, var_value_len);
        objectID_len = var_value_len;
        if (objectID[objectID_len - 1]) {
            objectID[objectID_len++] = '\0'; /* a valid one needs a null */
            if (debug_lvl > 0)
                printf("...added a terminating null to objectID\n");
        }
        break;
    case 4: /* an empty variable, cannot set */
        if (debug_lvl > 0) printf("...Ignored set EMPTY, readOnly\n");
        packet = mkDPIresponse(SNMP_READ_ONLY, NULL);
        break;
    case 5: /* Internet address */
        ulp = (unsigned long *)var_value;
        ipaddr = *ulp;
        break;
    case 6: /* counter (unsigned) */
        ulp = (unsigned long *)var_value;
        counter = *ulp;
        break;
    case 7: /* gauge (unsigned) */
        ulp = (unsigned long *)var_value;
        gauge = *ulp;
        break;
    case 8: /* time ticks (unsigned) */
        ulp = (unsigned long *)var_value;
        ticks = *ulp;
        break;
    }
```

```

case 9: /* a display_string (printable ascii only) */
    free(dstring);
    dstring = (char *)malloc(var_value_len + 1);
    bcopy(var_value, dstring, var_value_len);
    dstring[var_value_len] = '\0'; /* so we can use it as a string */
    DO_ATOE(dstring);
    break;
case 10: /* a request to execute a command */
    free(command);
    command = (char *)malloc(var_value_len + 1);
    bcopy(var_value, command, var_value_len);
    command[var_value_len] = '\0'; /* so we can use it as a string */
    DO_ATOE(command);
    if (strcmp("all_traps",command) == 0) do_trap = ALL_TRAPS;
    else if (strcmp("std_traps",command) == 0) do_trap = STD_TRAPS;
    else if (strcmp("ent_traps",command) == 0) do_trap = ENT_TRAPS;
    else if (strcmp("ent_trapse",command) == 0) do_trap = ENT_TRAPSE;
    else if (strcmp("all_traps",command) == 0) do_trap = ALL_TRAPS;
    else if (strcmp("quit",command) == 0) do_quit = TRUE;
    else break;
    if (debug_lvl > 0)
        printf("...Action requested: %s set to: %s\n",
            DPI_var]10[, command);
    break;
default: /* NoSuchName */
    if (debug_lvl > 0)
        printf("...Ignored set for %s, NoSuchName\n", var_oid);
    packet = mkDPIresponse(SNMP_NO_SUCH_NAME,NULL);
    break;
} /* end switch (var_index) */
if (packet) send_packet(packet);
}

#ifdef _NO_PROTO /* for classic K&R C */
static void issue_std_traps()
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void issue_std_traps(void)
#endif /* _NO_PROTO */
{
    trap_stype = 0;
    trap_data = dpi_hostname;
    for (trap_gtype=0; trap_gtype<6; trap_gtype++) {
        issue_one_trap();
        if (trap_gtype == 0) sleep(10); /* some managers purge cache */
    }
}

#ifdef _NO_PROTO /* for classic K&R C */
static void issue_ent_traps()
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void issue_ent_traps(void)
#endif /* _NO_PROTO */
{
    char temp_string]256[;

    trap_gtype = 6;
    for (trap_stype = 1; trap_stype < 10; trap_stype++) {
        trap_data = temp_string;
        switch (trap_stype) {
            case 1 :
                sprintf(temp_string,"%ld",number);
                break;
            case 2 :
                sprintf(temp_string,"%s",ostring);
                break;
            case 3 :
                trap_data = objectID;

```

Client Sample Program

```
        break;
    case 4 :
        trap_data = "";
        break;
    case 5 :
        trap_data = dpi_hostname;
        break;
    case 6 :
        sleep(1); /* give manager a break */
        sprintf(temp_string,"%lu",counter);
        break;
    case 7 :
        sprintf(temp_string,"%lu",gauge);
        break;
    case 8 :
        sprintf(temp_string,"%lu",ticks);
        break;
    case 9 :
        trap_data = dstring;
        break;
    } /* end switch (trap_stype) */
    issue_one_trap();
}

/* issue a set of extended traps, pass enterprise ID and multiple
 * variable (assume octect string) as passed by caller
 */
#ifdef _NO_PROTO /* for classic K&R C */
static void issue_ent_trapse()
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void issue_ent_trapse(void)
#endif /* _NO_PROTO */
{
    int i, n;
    struct dpi_set_packet *data = NULL;
    unsigned char *packet = NULL;
    unsigned long ipaddr, ulnum;
    char oid]256[;
    char *cp;

    trape_gtype = 6;
    trape_eprise = ENTERPRISE_OID;
    for (n=11; n < (11+OID_COUNT_FOR_TRAPS); n++) {
        data = 0;
        trape_stype = n;
        for (i=1; i<=(n-10); i++)
            data = addtaset(data, i);
        if (data == 0) {
            printf("Could not make dpi_set_packet\n");
            return;
        }
        packet = mkDPITrape(trape_gtype,trape_stype,data,trape_eprise);
        if ((debug_lvl > 0) && (packet)) {
            printf("sending trape packet: %lu %lu enterprise=%s\n",
                trape_gtype, trape_stype, trape_eprise);
        }
        if (packet) send_packet(packet);
        else printf("Could not make trape packet\n");
    }
}

/* issue one extended trap, pass enterprise ID and multiple
 * variable (assume octect string) as passed by caller
 */
#ifdef _NO_PROTO /* for classic K&R C */
static void issue_one_trapse()
```

```

#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void issue_one_trap(void)
#endif /* _NO_PROTO */
{
    struct dpi_set_packet *data = NULL;
    unsigned char *packet = NULL;
    char oid]256[;
    char *cp;
    int i;

    for (i=0; i<trape_datacnt; i++) {
        sprintf(oid,"%s2.%d",OID,i);
        /* assume an octet_string (could have hex data) */
        data = mkDPIList(data, oid, SNMP_TYPE_STRING,
            strlen(trape_data[i]), trape_data[i]);
        if (data == 0) {
            printf("Could not make dpiset_packet\n");
        } else if (debug_lvl > 0) {
            printf("Preparing: ]oid=%s[ value: ", oid);
            printf("");
            for (cp = trape_data[i]; *cp; cp++) /* loop through data */
                printf("%2.2x",*cp); /* hex print one byte */
            printf("\n");
        }
    }
    packet = mkDPITrape(trape_gtype,trape_stype,data,trape_eprise);
    if ((debug_lvl > 0) && (packet)) {
        printf("sending trape packet: %lu %lu enterprise=%s\n",
            trape_gtype, trape_stype, trape_eprise);
    }
    if (packet) send_packet(packet);
    else printf("Could not make trape packet\n");
}

#ifdef _NO_PROTO /* for classic K&R C */
static void issue_one_trap()
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void issue_one_trap(void)
#endif /* _NO_PROTO */
{
    long int num; /* must be 4 bytes */
    struct dpi_set_packet *data = NULL;
    unsigned char *packet = NULL;
    unsigned long ipaddr, ulnum;
    char oid]256[;
    char *cp;

    switch (trap_gtype) {
        /* all traps are handled more or less the same sofar. */
        /* could put specific handling here if needed/wanted. */
        case 0: /* simulate cold start */
        case 1: /* simulate warm start */
        case 4: /* simulate authentication failure */
            strcpy(oid,"none");
            break;
        case 2: /* simulate link down */
        case 3: /* simulate link up */
            strcpy(oid,ifIndex);
            num = 1;
            data = mkDPISet(oid, SNMP_TYPE_NUMBER, sizeof(num), &num);
            break;
        case 5: /* simulate EGP neighbor loss */
            strcpy(oid,egpNeighAddr);
            ipaddr = lookup_host(trape_data);
            data = mkDPISet(oid, SNMP_TYPE_INET, sizeof(ipaddr), &ipaddr);
            break;
        case 6: /* simulate enterprise specific trap */
    }
}

```

Client Sample Program

```
    sprintf(oid,"%s%d.0",OID, trap_stype);
    switch (trap_stype) {
    case 1: /* a number */
        num = strtol(trap_data,(char **)0,10);
        data = mkDPiset(oid, SNMP_TYPE_NUMBER, sizeof(num), &num);
        break;
    case 2: /* an octet_string (could have hex data) */
        data = mkDPiset(oid,SNMP_TYPE_STRING,strlen(trap_data),trap_data);
        break;
    case 3: /* object id */
        data = mkDPiset(oid,SNMP_TYPE_OBJECT,strlen(trap_data) + 1,
                        trap_data);
        break;
    case 4: /* an empty variable value */
        data = mkDPiset(oid, SNMP_TYPE_EMPTY, 0, 0);
        break;
    case 5: /* internet address */
        ipaddr = lookup_host(trap_data);
        data = mkDPiset(oid, SNMP_TYPE_INTERNET, sizeof(ipaddr), &ipaddr);
        break;
    case 6: /* counter (unsigned) */
        ulnum = strtoul(trap_data,(char **)0,10);
        data = mkDPiset(oid, SNMP_TYPE_COUNTER, sizeof(ulnum), &ulnum);
        break;
    case 7: /* gauge (unsigned) */
        ulnum = strtoul(trap_data,(char **)0,10);
        data = mkDPiset(oid, SNMP_TYPE_GAUGE, sizeof(ulnum), &ulnum);
        break;
    case 8: /* time ticks (unsigned) */
        ulnum = strtoul(trap_data,(char **)0,10);
        data = mkDPiset(oid, SNMP_TYPE_TICKS, sizeof(num), &ulnum);
        break;
    case 9: /* a display_string (ascii only) */
        DO_ETOA(trap_data);
        data = mkDPiset(oid,SNMP_TYPE_STRING,strlen(trap_data),trap_data);
        DO_ATOE(trap_data);
        break;
    default: /* handle as string */
        printf("Unknown specific trap type: %s, assume octet_string\n",
              trap_stype);
        data = mkDPiset(oid,SNMP_TYPE_STRING,strlen(trap_data),trap_data);
        break;
    } /* end switch (trap_stype) */
    break;
default: /* unknown trap */
    printf("Unknown general trap type: %s\n", trap_gtype);
    return;
    break;
} /* end switch (trap_gtype) */

packet = mkDPITrap(trap_gtype,trap_stype,data);
if ((debug_lvl > 0) && (packet)) {
    printf("sending trap packet: %u %u ]oid=%s[ value: ",
          trap_gtype, trap_stype, oid);
    if (trap_stype == 2) {
        printf("");
        for (cp = trap_data; *cp; cp++) /* loop through data */
            printf("%2.2x",*cp); /* hex print one byte */
        printf("H\n");
    } else printf("%s\n", trap_data);
    }
if (packet) send_packet(packet);
else printf("Could not make trap packet\n");
}

#ifdef _NO_PROTO /* for classic K&R C */
static void send_packet(packet) /* DPI packet to agent */
```

```

char *packet;
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void send_packet(const char *packet) /* DPI packet to agent */
#endif /* _NO_PROTO */
{
    int rc;

    if (debug_lvl > 2) {
        printf("...Sending DPI packet:\n");
        dump_bfr(packet, PACKET_LEN(packet));
    }
#ifdef OS2
    rc = send(dpi_fd,packet,PACKET_LEN(packet),0);
#else
    rc = write(dpi_fd,packet,PACKET_LEN(packet));
#endif
    if (rc != PACKET_LEN(packet)) DO_ERROR("send_packet: write");
    /* no need to free packet (static buffer in mkDPI.... routine) */
}

#ifdef _NO_PROTO /* for classic K&R C */
static void do_register() /* register our objectIDs with agent */
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void do_register(void) /* register our objectIDs with agent */
#endif /* _NO_PROTO */
{
    int i, rc;
    char toid]256[;

    if (debug_lvl > 0) printf("Registering variables:\n");
    for (i=1; i<=OID_COUNT; i++) {
        sprintf(toid,"%s%d.",OID,i);
        packet = mkDPIregister(toid);
#ifdef OS2
        rc = send(dpi_fd, packet, PACKET_LEN(packet),0);
#else
        rc = write(dpi_fd, packet, PACKET_LEN(packet));
#endif
        if (rc <= 0) {
            DO_ERROR("do_register: write");
            printf("Quitting, unsuccessful register for %s\n",toid);
            close(dpi_fd);
            exit(1);
        }
        if (debug_lvl > 0) {
            printf("...Registered: %-25s oid: %s\n",DPI_var[i],toid);
            printf(".....Initial value: ");
            print_val(i); /* prints \n at end */
        }
    }
}

/* add specified variable to list of variable in the dpi_set_packet
*/
#ifdef _NO_PROTO /* for classic K&R C */
struct dpi_set_packet *addtoset(data, stype)
struct dpi_set_packet *data;
int stype;
#else /* _NO_PROTO */ /* for ANSI-C compiler */
struct dpi_set_packet *addtoset(struct dpi_set_packet *data, int stype)
#endif /* _NO_PROTO */
{
    char var_oid]256[;

    sprintf(var_oid,"%s%d",OID, stype);
    switch (stype) {
    case 1: /* a number */

```

Client Sample Program

```
        data = mkDPIList(data, var_oid, SNMP_TYPE_NUMBER,
                        sizeof(number), &number);
        break;
case 2: /* an octet_string (can have binary data) */
        data = mkDPIList(data, var_oid, SNMP_TYPE_STRING,
                        ostring_len, ostring);
        break;
case 3: /* object id */
        data = mkDPIList(data, var_oid, SNMP_TYPE_OBJECT,
                        objectID_len, objectID);
        break;
case 4: /* some empty variable */
        data = mkDPIList(data, var_oid, SNMP_TYPE_EMPTY, 0, NULL);
        break;
case 5: /* internet address */
        data = mkDPIList(data, var_oid, SNMP_TYPE_INTERNET,
                        sizeof(ipaddr), &ipaddr);
        break;
case 6: /* counter (unsigned) */
        data =mkDPIList(data, var_oid, SNMP_TYPE_COUNTER,
                        sizeof(counter), &counter);
        break;
case 7: /* gauge (unsigned) */
        data = mkDPIList(data, var_oid, SNMP_TYPE_GAUGE,
                        sizeof(gauge), &gauge);
        break;
case 8: /* time ticks (unsigned) */
        data = mkDPIList(data, var_oid, SNMP_TYPE_TICKS,
                        sizeof(ticks), &ticks);
        break;
case 9: /* a display_string (printable ascii only) */
        DO_ETOA(dstring);
        data = mkDPIList(data, var_oid, SNMP_TYPE_STRING,
                        strlen(dstring), dstring);
        DO_ATOE(dstring);
        break;
} /* end switch (stype) */
return(data);
}

#ifdef _NO_PROTO /* for classic K&R C */
static void print_val(index)
int index;
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void print_val(const int index)
#endif /* _NO_PROTO */
{
    char *cp;
    struct in_addr display_ipaddr;

    switch (index) {
case 1 :
        printf("%ld\n", number);
        break;
case 2 :
        printf("");
        for (cp = ostring; cp < ostring + ostring_len; cp++)
            printf("%2.2x", *cp);
        printf("'H\n");
        break;
case 3 :
        printf("%s\n", objectID_len, objectID);
        break;
case 4 :
        printf("no value (EMPTY)\n");
        break;
case 5 :
```

```

        display_ipaddr.s_addr = (u_long) ipaddr;
        printf("%s\n",inet_ntoa(display_ipaddr));
/* This worked on VM, MVS and AIX, but not on OS/2
 * printf("%d.%d.%d.%d\n", (ipaddr >> 24), ((ipaddr << 8) >> 24),
 *      ((ipaddr << 16) >> 24), ((ipaddr << 24) >> 24));
 */
        break;
    case 6 :
        printf("%lu\n",counter);
        break;
    case 7 :
        printf("%lu\n",gauge);
        break;
    case 8 :
        printf("%lu\n",ticks);
        break;
    case 9 :
        printf("%s\n",dstring);
        break;
    case 10 :
        printf("%s\n",command);
        break;
    } /* end switch(index) */
}

#ifdef _NO_PROTO /* for classic K&R C */
static void check_arguments(argc, argv) /* check arguments */
int argc;
char *argv[];
#else /* for ANSI-C compiler */
static void check_arguments(const int argc, char *argv[])
#endif /* _NO_PROTO */
{
    char *hname, *cname;
    int i, j;

    dpi_userid = hname = cname = NULL;
    for (i=1; argc > i; i++) {
        if (strcmp(argv[i],"-d") == 0) {
            i++;
            if (argc > i) {
                debug_lvl = atoi(argv[i]);
                if (debug_lvl >= 5) {
                    DPIdebug(1);
                }
            }
        }
        else if (strcmp(argv[i],"-trap") == 0) {
            if (argc > i+3) {
                trap_gtype = atoi(argv[i+1]);
                trap_stype = atoi(argv[i+2]);
                trap_data = argv[i+3];
                i = i + 3;
                do_trap = ONE_TRAP;
            } else usage(argv[0], 1);
        } else if (strcmp(argv[i],"-trape") == 0) {
            if (argc > i+4) {
                trape_gtype = strtoul(argv[i+1],(char**)0,10);
                trape_stype = strtoul(argv[i+2],(char**)0,10);
                trape_eprise = argv[i+3];
                for (i = i + 4, j = 0;
                    (argc > i) && (j < MAX_TRAPE_DATA);
                    i++, j++) {
                    trape_data[j] = argv[i];
                }
                trape_datacnt = j;
                do_trap = ONE_TRAPE;
                break; /* -trape must be last option */
            }
        }
    }
}

```

Client Sample Program

```
    } else usage(argv[0], 1);
  } else if (strcmp(argv[i], "-all_traps") == 0) {
    do_trap = ALL_TRAPS;
  } else if (strcmp(argv[i], "-std_traps") == 0) {
    do_trap = STD_TRAPS;
  } else if (strcmp(argv[i], "-ent_traps") == 0) {
    do_trap = ENT_TRAPS;
  } else if (strcmp(argv[i], "-ent_trapse") == 0) {
    do_trap = ENT_TRAPSE;
#ifdef VM || defined(MVS)
  } else if (strcmp(argv[i], "-inet") == 0) {
    use_iucv = 0;
  } else if (strcmp(argv[i], "-iucv") == 0) {
    use_iucv = TRUE;
  } else if (strcmp(argv[i], "-u") == 0) {
    use_iucv = TRUE; /* -u implies -iucv */
    i++;
    if (argc > i) {
      dpi_userid = argv[i];
    }
  }
#endif
  } else if (strcmp(argv[i], "?") == 0) {
    usage(argv[0], 0);
  } else {
    if (hname == NULL) hname = argv[i];
    else if (cname == NULL) cname = argv[i];
    else usage(argv[0], 1);
  }
  if (hname == NULL) hname = LOOPBACK; /* use default */
  if (cname == NULL) cname = PUBLIC_COMMUNITY_NAME; /* use default */
#ifdef VM || defined(MVS)
  if (dpi_userid == NULL) dpi_userid = SNMPAGENTUSERID;
  if (debug_lvl > 2)
    printf("hname=%s, cname=%s, userid=%s\n", hname, cname, dpi_userid);
#else
  if (debug_lvl > 2)
    printf("hname=%s, cname=%s\n", hname, cname);
#endif
  if (use_iucv != TRUE) {
    DO_ETOA(cname); /* for VM or MVS */
    dpi_port = query_DPI_port(hname, cname);
    DO_ATOE(cname); /* for VM or MVS */
    if (dpi_port == -1) {
      printf("No response from agent at %s(%s)\n", hname, cname);
      exit(1);
    }
  } else dpi_port == -1;
  dpi_hostname = hname;
}

#ifdef _NO_PROTO /* for classic K&R C */
static void usage(pname, exit_rc)
char *pname;
int exit_rc;
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void usage(const char *pname, const int exit_rc)
#endif /* _NO_PROTO */
{
  printf("Usage: %s [-d debug_lvl] [-trap g_type s_type data]", pname);
  printf(" ]-all_traps[\n");
  printf("%s]-trape g_type s_type enterprise data1 data2 .. datan[\n",
    strlen(pname)+8, "");
  printf("%s]-std_traps[ ]-ent_traps[ ]-ent_trapse[\n",
    strlen(pname)+8, "");
#ifdef VM || defined(MVS)
  printf("%s]-iucv[ ]-u agent_userid[\n", strlen(pname)+8, "");
#endif
}
```

```

printf("%*s", strlen(pname)+8, "");
printf("-inet [ ]agent_hostname ]community_name[[]\n");
printf("default: -d 0 -iucv -u %s\n", SNMPAGENTUSERID);
printf("      -inet %s %s\n", LOOPBACK, PUBLIC_COMMUNITY_NAME);
#else
printf("%*s]agent_hostname ]community_name[[]\n",strlen(pname)+8,"");
printf("default: -d 0 %s %s\n", LOOPBACK, PUBLIC_COMMUNITY_NAME);
#endif
exit(exit_rc);
}

#ifdef _NO_PROTO /* for classic K&R C */
static void init_variables() /* initialize our variables */
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void init_variables(void) /* initialize our variables */
#endif /* _NO_PROTO */
{
    char ch, *cp;

    ostring = (char *)malloc(strlen(OSTRING) + 4 + 1 );
    bcopy(OSTRING,ostring,strlen(OSTRING));
    ostring_len = strlen(OSTRING);
    for (ch=1;ch<5;ch++) /* add hex data 0x01020304 */
        ostring[ostring_len++] = ch;
    ostring[ostring_len] = '\0'; /* so we can use it as a string */
    objectID = (char *)malloc(strlen(OID));
    objectID_len = strlen(OID);
    bcopy(OID,objectID,strlen(OID));
    if (objectID[objectID_len - 1] == '.') /* if trailing dot, */
        objectID[objectID_len - 1] = '\0'; /* remove it */
    else objectID_len++; /* length includes null */
    dstring = (char *)malloc(strlen(DSTRING)+1);
    bcopy(DSTRING,dstring,strlen(DSTRING)+1);
    command = (char *)malloc(strlen(COMMAND)+1);
    bcopy(COMMAND,command,strlen(COMMAND)+1);
    ipaddr = dpi_ipaddress;
}

#ifdef _NO_PROTO /* for classic K&R C */
static void init_connection() /* connect to the DPI agent */
#else /* _NO_PROTO */ /* for ANSI-C compiler */
static void init_connection(void) /* connect to the DPI agent */
#endif /* _NO_PROTO */
{
    int rc;
    int sasize; /* size of socket structure */
    struct sockaddr_in sin; /* socket address AF_INET */
    struct sockaddr *sa; /* socket address general */
#ifdef VM || defined(MVS)
    struct sockaddr_iucv siu; /* socket address AF_IUCV */
#endif

    if (use_iucv == TRUE) {
        printf("Connecting to %s DPI_port %d userid %s (TCP, AF_IUCV)\n",
            dpi_hostname,dpi_port,dpi_userid);
        bzero(&siu,sizeof(siu));
        siu.siucv_family = AF_IUCV;
        siu.siucv_addr = dpi_ipaddress;
        siu.siucv_port = dpi_port;
        memset(siu.siucv_nodeid, ' ', sizeof(siu.siucv_nodeid));
        memset(siu.siucv_userid, ' ', sizeof(siu.siucv_userid));
        memset(siu.siucv_name, ' ', sizeof(siu.siucv_name));
        bcopy(dpi_userid, siu.siucv_userid, min(8,strlen(dpi_userid)));
        bcopy(SNMP_IUCV_NAME, siu.siucv_name, min(8,strlen(SNMP_IUCV_NAME)));
        dpi_fd = socket(AF_IUCV, SOCK_STREAM, 0);
        sa = (struct sockaddr *) &siu;
        sasize = sizeof(struct sockaddr_iucv);
    }
}

```

Client Sample Program

```
    } else {
#endif
    printf("Connecting to %s DPI_port %d (TCP, AF_INET)\n",
           dpi_hostname,dpi_port);
    bzero(&sin,sizeof(sin));
    sin.sin_family    = AF_INET;
    sin.sin_port      = htons(dpi_port);
    sin.sin_addr.s_addr = dpi_ipaddress;
    dpi_fd = socket(AF_INET, SOCK_STREAM, 0);
    sa      = (struct sockaddr *) &sin;
    sasize = sizeof(struct sockaddr_in);
#if defined(VM) || defined (MVS)
    }
#endif
    if (dpi_fd < 0) {                                /* exit on error */
        DO_ERROR("init_connection: socket");
        exit(1);
    }
    rc = connect(dpi_fd, sa, sasize);                /* connect to agent */
    if (rc != 0) {                                    /* exit on error */
        DO_ERROR("init_connection: connect");
        close(dpi_fd);
        exit(1);
    }
}

#ifdef _NO_PROTO                                    /* for classic K&R C */
static void dump_bfr(buf, len)                      /* hex dump buffer */
char *buf;
int len;
#else /* _NO_PROTO */                               /* for ANSI-C compiler */
static void dump_bfr(const char *buf, const int len)
#endif /* _NO_PROTO */
{
    register int i;

    if (len == 0) printf("    empty buffer\n"); /* buffer is empty */
    for (i=0;i<len;i++) {                            /* loop through buffer */
        if ((i&15) == 0) printf("    ");           /* indent new line */
        printf("%2.2x", (unsigned char)buf[i]); /* hex print one byte */
        if ((i&15) == 15) printf("\n");          /* nl every 16 bytes */
        else if ((i&3) == 3) printf(" ");        /* space every 4 bytes */
    }
    if (i&15) printf("\n");                        /* always end with nl */
}

unsigned long lookup_host(const char *hostname)
{
    register unsigned long ret_addr;

    if ((*hostname >= '0') && (*hostname <= '9'))
        ret_addr = inet_addr(hostname);
    else {
        struct hostent *host;
        struct in_addr *addr;

        host = gethostbyname(hostname);
        if (host == NULL) return(0);
        addr = (struct in_addr *) (host->h_addr_list[0]);
        ret_addr = addr->s_addr;
    }
    return(ret_addr);
}
```

Compiling and Linking the DPISAMPLE.C Source Code

When compiling the Sample DPI Subagent program you may specify the following compile time flags:

NO_PROTO

The DPISAMPLE.C code assumes that it is compiled with an ANSI-C compliant compiler. It can be compiled without ANSI-C by defining this flag.

VM Indicates that compilation is for VM and uses VM-specific includes. Some VM/MVS specific code is compiled.

Client Sample Program

Chapter 8. SMTP Virtual Machine Interfaces

Electronic mail (e-mail) is prepared using local mail preparation facilities (or, *user agents*) such as the CMS NOTE and SENDFILE commands; these facilities are not discussed here. This chapter describes the interfaces to the SMTP virtual machine itself, and may be of interest to users who implement electronic mail programs that communicate with the IBM z/VM implementation of SMTP.

The interfaces to the SMTP virtual machine are:

- The TCP/IP network

SMTP commands and replies can be sent and received interactively over a TCP network connection. Mail from TCP network sites destined for local VM users (or users on an RSCS network attached to the local z/VM system) arrives over this interface. All commands and data received and transmitted through this interface must be composed of ASCII characters.

- The local z/VM system (and systems attached to the local z/VM system by an RSCS network)

SMTP commands can be written to a batch file and then spooled to the virtual reader of the SMTP virtual machine. SMTP processes each of the commands in this file, in order, as if they had been transmitted over a TCP connection. This is how mail is sent from local z/VM users (or users on an RSCS network attached to the local z/VM system) to recipients on the TCP network. Batch SMTP (or, BSMTP) files must contain commands and data composed of EBCDIC characters.

SMTP Transactions

Electronic mail is sent by a series of request/response transactions between a client, the *sender-SMTP*, and a server, the *receiver-SMTP*. These transactions pass (1) the message proper, which is composed of a *header* and a *body* (which by definition, are separated by the first blank line present in this information), and (2) SMTP commands, which are referred to as (and comprise) the mail *envelope*. These commands contain additional information about the mail, such as the host sending the mail and its source and destination addresses. Envelope addresses may be derived from information in the message header, supplied by the user interface, or derived from local configuration information.

The SMTP envelope is constructed at the *sender-SMTP* site. If this is the originating site, the information is typically provided by the user agent when the message is first queued for the *sender-SMTP* program. Each intermediate site receives the piece of mail and resends it on to the next site using an envelope that it creates. The content of the new envelope may be different from that of the one it received.

The envelope contains, at a minimum, the HELO or EHLO, MAIL FROM:, RCPT TO:, DATA, and QUIT commands. These, and other commands that can optionally appear in the envelope, are described in the next section. Some of these commands can appear more than once in an envelope. Also, more than one piece of mail can be sent using a given envelope.

SMTP Commands

This section describes SMTP commands that are recognized by the z/VM SMTP implementation. These commands are used to interface with user agent mail facilities (such as the CMS NOTE and SENDFILE commands) as well as with other SMTP servers.

For more complete information about SMTP and the commands that can be used with this protocol, it is suggested that you review the following RFCs:

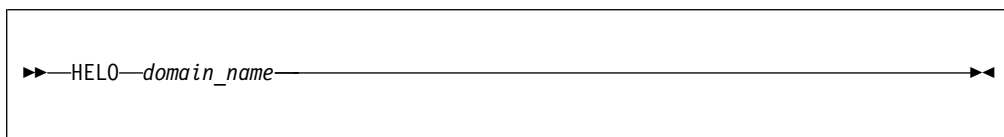
- RFC 2821, *Simple Mail Transfer Protocol*
- RFC 822, *Standard for the Format of ARPA Internet Text Messages*
- RFC 1870, *SMTP Service Extension for Message Size Declaration*
- RFC 1652, *SMTP Service Extension for 8bit-MIME transport*

These RFCs are the basis for modern naming specifications associated with the SMTP protocol.

Note: The SMTP commands SEND, SOML, SAML, and TURN are not supported by the z/VM SMTP implementation, so are not described here.

HELO

The HELO command is used to identify the domain name of the sending host to SMTP. This command is used to initiate a mail transaction, and must be sent (once) before a MAIL FROM: command is used.



Operand

Description

domain_name

Specifies the domain name of the sending host. The *domain_name* may be specified as either:

- a domain name
- an IP address in decimal integer form that is prefixed by the number or (US) pound sign (“#” or X'7B')
- an IP address in dotted-decimal form, enclosed in brackets.
- the string “IPv6:” followed by an IPv6 address in full or compressed form (IPv6 mapped IPv4 addresses are acceptable).

When HELO commands are received over a TCP connection, SMTP replies with the message 250 *SMTP_server_domain* is my domain name. The SMTP server client verification exit or built-in client verification function can be used to determine if the provided *domain_name* matches the client IP address and to include the result of that determination in the mail headers. See *z/VM: TCP/IP Planning and Customization* for detailed information about configuring SMTP to use this support.

When HELO commands are received over a batch SMTP connection, SMTP replies with the message 250 *SMTP_server_domain* is my domain name. Additional text is included with this message that indicates whether the provided *domain_name* does

or does not match the host name of the spool file origination point. The 250 reply code indicates the HELO command is accepted and that SMTP commands can continue to be sent and received.

EHLO

The EHLO command operates and can be used in the same way as the HELO command. However, it additionally requests that the returned reply should identify specific SMTP service extensions that are supported by the SMTP server.

```
▶▶—EHLO—domain_name————▶▶
```

Operand

Description

domain_name

Specifies the domain name of the sending host. The *domain_name* may be specified as either:

- a domain name
- an IP address in decimal integer form that is prefixed by the number or (US) pound sign (“#” or X'7B')
- an IP address in dotted-decimal form, enclosed in brackets.
- the string “IPv6:” followed by an IPv6 address in full or compressed form (IPv6 mapped IPv4 addresses are acceptable).

If a server does not support SMTP service extensions, the client receives a negative reply to its EHLO command. When this occurs, the client should either supply a HELO command, if the mail being delivered can be processed without the use of SMTP service extensions, or it should end the current mail transaction.

If a client receives a positive response to an EHLO command, the server is then known to support one or more SMTP service extensions. This reply then can be further used by the client to determine whether certain kinds of mail can be effectively processed by that server.

For example, if the positive response includes the SIZE keyword, the server supports the SMTP service extension for Message Size Declaration. Whereas, if this response includes the 8BITMIME keyword, the server supports the SMTP service extension for 8-bit MIME transport.

SMTP supports the following service extensions:

```
EXPN HELP SIZE 8BITMIME
```

Following is an example of a positive reply to a client (c) EHLO command from an SMTP server (s) that supports these service extensions:

```
s: (wait for connection on TCP port 25)
c: (open connection to server)
s: 220 HOSTA.IBM.COM running IBM VM SMTP Level 320 on Sat, 1 May 99 ...
c: EHLO HOSTB.IBM.COM
s: 250-HOSTA.IBM.COM is my domain name.
s: 250-EXPN
```

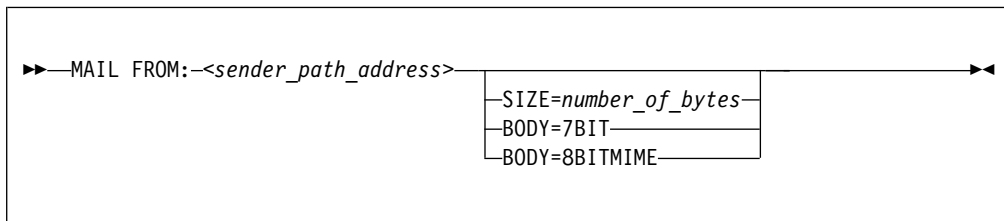
SMTP Virtual Machine Interfaces

```
s: 250-HELP
s: 250-8BITMIME
s: 250 SIZE 524288
...
```

The hyphen (-), when present as the fourth character of a response, indicates the response is continued on the next line.

MAIL FROM

The MAIL FROM: command is used (once), after a HELO or EHLO command, to identify the sender of a piece of mail.



Operand

Description

sender_path_address

Specifies the full path address of the sender of the mail. Definitions for valid *sender_path_address* specifications can be obtained from the RFCs that define the naming conventions used throughout the Internet. For detailed information, consult the RFCs listed in the section “SMTP Commands” on page 330.

SIZE=number_of_bytes

Specifies the size of the mail, in bytes, including *carriage return/line feed* (CRLF, X'0D0A') pairs. The SIZE parameter has a range from 0 to 2,147,483,647.

BODY=7BIT

Specifies that the message is encoded using seven significant bits per 8-bit octet (byte). In practice, however, the body is typically encoded using all eight bits.

BODY=8BITMIME

Specifies that the message is encoded using all eight bits of each octet (byte) and may contain MIME headers.

Note: The SIZE, BODY=7BIT, and BODY=8BITMIME options of the MAIL FROM: command should be used only if an EHLO command was used to initiate a mail transaction. If an EHLO command was not used for this purpose, SMTP ignores these parameters if they are present.

If the SMTP server is known to support the SMTP service extension for Message Size Declaration, the client sending the mail can specify the optional SIZE= parameter with its MAIL FROM: commands. The client then can use the responses to these commands to determine whether the receiving SMTP server has sufficient resources available to process its mail before any data is transmitted to that server.

When a MAIL FROM: command is received that includes the optional SIZE= parameter, the SMTP server compares the supplied *number_of_bytes* value to its allowed maximum message size (defined by the MAXMAILBYTES statement in the

SMTP CONFIG file) to determine if the mail should be accepted. If *number_of_bytes* exceeds the MAXMAILBYTES value, a reply code 552 is returned to the client.

The SIZE= parameter is evaluated only for MAIL FROM: commands received over a TCP connection; this parameter and its value are ignored when they are received over a batch connection.

RCPT TO

The RCPT TO: command specifies the recipient(s) of a piece of mail. This command can be repeated any number of times.

```
▶▶RCPT TO:~<recipient_path_address>~▶▶
```

Operand

Description

recipient_path_address

Specifies the full path address of a mail recipient. Definitions for valid *recipient_path_address* specifications can be obtained from the RFCs that define the naming conventions used throughout the Internet. For detailed information, consult the RFCs listed in the section “SMTP Commands” on page 330.

A RCPT TO: command must be used after a MAIL FROM: command. If the host system is not aware of the recipient’s host, a negative reply is returned in response to the RCPT TO: command.

DATA

The DATA command indicates that the next information provided by the client should be construed as the text of the mail being delivered (that is, the *header* and *body* of the mail message).

```
▶▶DATA~▶▶
```

The DATA command has no parameters.

The DATA command is used after a HELO or EHLO command, a MAIL FROM: command, and at least one RCPT TO: command have been accepted. When the DATA command has been accepted, the following response (reply code 354) is returned to indicate that the body of the mail can be transmitted:

```
354 Enter mail body. End new line with just a '.'
```

The body of the mail is terminated by transmitting a single ASCII period (.) on a line by itself. When SMTP detects this “end of data” indicator, it returns the following reply:

```
250 Mail Delivered
```

SMTP Virtual Machine Interfaces

When mail is received over a TCP connection, this ASCII period should be followed by the ASCII CR-LF sequence (*carriage return/line feed* sequence, X'0D0A'). If any record in the body of the mail begins with a period, the sending SMTP program must convert the period into a pair of periods (.). Then, when the receiving SMTP encounters a record in the body of the mail that begins with two periods, it discards the leading period. This convention permits the mail body to contain records that would otherwise be incorrectly interpreted as the “end of data” indicator. These rules must be followed over both TCP and batch SMTP connections. The CMS NOTE and SENDFILE execs perform this period doubling on all mail spooled to SMTP. If the body of the mail in a batch SMTP command file is not explicitly terminated by a record with a single period, SMTP supplies one.

After the “end of data” indicator has been received, the SMTP connection is reset to its initial state (that is, the state before any sender or recipients have been specified). Additional MAIL FROM:, RCPT TO:, DATA, and other commands can again be sent. If no further mail is to be delivered through this connection, the connection should then be terminated with a QUIT command. If the QUIT command is omitted from the end of a batch SMTP command file, the QUIT is implicit — SMTP will proceed as if it had been provided.

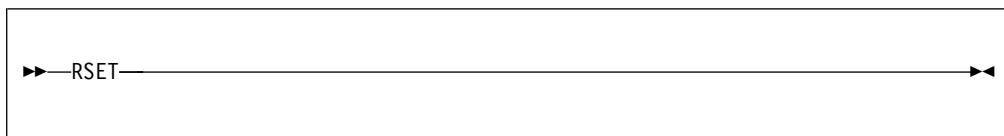
If SMTP runs out of local mail storage space, it returns a 451 reply code to the sender-SMTP client. Local mail storage space is constrained by the size of the SMTP server A-disk (191 minidisk). For a *large* batch SMTP file, disk storage equivalent to four times the size of that file may be required for it to be processed by SMTP.

If the body of the mail being delivered is found to exceed the MAXMAILBYTES value established in the SMTP CONFIG file, a reply code 552 is returned to the client. See the *z/VM: TCP/IP Planning and Customization* for more information about the MAXMAILBYTES configuration statement.

When mail arrives over a batch SMTP connection from an RSCS network host, and the REWRITE822HEADER configuration option was specified in the SMTP configuration file, then header fields are modified to ensure that all addresses are fully qualified domain names. See the *z/VM: TCP/IP Planning and Customization* for more information about the header rewriting.

RSET

The RSET command resets an SMTP connection to an initial state. That is, all information about the current mail transaction is discarded, and the connection is ready to process a new mail transaction.



The RSET command has no parameters.

QUIT

The QUIT command terminates an SMTP connection.

```

>> QUIT <<

```

The QUIT command has no parameters.

NOOP

The NOOP command has no intrinsic function. However, it will cause the receiver-SMTP to return an “OK” response (reply code 250).

```

>> NOOP <<

```

The NOOP command has no parameters.

HELP

The HELP command returns brief information about one or more SMTP commands.

```

>> HELP <<
      command_name

```

Operand

Description

command_name

Identifies a specific SMTP command.

The HELP command returns a multiple-line reply with brief help information about the SMTP commands supported by a host. If an SMTP command is specified for *command_name*, information about that specific command is returned.

QUEU

The QUEU command returns a multiple-line reply with information about the content of the mail processing queues maintained within the SMTP server.

```

>> QUEU <<
      DATE

```

Operand

Description

DATE Causes information about the age of any queued mail to be included in the QUEU command response. By default, age information is not included in such responses.

SMTP Virtual Machine Interfaces

The z/VM SMTP server maintains various internal queues for handling mail, that can be generalized to two categories — the **mail** (delivery) queues, and the mail resolution (or, **resolver**) queues. The QUEU command returns a multiple-line reply with information about the content of these queues, which are described in more detail here.

Mail Delivery Queues

Queue Name

Description

Spool Contains mail that is destined for recipients on the local z/VM system, or for recipients on an RSCS system attached to the local z/VM system. This queue is generally empty, because SMTP can deliver this mail quickly by spooling it directly to the local recipient, or to the RSCS virtual machine for delivery to an RSCS network recipient.

Active Identifies mail that is currently being transmitted by SMTP to a TCP network destination. All mail queued for that same destination is shown to be *Active*.

Queued

Identifies mail that has arrived over either a TCP or batch SMTP connection that is to be forwarded to a TCP network destination (possibly because of source routing). When SMTP obtains sufficient resources from the TCPIP virtual machine to process this mail, it is transferred to the *Active* queue.

Retry Identifies mail for which SMTP has made one or more previous delivery attempts that were not successful. Delivery attempts may fail for a variety of reasons; two common reasons are:

- The SMTP server could not open a connection to deliver the mail.
- Delivery of the mail was interrupted for some reason, such as a broken connection or a temporary error condition at the target host.

After the RETRYINT interval (defined in the SMTP CONFIG file) has passed, mail in the *Retry* queue is promoted to the *Queued* queue (or state) for another delivery attempt. For more information about the RETRYINT configuration parameter, see the *z/VM: TCP/IP Planning and Customization*.

Undeliverable

Identifies mail that SMTP cannot deliver to a local z/VM recipient, or to a recipient on the RSCS network attached to the local VM system, due to insufficient spooling resources on the local z/VM system. After spool space has been increased and SMTP has been reinitialized, delivery of this mail is again attempted.

Mail Resolution Queues

The mail resolution (or, *resolver*) queues are used to maintain the status of host resolution queries — performed through DNS services — for mail host domains, originators, and recipients, when such resolution is necessary. If the SMTP server is configured to *not* use a name server, but only local host tables, these queues are not used.

Several notes regarding the response information associated with mail resolution queues follow:

- If a queue is empty the word Empty appears in the response, to the right of the name of that queue.

- If a queue contains active queries, a line that identifies that queue will be present; information about the mail in that queue, and its associated query (or queries) is provided immediately after this identification line.
- Because of timing situations that can occur within the SMTP server, a queue identification line may at times show that a queue is active (that is, Empty is not indicated), but no mail entries will be present.

Queue Name**Description****Process**

This queue is generally empty, as it contains queries that have not yet been acted upon by the SMTP server. Once a query has been initially processed, it is placed in the *Resolver Send* queue.

Send Identifies queries that are awaiting SMTP resolver processing. SMTP staggers the number of queries it submits to a name server, to prevent overloading the network and the name server.

Wait Identifies queries for which the SMTP server is waiting a response from a name server. Queries remain in this queue for a specific amount of time, within which a reply should be received from the name server.

If a query is successful, that query is then placed in the *Resolver Completed* queue.

If a reply is not received for a query within the allotted time (that is, the resolver time-out has expired), that query is removed from this queue and placed in the *Resolver Retry* queue.

Note: The duration of the resolver time-out period can be controlled using the TCPIP DATA file RESOLVERTIMEOUT configuration statement. See the *z/VM: TCP/IP Planning and Customization* for more information about this statement.

Retry Identifies queries that have previously failed, possibly because:

- a name server response was not received for a query (within the designated time-out period), or
- the name server returned a temporary error that has forced the SMTP server to retry a query. A temporary error occurs if, for example, the name server truncates a packet, or if the name server detects a processing error.

Note: Mail for which queries are present in this queue can be significantly affected by the values defined for the RESOLVERRETRYINT and RETRYAGE configuration statements in the SMTP CONFIG file. See the *z/VM: TCP/IP Planning and Customization* for more information about these statements.

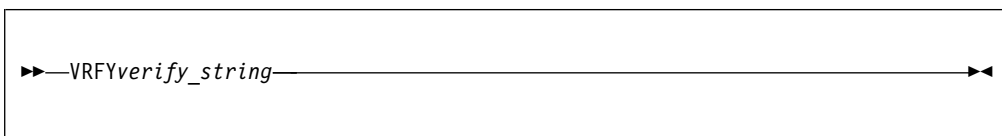
Completed

Identifies queries that have been resolved and are waiting to be recorded by SMTP (and, possibly incorporated within a piece of mail). After the resolved information has been recorded, SMTP attempts to deliver the mail.

Error Identifies queries for which a name server response was obtained, but for which no answer was obtained. Mail that corresponds to such queries is returned to the originator as undeliverable, with an unknown recipient error indicated.

VRFY

The VRFY (“verify”) command determines if a given mailbox or user ID exists on the host where SMTP is running.



Operand

Description

verify_string

Specifies the name of a mailbox or user ID whose existence is to be verified.

The z/VM implementation of SMTP responds to the VRFY command and the EXPN command (see the EXPN command below) in the same manner. Thus, the VRFY command can be used with z/VM systems to expand a mailing list defined on such system; when this is done, a multiple-line reply may be returned in response to the VRFY command.

The VRFY command can also be used to verify the existence of the POSTMASTER mailbox or mailboxes defined for a system.

On z/VM systems, mailing lists are defined by the site administrator and are stored in the SMTP NAMES file; POSTMASTER mailboxes are defined by the POSTMASTER configuration statement in the SMTP CONFIG file. See the *z/VM: TCP/IP Planning and Customization* for more information about defining mailing lists and specifying POSTMASTER mailboxes.

Some example VRFY commands (issued against an SMTP server running on host TESTVM1 at “somewhere.com”) and their corresponding responses follow:

```
vrfy tcpmaint 250 <tcpmaint@abcvml.somewhere.com>

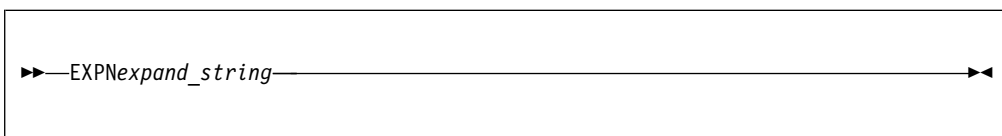
vrfy tcpadmin-list 250-<tcpmaint@abcvml.somewhere.com>
250-<tcpadmin@abcvml.somewhere.com>
250-<tcpadmin@adminpc.somewhere.com>
250 <maint@abcvml.somewhere.com>

vrfy postmaster 250-<TCPMAINT@TESTVM1.somewhere.com>
250-<TCPADMIN@TESTVM1.SOMEWHERE.COM>
250 <TCPADMIN@ADMINPC.SOMEWHERE.COM>
```

The hyphen (-), when present as the fourth character of a response, indicates the response is continued on the next line.

EXPN

The EXPN (“expand”) command expands a mailing list defined on the host where SMTP is running.



Operand
Description

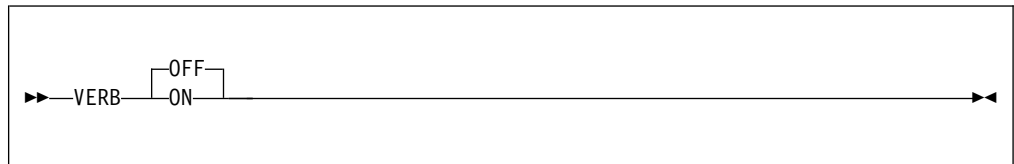
expand_string

Specifies the name of the mailing list to be expanded.

The EXPN command operates and can be used in the same way as the VRFY command.

VERB

The VERB command is used to enable or disable “verbose” mode for batch SMTP connections.



Operand
Description

ON Specifies that verbose mode is to be enabled (turned on). When verbose mode is enabled for a batch SMTP connection, SMTP commands and their associated replies are recorded in a batch SMTP response file; this file is sent back to the origination point of the batch SMTP command file when the batch transaction is complete.

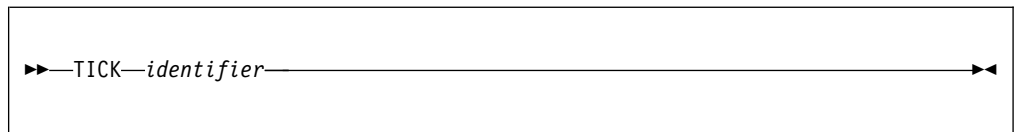
OFF Specifies that verbose mode is to be disabled (turned off); this is the default. When verbose mode is disabled for a batch SMTP connection, only SMTP replies are recorded in the batch SMTP response file; this file is not returned to the origination point of the batch SMTP command file.

See “SMTP Command Responses” on page 340 for more information about the batch SMTP response file, how this file is handled, and how origination points are determined.

Note: The VERB command has no effect when issued over a TCP connection.

TICK

The TICK command can be used (in conjunction with the VERB ON command) to cause an identifier string to be inserted into a batch SMTP response file.



Operand
Description

identifier

Specifies an identification string to be included in a batch SMTP response file.

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This command can be useful for some mail systems that keep track of batch SMTP response files and their content.

Note: The TICK command has no effect when it is issued over a TCP connection.

SMTP Command Example

The following is an example of an SMTP envelope and its contained piece of mail. The SMTP commands that comprise the *envelope* are in upper case boldface text. The information after the DATA command, and before the single ASCII period (the “end of data” indicator) is the message *header* and *body*. The body is distinguished from the header by the blank line that follows the “Subject: Update” line of text.

```
HELO yourhost.yourdomain.edu
MAIL FROM: <carol@yourhost.yourdomain.edu>
RCPT TO: <msgs@host1.somewhere.com>
RCPT TO: <alice@host2.somewhere.com>
DATA
Date: Sun, 30 Nov 98 nn:nn:nn EST
From: Carol <carol@yourhost.yourdomain.edu>
To: <msgs@host1.somewhere.com>
Cc: <alice@host2.somewhere.com>
Subject: Update
```

```
Mike: Cindy stubbed her toe. Bobby went to
      baseball camp. Marsha made the cheerleading team.
      Jan got glasses. Peter has an identity crisis.
      Greg made dates with 3 girls and couldn't
      remember their names.
```

```
.
QUIT
```

SMTP Command Responses

The z/VM SMTP server can accept SMTP commands that arrive over a TCP connection or over a batch SMTP (BSMTP) connection. With either type of connection, a response (or, reply) is generated for each command received by SMTP. Each reply is prefixed with a three-digit number, or code. The nature of each response can be determined by inspecting the **first digit** of this reply code; possible values for this digit are:

Digit Description

- 0 Echo reply; used **only** in batch SMTP response files. Received commands are “echoed” in these files to provide contextual information for other reply codes.
- 1 Positive Preliminary reply. SMTP does not use a 1 as the first digit of a reply code, because there are no SMTP commands for which such a reply is applicable.
- 2 Positive Completion reply; command accepted.
- 3 Positive Intermediate reply; data associated with the command should now be provided.
- 4 Temporary Negative Completion reply; try the command again, but at a later time.
- 5 Permanent Negative Completion reply; the command has been rejected.

For SMTP commands that arrive over a TCP connection, all responses (positive or negative) are returned over that TCP connection.

Similarly, for SMTP commands that arrive over a batch SMTP connection, all responses are written to a batch SMTP response file. If verbose mode is enabled for

a batch SMTP connection (through use of the VERB ON command), SMTP returns this response file to the origination point of the spool file. The origination point is determined either from the ORIGINID field of the spool file (if the spool file was generated on the same z/VM system as the SMTP virtual machine) or from the spool file TAG field (if the spool file arrived from a remote system through the RSCS network). If the batch SMTP connection is not in verbose mode, the batch SMTP response file is not returned to the point of origin.

If an error occurs during the processing of commands over a batch SMTP connection, such as reception of a negative response (with a first digit of 4 or 5), an error report is mailed back to the sender of the mail. The sender is determined from the last valid MAIL FROM: command that was received by SMTP. If the sender cannot be determined from a MAIL FROM: command, the sender is assumed to be the origination point of the batch SMTP command file. The error report mailed to the sender includes the batch SMTP response file and the text of the undeliverable mail.

Note: All SMTP commands and data that arrive over TCP or batch SMTP connections are subject to the restrictions imposed by both SMTP conventions and constants defined in either the SMTPGLOB COPY file, or within other SMTP source files. Any changes made to these files to overcome a restriction will require the affected source files to be recompiled, and the SMTP module to be rebuilt. Several significant restrictions, the relevant constants, and their default values are:

- Command lines must not exceed *MaxCommandLine* (552 characters).
- Data lines longer than *MaxDataLine* (32767 characters) are wrapped.
- Path addresses must not exceed *MaxPathLength* (256 characters).
- Domain names must not exceed *MaxDomainName* (256 characters).
- User names, the local part of a mailbox specification, must not exceed *MaxUserName* (256 characters).

Path Address Modifications

When SMTP processes MAIL FROM: and RCPT TO: commands, the *path addresses* specified with these commands may be modified by SMTP due to use of the SOURCEROUTES configuration statement, or based on the content of the path addresses themselves. See the *z/VM: TCP/IP Planning and Customization* for more information about the SOURCEROUTES statement and its affect on path addresses. For content-based changes, certain path addresses will be rewritten by SMTP as follows:

1. If the local part of a mailbox name includes a percent sign (%) *and* the domain of the mailbox is that of the host system where SMTP is running, the given domain name is eliminated, and the portion of the “local part” to the right of the percent sign (%) is used as the destination domain. For example, the path address:

```
john%yourvm@ourvm.our.edu
```

is rewritten by SMTP running at “ourvm.our.edu” as:

```
john@yourvm
```

2. Path addresses with source routes are accepted and rewritten to remove the domain name of the host system where SMTP is running. For example, the path address:

```
@ourvm.our.edu,@next.host.edu:john@yourvm
```

is rewritten by SMTP running at “ourvm.our.edu” as:

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@next.host.edu:john@yourvm

Definitions for “valid path format” specifications can be obtained from the RFCs that define the naming conventions used throughout the Internet. For detailed information, consult the RFCs listed in the section “SMTP Commands” on page 330.

Batch SMTP Command Files

Batch SMTP command files are files that contain an SMTP envelope (as described in “SMTP Transactions” on page 329) which are sent to the virtual reader of the SMTP virtual machine using the CMS PUNCH, DISK DUMP, SENDFILE, or NETDATA SEND commands. For a description of these commands, see the *z/VM: CMS Command Reference*. These files are encoded using EBCDIC.

Batch SMTP command files can be sent by users on the same z/VM system, or any system connected through an RSCS network. For information about RSCS networks, see the *RSCS General Information*.

Batch SMTP files may be modified when they are processed by the SMTP server, as follows:

- All trailing blanks are removed from each record of a file sent in PUNCH format. Trailing blanks are preserved for files sent in NETDATA or DISK DUMP format.
- A record that is entirely blank will be treated as a record with a single blank.

Batch SMTP Examples

The following sections contain examples that demonstrate batch SMTP capabilities.

Sending Mail to a TCP Network Recipient

The example that follows shows the content of a batch SMTP file used to send mail from a CMS user (CAROL at YOURHOST) to two TCP network recipients. The VERB ON command will cause a batch SMTP response file to be returned to the CMS user CAROL. The text included with the TICK command will appear in this file as well, so that the nature of the response file will be evident when it is returned.

```
VERB ON
TICK Carol's Batch Test File
HELO yourhost.yourdomain.edu
MAIL FROM: <carol@yourhost.yourdomain.edu>
RCPT TO: <msgs@host1.somewhere.com>
RCPT TO: <alice@host2.somewhere.com>
DATA
Date: Sun, 30 Nov 98 nn:nn:nn EST
From: Carol <carol@yourhost.yourdomain.edu>
To: <msgs@host1.somewhere.com>
Cc: <alice@host2.somewhere.com>
Subject: Update
```

```
Mike: Cindy stubbed her toe. Bobby went to
      baseball camp. Marsha made the cheerleading team.
      Jan got glasses. Peter has an identity crisis.
      Greg made dates with 3 girls and couldn't
      remember their names.
```

```
.
QUIT
```

With the exception of the VERB and TICK commands, this sample batch SMTP file contains commands that are identical to those shown in “SMTP Command Example” on page 340.

Following is the batch SMTP response file (BSMTP REPLY) produced for the previous command file:

```

220-YOURHOST.YOURDOMAIN.EDU running IBM VM SMTP Level 320 on Sun, 30 Nov 1998 nn
220 :nn:n EST
050 VERB ON
250 Verbose Mode On
050 TICK Carol's Batch Test File
250 OK
050 HELO yourhost.yourdomain.edu
250 YOURHOST.YOURDOMAIN.EDU is my domain name. Yours too, I see!
050 MAIL FROM: <carol@yourhost.yourdomain.edu>
250 OK
050 RCPT TO: <msgs@host1.somewhere.com>
250 OK
050 RCPT TO: <alice@host2.somewhere.com>
250 OK
050 DATA
354 Enter mail body. End by new line with just a '.'
250 Mail Delivered
050 QUIT
221
YOURHOST.YOURDOMAIN.EDU running IBM VM SMTP Level 320 closing connection

```

Querying SMTP Delivery Queues

The SMTP delivery queues can be queried by sending a file that contains VERB ON and QUEU commands to the SMTP virtual machine. A batch SMTP response file that contains the QUEU command results is then returned to the originating user ID.

The SMTPQUEU EXEC (supplied with TCP/IP for z/VM on the TCPMAINT 592 “Client-code” minidisk) generates such a file and sends it to the SMTP virtual machine.

Sample content for a BSMTP REPLY file returned in response to an SMTPQUEU command follows:

```

220-YOURHOST.YOURDOMAIN.EDU running IBM VM SMTP Level 320 on Sun, 30 Nov 1998 nn
220 :nn:n EST
050-VERB ON
050
250 Verbose Mode On
050-QUEU
050
250-Queues on YOURHOST.YOURDOMAIN.EDU at nn:nn:nn EST on 11/30/98
250-Spool Queue: Empty
250-Queue for Site: 123.45.67.89 RETRY QUEUE Last Tried: nn:nn:nn
250-Note 00000005 to <MSG@HOST1.SOMEWHERE.COM>
250-Queue for Site: 98.76.54.32 RETRY QUEUE Last Tried: nn:nn:nn
250-Placeholder...no files queued for this site
250-Undeliverable Queue: Empty
250-Resolution Queues:
250-Resolver Process Queue: Empty
250-Resolver Send Queue: Empty
250-Resolver Wait Queue:
250-00000013 <userx@somehost.nowhereville.com>
250-Resolver Retry Queue: Empty
250-Resolver Completed Queue: Empty
250-Resolver Error Pending Queue: Empty
250 OK

```

SMTP Exit Routines

The SMTP user exits described in the next sections allow you greater control over each piece of mail that is processed by the SMTP server. To effectively use these exits and their parameters, it is necessary to understand SMTP transactions. Refer to the previous sections in this chapter for information about the commands, messages, and replies that are used to facilitate e-mail transactions between the sender and receiver of a piece of mail.

Prior to customizing the server exits described in this section, ensure that you have reviewed the exit limitations and customization recommendations presented in the "Customizing Server-specific Exits" section of the *z/VM: TCP/IP Planning and Customization*.

Client Verification Exit

When a client connects to SMTP, the originating mail domain must be provided. The client verification exit can be used to verify that the domain name provided by a client matches that client's IP address. Thus, this exit allows flexibility on actions you can take to deal with *spoofing* problems. In spoofing, the client provides a falsified domain in order to cause mail to appear to have come from someone (or somewhere) else. When client verification is performed, you might choose to include the verification results in mail headers, or possibly reject future communications on a connection.

With the client verification exit, you can perform any or all of the following:

- Reject mail from a particular host.
- Mark certain trusted sites as verified, but perform verification on all others.
- Control which users can use a particular SMTP server.

The exit can be further customized to perform additional actions that are unique or required for your environment.

Note: The client verification exit is called for each HELO or EHLO command processed for each mail item received from the network. Client verification is not performed for mail items received from the SMTP virtual reader.

Built-in Client Verification Function

In addition to the exit, SMTP can be configured to perform client verification through internal processing. When this support is enabled, this "built-in" client verification function will be called for each HELO or EHLO processed for each mail item. See the *z/VM: TCP/IP Planning and Customization* for detailed information about configuring SMTP to use this support.

The built-in client verification function of the SMTP server can be used to determine if a client host name and client IP address match, and to include the result of that determination in the mail headers. This function will perform a DNS lookup against the HELO or EHLO command data provided by a client, and will then insert a message into the mail header that reflects the result of this lookup.

Client verification performed using the built-in function has three possible outcomes:

Success

The data the client provided in the HELO or EHLO command corresponds to the client address. The following line is inserted into the mail header:

X-Comment: *localhost*: Mail was sent by *host*

Failure

The data the client provided in the HELO or EHLO command is not associated with the client IP address. In this case, a reverse name lookup is done against the client IP address to determine the actual host name. The following line is inserted into the mail header:

X-Comment: *localhost*: Host *host* claimed to be *helodata*

Unknown

The validation could not be performed. This situation could occur if the name server is not responding, or the verification could not be performed in the allotted time (as controlled by the VERIFYCLIENTDELAY statement). The following line is inserted into the mail header:

X-Warning: *localhost*: Could not confirm that host [*ipaddr*] is *helodata*

The terms used in the previously listed mail header messages are described in more detail here:

localhost

the local VM host name

helodata

the data the client provided with the HELO or EHLO command

host the host name determined by the reverse DNS lookup; if a host name is not found, "unknown host" will be used

ipaddr

the client IP address.

Client Verification Exit Parameter Lists

The parameter lists passed to the REXX and the assembler exit routines follow. When you customize either of these exits, keep in mind the following:

- Because an identical exit parameter list definition is used for *all* of the SMTP user exits, not all parameters may be meaningful for *this* exit. Parameters that are not used by this exit are indicated in the exit parameter lists; their values should be ignored.
- For the REXX exit, the value of an unused parameter will be such that any parsing will not be affected.

Parameter descriptions that pertain to both the REXX and assembler exits are provided in the "Parameter Descriptions" on page 347.

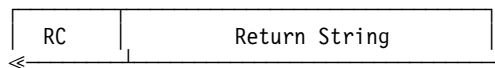
REXX Parameter List

Inputs:

Table 72. Client Verification REXX Exit Parameter List

Argument	Description
ARG(1)	Parameter list defined as follows: <ul style="list-style-type: none"> • Exit type • Version number • Mail record ID • Port number of SMTP server • IPv4 address of SMTP server • Port number of client • IPv4 address of client • Filename of note on disk • Verify client status • Maximum length of Return String • IPv6 address of SMTP server • IPv6 address of client • Exit flags
ARG(2)	SMTP command string
ARG(3)	HELO/EHLO name
ARG(4-6)	Not used

Outputs: The following are returned to the caller in the RESULT variable via a REXX RETURN statement:



Argument

Description

RC The exit return code; this must be a 4-byte binary value.

Return String

An exit-specified string; the returned value must have a length less than or equal to the maximum length passed to the exit.

Assembler Parameter List

Following is the parameter list that is passed to the assembler exit routine. General Register 1 points to the parameter list.

Table 73. Client Verification ASSEMBLER Exit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type
+4	4	Input	Int	Version number
+8	4	Input	Int	Mail record ID
+12	4	Input	Int	Port number of SMTP server
+16	4	Input	Int	IPv4 address of SMTP server
+20	4	Input	Int	Port number of client

Table 73. Client Verification ASSEMBLER Exit Parameter List (continued)

Offset in Decimal	Len	In/Out	Type	Description
+24	4	Input	Int	IPv4 address of client
+28	4	Input	Ptr	Address of SMTP command string
+32	4	Input	Int	Length of SMTP command string
+36	4	Input	Ptr	Address of HELO/EHLO name
+40	4	Input	Int	Length of HELO/EHLO name
+44	24			Not used
+68	4	Input	Int	Verify Client status
+72	4	Output	Ptr	Address of Return String
+76	4	Output	Int	Length of Return String
+80	4	Input	Int	Maximum length of Return String
+84	16	Input	Char	IPv6 address of SMTP server
+100	16	Input	Char	IPv6 address of client
+116	1	Input	Char	Exit flags
+117	3			Not used
+120	8			Not used
+128	4	Input/ Output	Char	User Word 1
+132	4	Input/ Output	Char	User Word 2
+136	4	Output	Int	Return code from exit

Parameter Descriptions

Exit type

A four-character field that indicates the type of exit called. For the client verification exit, this is **VERX**.

Version number

The parameter list version number; if the parameter list format is changed, the version number will change. Your exit should verify it has received the expected version number. The current version number is **2**.

Mail record ID

A number that uniquely identifies a piece of mail so that multiple exit calls can be correlated to the same piece of mail. A value of **0** indicates a mail record ID is not available.

Port number of SMTP server

The port number used by the SMTP server for this connection.

IP address of SMTP server

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv4 address to determine in which part of the network the client host resides.

Port number of client

If the connection no longer exists, **-1** is supplied. Otherwise, this is the port number used by the foreign host for this connection.

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IP address of client

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form.

SMTP command string

Contains the HELO/EHLO command and the domain specified for this command. The string has been converted to uppercase (for example, "HELO DOMAIN1").

HELO/EHLO name

A string that contains the name specified on the HELO or EHLO command; this string may be either:

- a domain name
- an IP address in decimal integer form that is prefixed by the number or (US) pound sign ("#" or X'7B')
- an IP address in dotted-decimal form, enclosed in brackets.

For example, if the command HELO #123456 is provided by an SMTP client, this parameter would contain #123456.

The name has already been verified to have the correct syntax.

Verify Client status

A number that indicates client verification results. For this exit, client verification results are unknown when the exit receives control; thus, this field will contain a 3. Possible values and their meanings are:

- 0 Client verification passed.
- 1 Client verification failed.
- 2 Client verification was not performed.
- 3 Client verification results are unknown.

Return String

When the exit returns a return code of 3, this value is appended to the X-Comment that is inserted in the mail header. When the exit returns a return code of 5, the *Return String* value is appended to the 550 reply code.

Maximum length of Return String

The current maximum is 512 bytes; ensure the *Return String* length is less than this value. If the returned string is longer than the indicated maximum, the return string is truncated and the following message is displayed on the SMTP server console:

```
Return data from exit exitname exittype too long, data truncated
```

Normal processing continues.

IPv6 address of SMTP server

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv6 address to determine in which part of the network the client host resides.

IPv6 address of client

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form.

Exit flags

Flags passed to the exit.

X'00'

IPv4 addresses passed

X'01'

IPv6 addresses passed

User Word 1

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

User Word 2

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

Return Codes from the Client Verification Exit Routine

Following are the return codes recognized by SMTP for this exit.

Table 74. Client Verification Exit Return Codes

Return Code	Explanation
0	Do not verify client. A comment will not be inserted in the mail header.
1	Perform verification using the built-in client verification function.
2	Mark as verified. The following comment will be inserted in the mail header: <i>X-Comment: localhost: Mail was sent by host</i>
3	The following comment will be inserted in the mail header: <i>X-Comment: Return String</i> where the value for <i>Return String</i> can be specified by the exit.
4	Disable the exit. The following message will be displayed on the SMTP console: <i>VERIFYCLIENT EXIT function disabled</i> The exit will no longer be called. The client will not be verified and no comment will be inserted in the mail header.
5	Reject this command with: <i>550 Return String</i> If a return string is not provided by the exit, then the default message will be displayed: <i>550 Access denied</i> All future communications on this connection will be rejected with this 550 message.
Other	Any return code other than the above causes SMTP to issue this message: <i>Unexpected return from user exit exitname exittype, RC = rc</i> SMTP treats this return code as if it were a return code of 0.

Client Verification Sample Exits

Sample Client Verification exit routines are supplied with TCP/IP on the TCPMAINT 591 disk. The supplied samples are:

SMTPVERX SAMPEXEC

REXX exit routine that contains a sample framework for performing client verification actions. Your customized exit should be stored on the TCPMAINT 198 disk as SMTPVERX EXEC.

SMTPVERX SAMPASM

Assembler exit routine that contains a sample framework for performing client verification actions. Your customized exit should be stored on the TCPMAINT 198 disk as file SMTPVERX ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMFHLASM SMTPVERX DMSVM command), and the resulting text deck placed on the TCPMAINT 198 disk.

These samples are for illustrative purposes only. They should be modified to meet the needs of your installation before placing them in a production environment. The assembler exit will have better performance characteristics than the REXX exit. For best REXX performance, the SMTP server will EXECLOAD any REXX exit.

Using the Mail Forwarding Exit

When SMTP clients use the VM SMTP server to send mail to hosts that their workstations cannot reach directly, this is an instance of *mail forwarding*. The mail forwarding exit provides a mechanism to control this activity. When SMTP determines the addressee specified on a RCPT TO: command is not “*defined on*” the local system, it has detected mail forwarding, and it will call this exit routine.

The phrase “*defined on*” in the previous paragraph is meant to convey that SMTP considers a user to be a *local user*, in addition to any other criteria, if that user is defined in the **SMTP NAMES** file — regardless of whether mail delivery to that user is performed via spooling (RSCS services) or through a network TCP connection. Also, keep in mind that the determination of whether mail forwarding is occurring is made on a recipient-by-recipient basis, not on other aspects of a given piece of mail. A piece of mail with multiple recipients can contain occurrences of both mail forwarding and local delivery.

With the mail forwarding exit, you can perform any or all of the following:

- Allow mail forwarding and mail delivery to proceed without interruption.
- Disallow mail forwarding from a known sender of “junk” mail, and possibly reject future communications on a connection used for this purpose.
- Intercept mail from specific clients and forward that mail to a local VM user ID for further analysis.
- Restrict the ability to forward mail to a particular set of hosts.

The exit can be further customized to perform additional actions that are required for your environment.

Note: The mail forwarding exit is only called for mail items received from the network; it is not called for mail items generated on the VM system or received via RSCS.

This exit can also be used to control *spamming*. Spamming is the act of sending mail to a large number of e-mail addressees and is often compared to the term “junk mail”, used to describe similar activities performed via postal services. *Spam* is a piece of mail that is perceived by the recipients to be unsolicited and unwanted. There are two aspects to consider when trying to control spamming problems:

- Is your system being used to relay spam messages to recipients throughout the internet?
- Are incoming spam messages to your local users seriously taxing or overloading your system?

The relaying of spam messages may be treated like any other type of mail forwarding. The exit can prevent delivery of all forwarded mail, prevent delivery of mail from particular sites known for spamming, or only allow delivery of mail from particular trusted sites. Handling spam messages directed to your local users will require the use of the SMTP command exit. When you address spamming problems, it's important to realize that one person may consider a piece of mail to be a spam, while the same piece of mail may be valuable to someone else. There are no explicit rules that determine what is and is not spam.

In addition to the exit, SMTP can be configured to enable or disable mail forwarding for **all** mail. If mail forwarding is disabled in this manner and SMTP determines the recipient specified on a RCPT TO: record is not defined on the local system, it has detected mail forwarding, and it will reject the delivery of the mail to that recipient. See the *z/VM: TCP/IP Planning and Customization* for more information about configuring SMTP to accept or reject all forwarded mail.

Mail Forwarding Exit Parameter Lists

The parameter lists passed to the REXX and the assembler exit routines follow. When you customize either of these exits, keep in mind the following:

- Because an identical exit parameter list definition is used for *all* of the SMTP user exits, not all parameters may be meaningful for *this* exit. Parameters that are not used by this exit are indicated in the exit parameter lists; their values should be ignored.
- For the REXX exit, the value of an unused parameter will be such that any parsing will not be affected.

Parameter descriptions that pertain to both the REXX and assembler exits are provided in the "Parameter Descriptions" on page 353.

REXX Parameter List

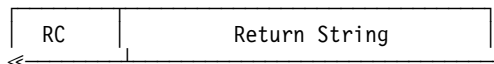
Inputs:

Table 75. Mail Forwarding REXX Exit Parameter List

Argument	Description
ARG(1)	Parameter list defined as follows: <ul style="list-style-type: none"> • Exit type • Version number • Mail record ID • Port number of SMTP server • IPv4 address of SMTP server • Port number of client • IPv4 address of client • Filename of note on disk • Verify client status • Maximum length of Return String • IPv6 address of SMTP server • IPv6 address of client • Exit flags
ARG(2)	SMTP command string
ARG(3)	HELO/EHLO name
ARG(4)	MAIL FROM: string
ARG(5)	Client domain name
ARG(6)	Not used

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Outputs: The following are returned to the caller in the RESULT variable via a REXX RETURN statement:



Argument

Description

RC The exit return code; this must be a 4-byte binary value.

Return String

An exit-specified string; the returned value must have a length less than or equal to the maximum length passed to the exit.

Assembler Parameter List

Following is the parameter list that is passed to the assembler exit routine. General Register 1 points to the parameter list.

Table 76. Mail Forwarding ASSEMBLER Exit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type
+4	4	Input	Int	Version number
+8	4	Input	Int	Mail record ID
+12	4	Input	Int	Port number of SMTP server
+16	4	Input	Int	IPv4 address of SMTP server
+20	4	Input	Int	Port number of client
+24	4	Input	Int	IPv4 address of client
+28	4	Input	Ptr	Address of SMTP command string
+32	4	Input	Int	Length of SMTP command string
+36	4	Input	Ptr	Address of HELO/EHLO name
+40	4	Input	Int	Length of HELO/EHLO name
+44	4	Input	Ptr	Address of client domain name
+48	4	Input	Int	Length of client domain name
+52	4	Input	Ptr	Address of MAIL FROM: string
+56	4	Input	Int	Length of MAIL FROM: string
+60	8	Input	Char	File name of note on disk
+68	4	Input	Int	Verify Client status
+72	4	Output	Ptr	Address of Return String
+76	4	Output	Int	Length of Return String
+80	4	Input	Int	Maximum length of Return String
+84	16	Input	Char	IPv6 address of SMTP server
+100	16	Input	Char	IPv6 address of client
+116	1	Input		Exit flags
+117	3			Not used
+120	8			Not used
+128	4	Input/ Output	Char	User Word 1
+132	4	Input/ Output	Char	User Word 2
+136	4	Output	Int	Return code from exit

Parameter Descriptions:

Exit type

A four-character field that indicates the type of exit called. For the mail forwarding exit, this is **FWDX**.

Version number

The parameter list version number; if the parameter list format is changed, the version number will change. Your exit should verify it has received the expected version number. The current version number is **2**.

Mail record ID

A number that uniquely identifies a piece of mail so that multiple exit calls can be correlated to the same piece of mail. A value of **0** indicates a mail record ID is not available.

Port number of SMTP server

The port number used by the SMTP server for this connection.

IP address of SMTP server

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv4 address to determine in which part of the network the client host resides.

Port number of client

If the connection no longer exists, **-1** is supplied. Otherwise, this is the port number used by the foreign host for this connection.

IP address of client

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form.

SMTP command string

Contains the name specified on the RCPT TO: command. The recipient path, enclosed in angle brackets (< and >), is included. The recipient path may be in any valid path format; it has already been verified to have the correct syntax. Because the recipient address has been resolved, this string may not exactly match the data provided with the RCPT TO: command.

For example, if the following has been specified by the SMTP client:

```
RCPT TO: <usera@host1>
```

the SMTP command string might contain: <usera@host1.com>

HELO/EHLO name

A string that contains the name specified on the HELO or EHLO command; this string may be either:

- a domain name
- an IP address in decimal integer form that is prefixed by the number or (US) pound sign (“#” or X'7B')
- an IP address in dotted-decimal form, enclosed in brackets.

For example, if the command HELO #123456 is provided by an SMTP client, this parameter would contain: #123456.

The name has already been verified to have the correct syntax.

Client domain name

The domain name that corresponds to the client IP address. The length of this field will be zero if:

- client verification was not performed

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- the results of client verification are unknown
- a reverse lookup failed

In all other cases, this will be a domain name.

MAIL FROM: string

Contains the name specified on the MAIL FROM: command. The sender path, enclosed in angle brackets (< and >), is included. The sender path may be in any valid path format; it has already been verified to have the correct syntax. Because the sender address has been resolved, this string may not exactly match the data provided with the MAIL FROM: command.

For example, if the following has been specified by the SMTP client:

```
MAIL FROM: <userb@host2>
```

the SMTP command string might contain: <userb@host2.com>

File name of note on disk

Name of the file created after the “end of data” (EOD) condition, a period (.), is received. Prior to either of these conditions, the file name is not defined; in this case, an asterisk (*) will be supplied.

Verify Client status

A number that indicates client verification results. Possible values and their meanings are:

- 0 Client verification passed.
- 1 Client verification failed.
- 2 Client verification was not performed.
- 3 Client verification results are unknown.

Return String

When the exit returns a return code of 1 or 5, this value is appended to the 551 or 550 reply code. When the exit returns a return code of 2, the *Return String* value should contain a VM user ID to which mail should be transferred.

Maximum length of Return String

The current maximum is 512 bytes; ensure the *Return String* length is less than this value. If the returned string is longer than the indicated maximum, the return string is truncated and the following message is displayed on the SMTP server console:

```
Return data from exit exitname exittype too long, data truncated
```

Normal processing continues.

IPv6 address of SMTP server

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv6 address to determine in which part of the network the client host resides.

IPv6 address of client

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form.

Exit flags

Flags passed to the exit.

```
X'00'
```

IPv4 addresses passed

```
X'01'
```

IPv6 addresses passed

User Word 1

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

User Word 2

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

Return Codes from the Mail Forwarding Exit Routine

Following are the return codes recognized by SMTP for this exit.

Table 77. Mail Forwarding Exit Return Codes

Return Code	Explanation
0	Accept and attempt mail delivery.
1	Reject mail with: 551 <i>Return String</i> If a return string is not provided by the exit, the following default message will be used: 551 User not local; please try <i>user@otherhost</i> If the server has already responded to the command, this return code will result in error mail being sent back to the sender.
2	Accept and forward to the local VM user ID specified by <i>Return String</i> . If the VM user ID is null or is not valid, the mail will be delivered to the local postmaster; the mail will not be delivered to the addressee.
4	Disable the exit. The following message will be displayed on the SMTP console: FORWARD MAIL EXIT function disabled The exit will no longer be called. SMTP will attempt to deliver this mail.
5	Reject this command with: 550 <i>Return String</i> If a return string is not provided by the exit, then the default message will be displayed: 550 Access denied All future communications on this connection will be rejected with this 550 message.
Other	Any return code other than the above causes SMTP to issue this message: Unexpected return from user exit <i>exitname</i> <i>exittype</i> , RC = <i>rc</i> SMTP treats this return code as if it were a return code of 0.

Mail Forwarding Sample Exits

Sample Mail Forwarding exit routines are supplied with TCP/IP on the TCPMAINT 591 disk. The supplied samples are:

SMTPFWDX SAMPEXEC

REXX exit routine that contains a sample framework for handling forwarded mail items. Your customized exit should be stored on the TCPMAINT 198 disk as file SMTPFWD XEXEC.

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SMTPFWDX SAMPASM

Assembler exit routine that contains a sample framework for handling forwarded mail items. Your customized exit should be stored on the TCPMAINT 198 disk as file SMTPFWDX ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMFHLASM SMTPFWDX DMSVM command), and the resulting text deck placed on the TCPMAINT 198 disk.

These samples are for illustrative purposes only. They should be modified to meet the needs of your installation before placing them in a production environment. The assembler exit will have better performance characteristics than the REXX exit. For best REXX performance, the SMTP server will EXECLOAD any REXX exit.

Using the SMTP Command Exit

The SMTP server can be configured to call an exit routine whenever certain SMTP commands are received, through use of the SMTP command exit. This exit can be defined such that is invoked for any or all the commands that follow:

HELO

The SMTP 'HELO' command.

EHLO

The SMTP 'EHLO' command.

MAIL

The SMTP 'MAIL FROM:' command.

RCPT

The SMTP 'RCPT TO:' command.

DATA

The SMTP 'DATA' command.

EOD The "end of data" condition. This occurs when a period (.) is received by the server, usually after all data has been transmitted.

VERFY

The SMTP 'VERFY' command.

EXPN

The SMTP 'EXPN' command.

RSET

The SMTP 'RSET' command.

PUNCH

The point in time when the server is about to deliver mail to a local destination on the same node or RSCS network; this command is unique to the VM TCP/IP SMTP server.

Note:

1. The person responsible for creating or maintaining programs that exploit this capability should be knowledgeable of the protocol(s) related to the SMTP commands that are processed using this exit.
2. Only one SMTP command exit can be active at a time.

The SMTP command exit could be used for a wide variety of purposes; several possible uses are included here:

- Reject particular SMTP commands. For example, you may not want your server to support the VRFY and EXPN commands.

Note: The SMTP server answers to the EXPN and/or VRFY commands. The EXPN command can be used to find the delivery address of mail aliases, or even the full name of the recipients, and the VRFY command may be used to check the validity of an account. Your mailer should not allow remote users to use any of these commands, because it gives them too much information.

- Handle the delivery of local mail in a specific manner.
- Screen and reject mail that contains offensive language, or fails to meet other criteria defined by your installation.

Note: Scanning the content of a message will severely degrade server performance.

SMTP Command Exit Parameter Lists

The parameter lists passed to the REXX and the assembler exit routines follow. When you customize either of these exits, keep in mind the in mind the following:

- Because an identical exit parameter list definition is used for *all* of the SMTP user exits, not all parameters may be meaningful for *this* exit. Parameters that are not used by this exit are indicated in the exit parameter lists; their values should be ignored.
- For the REXX exit, the value of an unused parameter will be such that any parsing will not be affected.

Parameter descriptions that pertain to both the REXX and assembler exits are provided in the “Parameter Descriptions” on page 358.

REXX Parameter List

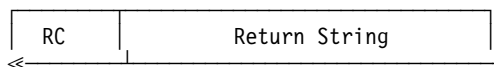
Inputs:

Table 78. SMTP Commands REXX Exit Parameter List

Argument	Description
ARG(1)	Parameter list defined as follows: <ul style="list-style-type: none"> • Exit type • Version number • Mail record ID • Port number of SMTP server • IPv4 address of SMTP server • Port number of client • IPv4 address of client • Filename of note on disk • Verify client status • Maximum length of Return String • IPv6 address of SMTP server • IPv6 address of client • Exit flags
ARG(2)	SMTP command string
ARG(3)	HELO/EHLO name
ARG(4)	MAIL FROM: string
ARG(5)	Client domain name
ARG(6)	Batch VM user ID

Outputs: The following are returned to the caller in the RESULT variable via a REXX RETURN statement:

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Argument

Description

RC The exit return code; this must be a 4-byte numeric value.

Return String

An exit-specified string; the returned value must have a length less than or equal to the maximum length passed to the exit.

Assembler Parameter List

Following is the parameter list that is passed to the assembler exit routine. General Register 1 points to the parameter list.

Table 79. SMTP Commands ASSEMBLER Exit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type
+4	4	Input	Int	Version number
+8	4	Input	Int	Mail record ID
+12	4	Input	Int	Port number of SMTP server
+16	4	Input	Int	IPv4 address of SMTP server
+20	4	Input	Int	Port number of client
+24	4	Input	Int	IPv4 address of client
+28	4	Input	Ptr	Address of SMTP command string
+32	4	Input	Int	Length of SMTP command string
+36	4	Input	Ptr	Address of HELO/EHLO name
+40	4	Input	Int	Length of HELO/EHLO name
+44	4	Input	Ptr	Address of client domain name
+48	4	Input	Int	Length of client domain name
+52	4	Input	Ptr	Address of MAIL FROM: string
+56	4	Input	Int	Length of MAIL FROM: string
+60	8	Input	Char	File name of note on disk
+68	4	Input	Int	Verify client status
+72	4	Output	Ptr	Address of Return String
+76	4	Output	Int	Length of Return String
+80	4	Input	Int	Maximum length of Return String
+84	16	Input	Char	IPv6 address of SMTP server
+100	16	Input	Char	IPv6 address of SMTP server
+116	1	Input	Char	Exit flags
+117	3			Not used
+120	8	Input	Char	Batch VM User ID
+128	4	Input/ Output	Char	User Word 1
+132	4	Input/ Output	Char	User Word 2
+136	4	Output	Int	Return code from exit

Parameter Descriptions:

Exit type

A four-character field that indicates the type of exit called. For the SMTP command exit, this is **CMDX**.

Version number

The parameter list version number; if the parameter list format is changed, the version number will change. Your exit should verify it has received the expected version number. The current version number is 2.

Mail record ID

A number that uniquely identifies a piece of mail so that multiple exit calls can be correlated to the same piece of mail. A value of 0 indicates a mail record ID is not available.

Port number of SMTP server

The port number used by the SMTP server for this connection.

IP address of SMTP server

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv4 address to determine in which part of the network the client host resides.

Port number of client

If the connection no longer exists, or if the command was received over a batch (BSMTP) connection, -1 is supplied. Otherwise, this is the port number used by the foreign host for this connection.

IP address of client

For the REXX exit, a dotted-decimal format IPv4 address is provided; for the assembler exit, this is an IPv4 address in decimal integer form. If the relevant SMTP command was received over a batch SMTP (BSMTP) connection, this field is 0.

File name of note on disk

Name of the file created after the "end of data" (EOD) condition, a period (.), is received. Prior to either of these conditions, the file name is not defined; in this case, an asterisk (*) will be supplied.

Verify Client status

A number that indicates client verification results. Possible values and their meanings are:

- 0 Client verification passed.
- 1 Client verification failed.
- 2 Client verification was not performed.
- 3 Client verification results are unknown.

SMTP command string

Contains the current command and parameters; the string has been converted to uppercase. For example, if this exit was called for the MAIL FROM: command, this string might contain: MAIL FROM: <USERA@MYDOMAIN>.

HELO/EHLO name

A string that contains the name specified on the HELO or EHLO command; this string may be either:

- a domain name
- an IP address in decimal integer form that is prefixed by the number or (US) pound sign ("#" or X'7B')
- an IP address in dotted-decimal form, enclosed in brackets.

For example, if the command HELO #123456 is provided by an SMTP client, this parameter would contain: #123456.

The name has already been verified to have the correct syntax.

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MAIL FROM: string

Contains the name specified on the MAIL FROM: command. The sender path, enclosed in angle brackets (< and >), is included. The sender path may be in any valid path format; it has already been verified to have the correct syntax. Because the sender address has been resolved, this string may not exactly match the data provided with the MAIL FROM: command.

For example, if the following has been specified by the SMTP client:

```
MAIL FROM: <userb@host2>
```

the SMTP command string might contain: <userb@host2.com>

Client domain name

The domain name that corresponds to the client IP address. This field will be a null string if:

- client verification was not performed
- the results of client verification are unknown
- a reverse lookup failed

In all other cases, this will be a domain name.

Batch VM user ID

This field is only used when SMTP commands arrive over a batch SMTP (BSMTP) connection. If this exit is called for batch SMTP connections, this field will contain the VM User ID that originated the mail. Otherwise, this field is not defined and will contain nulls.

User Word 1

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

User Word 2

Provided for use by the assembler exit only. The user word specified upon return from this exit will be passed back in this field for any future calls; 0 is the initial value. The SMTP server does not use this value in any way.

Return String

When the exit returns a return code of 1 or 5, this value is appended to the 550 reply code.

Maximum length of Return String

The current maximum is 512 bytes; ensure the *Return String* length is less than this value. If the returned string is longer than the indicated maximum, the return string is truncated and the following message is displayed on the SMTP server console:

```
Return data from exit exitname exittype too long, data truncated
```

Normal processing continues.

IPv6 address of SMTP server

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form. For multi-homed hosts, this address can be compared with the client IPv6 address to determine in which part of the network the client host resides.

IPv6 address of client

For the REXX exit, an IPv6 address in full or compressed form is provided; for the assembler exit, this is an IPv6 address in decimal integer form.

Exit flags

Flags passed to the exit.

X'00'

IPv4 addresses passed

X''

IPv6 addresses passed

Return Codes from the SMTP Command Exit Routine

Following are the return codes recognized by SMTP for this exit.

Table 80. SMTP Command Exit Return Codes

Return Code	Explanation
0	Accept command, and continue normal processing.
1	Reject mail with: <i>550 Return String</i> If a return string is not provided by the exit, the following default message will be used: <i>550 Command Rejected</i> This return code is not valid for the PUNCH command; if 1 is returned for a PUNCH command exit call, it will be handled as an invalid exit return code.
2	The PUNCH command has been handled by the exit routine; therefore, bypass file delivery. This return code is valid for only the PUNCH command.
3	PUNCH the mail to an alternate user ID that is specified in the return string that is passed back by the exit routine. If a return string is not provided by the exit, or the return string is too long for a VM user ID, then this return code is treated in the same manner as a return code of 0 and normal file delivery will occur. If the return string does contain a valid user ID, then the SMTP server will deliver this mail to that user ID with the distribution code set to the user ID of the original recipient. This return code is only valid for the PUNCH command.
4	Disable the exit. The following message will be displayed on the SMTP console: <i>SMTPCMDS EXIT function disabled</i> The exit will no longer be called. The command will be attempted, and processing will continue.
5	Reject this command with: <i>550 Return String</i> If a return string is not provided by the exit, then the default message will be displayed: <i>550 Access denied</i> All future communications on this connection will be rejected with this 550 message.
6	Treat this RCPT TO command as a NOOP. The SMTP server will just reply to the RCPT TO with "250 OK", but will take no action on it. This return code can be used to ignore a null RCPT TO command or to ignore a RCPT TO command based on the recipient information it contains. This return code is only valid for the RCPT TO command.

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Table 80. SMTP Command Exit Return Codes (continued)

Return Code	Explanation
Other	Any return code other than the above causes SMTP to issue this message: Unexpected return from user exit <i>exitname</i> <i>exittype</i> , RC = <i>rc</i> SMTP treats this return code as if it were a return code of 0.

SMTP Command Sample Exits

Sample SMTP Command exit routines are supplied with TCP/IP on the TCPMAINT 591 disk. The supplied samples are:

SMTPCMDX SAMPEXEC

REXX exit routine that contains a sample framework for SMTP command processing. Your customized exit should be stored on the TCPMAINT 198 disk as file SMTPCMDX EXEC.

SMTPCMDX SAMPASM

Assembler exit routine that contains a sample framework for SMTP command processing. Your customized exit should be stored on the TCPMAINT 198 disk as file SMTPCMDX ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMFLASM SMTPCMDX DMSVM command), and the resulting text deck placed on the TCPMAINT 198 disk.

These samples are for illustrative purposes only. They should be modified to meet the needs of your installation before placing them in a production environment. The assembler exit will have better performance characteristics than the REXX exit. For best REXX performance, the SMTP server will EXECLOAD any REXX exit.

Chapter 9. Telnet Exits

The Telnet server exits described in the sections that follow provide CP command simulation, TN3270E printer management, and system access control when Telnet connections are established with your host.

Prior to customizing the server exits described in this section, ensure that you have reviewed the exit limitations and customization recommendations presented in the "Customizing Server-specific Exits" section of the *z/VM: TCP/IP Planning and Customization*.

While the SCEXIT or PMEXIT is running, the TCP/IP service machine cannot service any other requests. Therefore, it is advised that processing performed within these exits should be minimized.

Also, in environments with a high rate of TN3270 and/or TN3270E session creation and termination, the use of a REXX exec could adversely affect performance. While calling such an exec may be useful for designing and testing a prototype, a production-level exit should be written in assembler. For such environments, the supplied sample Telnet session connection exit (SCEXIT SAMPASM) and printer management exit (PMEXIT SAMPASM) should be used as a basis for assemble files which directly perform any actions appropriate for your environment. It is recommended that execs be used only for designing and testing an exit prototype; for best performance, such execs should be EXECLOADED.

Telnet Session Connection Exit

When a Telnet client establishes a session with TCP/IP for VM and **InternalClientParms ConnectExit** has been specified, the exit routine receives control using standard OS linkage conventions. Register 1 points to a parameter list to be used by the exit.

Telnet Exit Parameter List

Table 81. Telnet Session Connection Exit Parameter List

Offset	Len	Name	In/Out	Description
+0	1	SCREASON	Input	Reason Exit was called X'01' - Client connect
+1	1	SCFLAGS1	Input	Flags 1... - Connection is IPv6xxx - Reserved
			Output	Flags 1... - Hide VM logo from client .1.. - Hide command simulation ..xx xxxx - Reserved
+2	2	Reserved		
+4	4	SCIPADDR	Input	IPv4 address of client
+8	2	SCPORT	Input	Telnet server port number

Telnet Session Connection Exit

Table 81. Telnet Session Connection Exit Parameter List (continued)

Offset	Len	Name	In/Out	Description
+10	2	SCCMDL	Input Output	Length of command buffer Length of command placed in buffer
+12	4	SCPCMD	Input	Address of command buffer
+16	4	SCRC	Output	Return code 0 = Give client VM logo 4 = Reject client, no message 8 = Perform command in SCPCMD; SCCMDL must be non-zero 12 = Same as 0, and disable exit 16 = Same as 4, and disable exit 20 = Same as 8, and disable exit All others will reject the client, and a message is displayed on the TCPIP virtual machine console.
+20	2	SCFPORT	Input	Client foreign port number
+22	2	Reserved		
+24	16	SCLUNAME	Input	Client-provided LU name
+40	4	SCLIPADD	Input	Local IPv4 address to which client connected
+44	32	SCCIPHER	Input	Encryption suite used by the connection. The string will be UNSECURED if it is not a secure connection.
+76	16	SCIP6ADD	Input	IPv6 address of client
+92	16	SCLIP6AD	Input	Local IPv6 address to which client connected

Sample Exit

Sample Telnet connection exit routines are supplied with TCP/IP on the TCPMAINT 591 minidisk. The supplied samples are:

SCEXIT SAMPEXEC

REXX exit routine that contains the logic for allowing or denying access by Telnet clients. Your customized exit should be stored on the TCPMAINT 198 disk as file SCEXIT EXEC.

SCEXIT SAMPASM

The assembler exit routine called by the Telnet server; the exit is used to call SCEXIT EXEC and to pass results back to the Telnet server. Your customized exit should be stored on the TCPMAINT 198 disk as file SCEXIT ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMHLASM SCEXIT DMSVM command), and the resulting text deck placed on the TCPMAINT 198 disk.

SCEXIT TEXTSAMP

TEXT file produced by assembly of the aforementioned SCEXIT SAMPASM assemble file. If the supplied SCEXIT assembler routine meets the needs of your installation in its supplied form, the SCEXIT TEXTSAMP file can be stored on the TCPMAINT 198 disk as file SCEXIT TEXT, and used as is, without the need to separately assemble the exit assembler source file.

The sample exit is enabled by including the following in PROFILE TCPIP:

```
InternalClientParms
  ConnectExit SCEXIT
EndInternalClientParms
```

Telnet Printer Management Exit

When a client establishes a TN3270E printer session with TCP/IP for VM and **InternalClientParms TN3270EExit** has been specified, the exit routine receives control when a printer session is established or terminated. The exit is called using standard CMS linkage conventions. General Register 1 points to a parameter list that the exit may use.

Telnet Printer Management Exit Parameter List

Table 82. Telnet Exit Parameter List

Offset	Len	Name	In/Out	Description
+0	1	PMXVERSN	Input	Parameter list version number X'02'
+1	1	PMXREASN	Input	Reason exit called X'00' - Printer connected X'01' - Printer disconnected
+2	1	PMXFLAG	Input	Flags 1... - Connection is IPv6 .xxx xxxx - Reserved
+3	1	Reserved		
+4	4	PMXIPADD	Input	IPv4 address of client
+8	2	PMXFPORT	Input	Client port number
+A	2	PMXLPORT	Input	Telnet server port number
+C	4	PMXLDEV	Input	Logical device number
+10	8	PMXLUNAM	Input	Logical unit name specified by client
+18	8	PMXUSER	Input	Associated user identifier. If no matching TN3270E configuration statement exists, contains "?"
+20	4	PMXVDEV	Input	Associated virtual device address. If no matching TN3270E configuration statement exists, contains "?"
+24	4	PMXRC	Output	Return code 0 = Accept client 4 = Reject client 8 = Same as 0, and disable exit 12 = Same as 4, and disable exit All others will reject client, and a message is displayed on the TCPIP virtual machine console.
+28	16	PMXIP6AD	Input	IPv6 address of client

Sample Exit

Sample printer management exit routines are supplied with TCP/IP on the TCPMAINT 591 minidisk. The supplied samples are:

Telnet Printer Management Exit

PMEXIT SAMPEXEC

REXX exit routine that contains the logic for allowing or denying access by TN3270 clients. Your customized exit should be stored on the TCPMAINT 198 disk as file PMEXIT EXEC.

PMEXIT SAMPASM

The assembler exit routine called by the Telnet server; the exit is used to call PMEXIT EXEC and to pass results back to the Telnet server. Your customized exit should be stored on the TCPMAINT 198 disk as file PMEXIT ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMHLASM PMEXIT DMSVM command, and the resulting text deck placed on the TCPMAINT 198 disk.

PMEXIT TEXTSAMP

TEXT file produced by assembly of the aforementioned PMEXIT SAMPASM assemble file. If the supplied PMEXIT assembler routine meets the needs of your installation in its supplied form, the PMEXIT TEXTSAMP file can be stored on the TCPMAINT 198 disk as file PMEXIT TEXT, and used as is, without the need to separately assemble the exit assembler source file.

Enable the sample exit by including the following in PROFILE TCPIP:

```
InternalClientParms
  TN3270EExit PMEXIT
EndInternalClientParms
```

Chapter 10. FTP Server Exit

The FTP server user exits described in the next sections allow you greater control over commands received by the FTP server and allows for auditing of FTP logins,logouts and file transfers.

Prior to customizing the server exit described in this section, ensure that you have reviewed the exit limitations and customization recommendations presented in the "Customizing Server-specific Exits" section of the *z/VM: TCP/IP Planning and Customization*.

The exit is enabled using the **FTAUDIT**, **FTCHKCMD**, and **FTCHKDIR** startup parameters on the SRVRFTP command or by using the FTP SMSG commands. The startup parameters and SMSG commands are documented in *z/VM: TCP/IP Planning and Customization*.

Since the use of the FTP exits adversely affects performance, it is advised that processing performed within the exit should be minimized. While calling a REXX exec is useful for designing an exit prototype, a production-level exit should be written entirely in assembler. For best performance, any REXX execs should be EXECLOADed.

The FTP Server Exit

The following are descriptions of sample FTP server exit routines.

Sample Exit

Sample FTP server exit routines are supplied with TCP/IP on the TCPMAINT 591 minidisk. The supplied samples are:

FTPEXIT SAMPEXEC

REXX exit routine that contains sample logic for login and directory control, and FTP command processing. Your customized exit should be stored on the TCPMAINT 198 disk as file FTPEXIT EXEC.

FTPEXIT SAMPASM

The assembler exit routine called by the FTP server; the exit is used to call FTPEXIT EXEC and to pass results back to the FTP server. Your customized exit should be stored on the TCPMAINT 198 disk as file FTPEXIT ASSEMBLE. The customized ASSEMBLE file must be assembled (by using the VMFHLASM FTPEXIT DMSVM command), and the resulting text deck placed on the TCPMAINT 198 disk.

FTPEXIT TEXTSAMP

TEXT file produced by assembly of the aforementioned FTPEXIT SAMPASM assemble file. If the supplied FTPEXIT assembler routine meets the needs of your installation in its supplied form, the FTPEXIT TEXTSAMP file can be stored on the TCPMAINT 198 disk as file FTPEXIT TEXT, and used as is, without the need to separately assemble the exit assembler source file.

These samples are for illustrative purposes only. They should be modified to meet the needs of your installation before placing them in a production environment.

Audit Processing

With the FTP server exit enabled for audit processing, the FTP Exit will be called for each of the following events:

- LOGIN
Auditing occurs following FTP user login validation
- LOGOUT
Logout occurs when a:
 - user enters a QUIT command
 - user enters a new USER command while already logged in
 - connection is dropped by an SMSG DROP command
 - client aborts the connection
 - connection is closed because the server is shutting down
 - connection times out
- DATA TRANSFER
Data transfers include the following commands:
 - APPE (client append command)
 - STOR, STOU (client put command)
 - RETR (client get command)
 - LIST, NLST (client dir, ls commands)

Note: Audit exit processing is enabled with the **FTAUDIT** startup parameter or with the **SMSG** command to enable exits.

Audit Processing Parameter List

Table 83. FTP Exit Audit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type (AUDX)
+4	4	Input	Int	Version number
+8	8	Input	Char	FTP server command
+16	4	Input	Ptr	Address of command argument string; the first halfword contains the length.
+20	8	Input	Char	Login user ID
+28	8	Input	Char	LOGONBY user ID
+36	4	Input	Int	IPv4 address of client
+40	4	Input	Ptr	Address of current working directory name; the first halfword contains the length.
+44	4	Input	Ptr	Address of target directory or file; the first halfword contains the length.

Table 83. FTP Exit Audit Parameter List (continued)

Offset in Decimal	Len	In/Out	Type	Description
+48	8	Input	Unsigned double	Number of bytes transferred.
+56	4	Input	Int	Control connection secure setting
+60	4	Input	Int	Data connection secure setting
+64	2	Input	Int	Port number of FTP server
+66	2	Input	Int	Port number of FTP client
+68	8	Input	Char	Event time (yyyy:mm:dd)
+76	8	Input	Char	Event time (hh:mm:ss)
+84	8	-	-	Not used
+92	4	Output	Int	Return code from exit
+96	16	Input	Char	IPv6 address of client
+112	16	Input	Char	Local IPv6 address

Audit Processing Parameter Descriptions

Exit Type

A 4 character field that indicates the type of exit processing to be performed. For audit processing, this is **AUDX**.

Version number

If the parameter list format is changed, then the version number will change. Your exit should verify it has received the expected version number. The current version number is 4.

FTP server command

This field contains one of the following commands: **LOGIN**, **LOGOUT**, **XFER**.

FTP command argument string

- For data transfer (XFER) commands, this string indicates the transfer direction. **SENDING** indicates data is being transferred to a client; **RECEIVING** indicates data is being received from a client.
- For login commands, this string indicates the command that initiated login validation processing (**USER** for anonymous logins or **PASS**)
- For logout commands, this string indicates the command or function which initiated the logout (**QUIT**, **USER**, **DROPPED**, **TIMEOUT**, **SHUTDOWN**, **ABORTED**).

Login user ID

The VM user identifier associated with this FTP session. All FTP client authorization checks are made using the login user ID.

FTP Server Exit

LOGONBY user ID

The alternate logon name whose password is used for login authorization checking. A user ID will be present in this field only when the client has issued a USER subcommand that includes the *userid/BY/byuserid* operands; otherwise, a hyphen (-) will be present.

IPv4 address of client

The IPv4 address in binary integer form.

Current working directory name

This field is not used for login or logout processing and will contain a hyphen (-). For data transfers, this field contains the type of directory in use, followed by the working directory name. For example:

Directory Type	Working Directory passed to FTPEXIT
Minidisk	DSK TERL.191
Shared File System	SFS SERVK1:TERL.
Byte File System	BFS ../VMBFS:BFS:TERL/
Virtual Reader	RDR TERL.RDR

Target file

Target file for data transfer. Minidisk, SFS, or RDR files are identified in upper case using the *filename.filetype* format. BFS files are identified using a mixed case *filename*, that can be up to 255 characters long. This field is not used for login and logout processing and will contain a hyphen (-).

Number of bytes transferred

- For data transfer (XFER) commands, this field contains the number of bytes transferred on the data connection.
- For login commands, this field contains a zero.
- For logout commands, this field contains a zero.

Control connection secure setting

The secure setting of the control connection. 0 indicates not applicable. 1 indicates clear (non-secure). 2 indicates secure using TLS.

Data connection secure setting

The secure setting of the data connection. 0 indicates not applicable. 1 indicates clear (non-secure). 2 indicates secure using TLS.

Port number of FTP server

The port number used by the FTP server for this control connection.

Port number of client

The port number used by the foreign host for this control connection.

Event date

The date format for this parameter is *yyyymmdd*.

Event time

The time format for this parameter is *hh:mm:ss*.

Return code from exit

An integer return code. For a list of return codes recognized by the FTP server see "Return Codes from Audit Processing" on page 371.

IPv6 address of client

The remote IPv6 address of this client, in octet binary format.

Local IPv6 address

The local IPv6 address to which this client connected, in octet binary format.

Return Codes from Audit Processing

Return Code	Use / Description
0	Continue processing.
8	Continue processing, but disable audit exit. The following message is displayed on the FTP server console: "FTP AUDX exit has been disabled".
Other	Any return code other than the above causes FTP to issue the message: "Unexpected return from user exit FTPEXIT AUDX, RC = rc". The server will treat this return code as if it were a return code of 0.

General Command Processing

With the FTP server exit enabled for general command exit processing, the FTP exit will be called to perform command validation for every received FTP command.

Commands that may be passed to this exit follow:

ABOR	ACCT	ALLO	APPE	CDUP	CWD
DELE	EPRT	EPSV	HELP	LIST	MKD
MODE	NLST	NOOP	PASS	PASV	PORT
PWD	QUIT	REIN	REST	RETR	RMD
RNFR	RNTO	SITE	SYST	STAT	STOR
STOU	STRU	TYPE	USER	UNKNOWN	XCWD
XMKD	XPWD				

Note: See RFC 959 for details about the above commands.

Note: See RFC 2428 for more details on EPSV and EPRT.

Also, the AUTH, PBSZ, and PROT commands described in RFC 4217 may be passed to this exit. See RFC 4217 for more details.

The general command exit can be used to perform additional security checking and then take an appropriate action, such as the following:

- Reject commands from a particular IP address, user ID or LOGONBY user ID
- Reject a subset of commands for anonymous users
- Reject transfer requests for specific files
- Reject all users from issuing store (APPE, STOR, STOU) commands

Note: General command exit processing is enabled with the FTCHKCMD startup parameter or with the SMSG command to enable exits.

General Command Processing Parameter List

Table 84. FTP Exit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type (CMDX)
+4	4	Input	Int	Version number

Table 84. FTP Exit Parameter List (continued)

Offset in Decimal	Len	In/Out	Type	Description
+8	8	Input	Char	FTP server command
+16	4	Input	Ptr	Address of command argument string; the first halfword contains the length.
+20	8	Input	Char	Login user ID
+28	8	Input	Char	LOGONBY user ID
+36	4	Input	Int	IPv4 address of client
+40	4	Input	Ptr	Address of current working directory name; The first halfword contains the length.
+44	12	-	-	Not used
+56	4	Input	Int	Control connection secure setting
+60	4	Input	Int	Data connection secure setting
+64	2	Input	Int	Port number of FTP server
+66	2	Input	Int	Port number of FTP client
+68	16	-	-	Not used
+84	4	Input	Int	Maximum length of return string
+88	4	Output	Int	Address of return string (message text)
+92	4	Output	Int	Return code from exit
+96	16	Input	Char	IPv6 address of client
+112	16	Input	Char	Local IPv6 address

General Command Processing Parameter Descriptions

Exit Type

A 4 character field that indicates the type of exit processing to be performed. For command exit processing, this is **CMDX**.

Version number

If the parameter list format is changed, then the version number will change. Your exit should verify it has received the expected version number. The current version number is 4.

FTP server command

Commands received by the server such as **USER**, **STOR**, and **DELE**.

FTP command argument string

The argument string provided by the client. For **ACCT** and **PASS** commands, the argument string will contain all asterisks (*********).

Login user ID

The VM user identifier associated with this FTP session. All FTP client authorization checks are made using the login user ID.

LOGONBY user ID

The alternate logon name (*userid*) whose password is used for login authorization checking. A user ID will be present in this field only when the client has issued a **USER** subcommand that includes the *userid/BY/byuserid* operands; otherwise, a hyphen (-) will be present.

IPv4 address of client

The IPv4 address in decimal integer form.

Current working directory name

This field contains the type of directory, followed by the working directory name. For example:

Directory Type	Working Directory passed to FTPEXIT
Minidisk	DSK TERI.191
Shared File System	SFS SERVK1:TERI.
Byte File System	BFS ../VMBFS:BFS:TERI/
Virtual reader	RDR TERI.RDR
No directory defined	-

Control connection secure setting

The secure setting of the control connection. 0 indicates not applicable. 1 indicates clear (non-secure). 2 indicates secure using TLS.

Data connection secure setting

The secure setting of data connections. 0 indicates not applicable. 1 indicates clear (non-secure). 2 indicates secure using TLS.

Port number of FTP server

The port number used by the FTP server for this control connection.

Port number of client

The port number used by the foreign host for this control connection.

Maximum length of return string

The current maximum is 1000 bytes. If the returned string is longer than the maximum, the return string is truncated.

Return string

A return string is to be included as part of the server reply to an FTP client. This string is used only when a return code of 4 or 12 is returned by the exit.

Return code from exit

An integer return code. For a list of return codes recognized by the FTP server see "Return Codes from General Command Processing" on page 374.

IPv6 address of client

The remote IPv6 address of this client, in octet binary format.

Local IPv6 address

The local IPv6 address to which this client connected, in octet binary format.

Example

If the FTP client provides the command "PUT PROFILE.EXEC", the parameter values provided to the FTPEXIT might be:

FTPEXIT Parameter Values

Exit Type	AUDX
FTP command	XFER
Client IP Address	9.111.32.29
UserID	TERI
ByUserID	-
Bytes transferred	2141
Control connection secure setting	1

FTPEXIT Parameter Values

Data connection secure setting	1
Server Port	1021
Client Port	21400
Event Date	19990309
Event Time	14:44:34
Working Directory	SFS SERVK1:TERI.
Command args	RECEIVING
Target File	PROFILE.EXEC
Remote IPv6 Address	0000:0000:0000:0000:0000:0000:0000:0000
Local IPv6 Address	0000:0000:0000:0000:0000:0000:0000:0000

Return Codes from General Command Processing

Return Code	Use / Description
0	Accept command and continue processing
4	Reject client command with "502 return_string". If return string is not provided, return the default message "502 command rejected".
8	Accept command, continue normal processing, but disable command exit processing. The following message is displayed on the FTP server console: "FTP CMDX exit has been disabled".
12	Same as 4 and disable command exit processing. The following message is displayed on the FTP server console: "FTP CMDX exit has been disabled".
Other	Any return code other than the above causes FTP to issue the message: "Unexpected return from user exit FTPEXIT CMDX, RC = rc". The server will treat this return code as if it were a return code of 0.

Change Directory Processing

With the FTP server the exit will be called to validate FTP directory changes and provide greater control over access to system resources by selectively honoring or refusing a client change directory request. The exit is called when an FTP client provides one of the following commands:

- **CWD** or **CD** to change the working directory
- **CDUP** to change the working directory to the parent directory
- **PASS** with a default directory defined in CHKIPADR EXEC
- **USER** for an anonymous login with a default directory defined in CHKIPADR EXEC
- **APPE**, **DELE**, **LIST**, **NLST**, **RETR**, **SIZE**, **STOR**, and **STOU** commands that involve an explicit change in directory.

Note: See RFC 959 for details about the above commands.

Also, the **AUTH**, **PBSZ**, and **PROT** commands described in RFC 4217 may be passed to this exit. See RFC 4217 for more details.

Change Directory Processing Parameter List

Table 85. FTP Exit Parameter List

Offset in Decimal	Len	In/Out	Type	Description
+0	4	Input	Char	Exit type (DIRX)
+4	4	Input	Int	Version number
+8	8	Input	Char	FTP server command
+16	4	Input	Ptr	Address of command argument string; the first halfword contains the length.
+20	8	Input	Char	Login user ID
+28	8	Input	Char	LOGONBY user ID
+36	4	Input	Int	IPv4 address of client
+40	4	Input	Ptr	Address of current working directory name; the first halfword contains the length.
+44	4	Input	Ptr	Address of target directory or file; the first halfword contains the length.
+48	16	-	-	Not used
+64	2	Input	Int	Port number of FTP server
+66	2	Input	Int	Port number of FTP client
+68	16	-	-	Not used
+84	4	input	Int	Maximum length of return string
+88	4	Output	Int	Address of return string (message text)
+92	4	Output	Int	Return code from exit
+96	16	Input	Char	IPv6 address of client
+112	16	Input	Char	Local IPv6 address

Change Directory Processing Parameter Descriptions

Exit Type

A 4 character field that indicates the type of exit processing to be performed. For CD command exit processing, this is **DIRX**.

Version number

If the parameter list format is changed, then the version number will change. Your exit should verify it has received the expected version number. The current version number is 4.

FTP server command

This field will contain **APPE**, **CWD**, **CDUP**, **DELE**, **LIST**, **NLST**, **PASS**, **RETR**, **SIZE**, **STOR**, **STOU**, or **USER**.

FTP command argument string

The argument string entered by the client. For **PASS** commands, the argument string will contain asterisks (*********).

Login user ID

The VM user identifier associated with this FTP session. All FTP client authorization checks are made using the login user ID.

LOGONBY user ID

The alternate logon name (*userid*) whose password is used for login authorization checking. A user ID will be present in this field only when the client has issued a **USER** subcommand that includes the *userid/BY/byuserid* operands; otherwise, a hyphen (-) will be present.

FTP Server Exit

IPv4 address of client

The IPv4 address in decimal integer form.

Current working directory name

This field contains the type of directory, followed by the working directory name. For example:

Directory Type	Working Directory Passed to FTPEXIT
Minidisk	DSK TERI.191
Shared File System	SFS SERVK1:TERI.
Byte File System	BFS ../VMBFS:BFS:TERI/
Virtual reader	RDR TERI.RDR
No directory defined	-

Target directory

This field contains the fully-qualified target directory for the command. Format of the target directory is similar to the current working directory name format. The following examples show representative values that would be passed to the exit for certain actions or requests made by a client user.

For user login:

```
FTP command      : PASS
Working Directory : -
Command args     : *****
Target Directory  : DSK TERI.191
```

For a CD to a BFS directory request:

```
FTP command      : CWD
Working Directory : DSK TERI.191
Command args     : ../VMBFS:BFS:SCOTT/
Target Directory  : BFS ../VMBFS:BFS:SCOTT/
```

For a CD to a BFS subdirectory request:

```
FTP command      : CWD
Working Directory : BFS ../VMBFS:BFS:SCOTT/
Command args     : SUBDIR
Target Directory  : BFS ../VMBFS:BFS:SCOTT/SUBDIR/
```

Port number of FTP server

The port number used by the FTP server for this control connection.

Port number of client

The port number used by the foreign host for this control connection.

Maximum length of return string

The current maximum is 1000 bytes. If the returned string is longer than the maximum, the return string is truncated.

Return string

A return string is to be included as part of the server reply to an FTP client. This string is used only when a return code of 4 or 12 is returned by the exit.

Return code from exit

An integer return code. For a list of return codes recognized by the FTP server see "Return Codes from the FTPEXIT Routine for CD Command Processing" on page 377.

IPv6 address of client

The remote IPv6 address of this client, in octet binary format.

Local IPv6 address

The local IPv6 address to which this client connected, in octet binary format.

Return Codes from the FTPEXIT Routine for CD Command Processing

Return Code	Use / Description
0	Accept command and continue normal processing
4	Reject client command with "502 <i>return_string</i> ". If <i>return_string</i> is not provided, display the default message "502 command rejected".
8	Accept command, continue normal processing, but disable CD command exit processing. The following message is displayed on the FTP server console: "FTP DIRX exit has been disabled".
12	Same as 4 and disable CD command exit processing. The following message is displayed on the FTP server console: "FTP DIRX exit has been disabled".
Other	Any return code other than the above causes FTP to issue the message: "Unexpected return from user exit FTPEXIT DIRX, RC = <i>rc</i> ". The server will treat this return code as if it were a return code of 0.

FTP Server Exit

Chapter 11. IMAP Authentication Exit

The IMAP authentication exit is a customizable exit that handles pre-authorized connections, user name and password validation, and mapping of client user names to IMAP mailstore names. The authentication exit routine runs in a separate authentication virtual machine (the authentication server) specified by the IMAP administrator through the AUTHENTICATEID statement in the IMAP configuration file. The authentication server establishes a CMS message queue and waits for the IMAP server to send requests. If the IMAP server opens the request queue and the authentication server is not running, it is autologged.

The IMAP authentication exit handles the following requests from the IMAP server:

- Interaction with the IMAP server during initialization and termination
- Acceptance or rejection of pre-authorized connections
- Control of user logins
- Mapping of client user names to IMAP mailstore names

The IMAP Authentication Exit

The following sections describe the IMAP authentication exit.

Sample Exit IMAPAUTH SAMPEXEC

A sample IMAP authentication exit routine is supplied with TCP/IP on the TCPMAINT 591 minidisk.

IMAPAUTH SAMPEXEC is a REXX exit routine that contains sample logic for authenticating an IMAP client and mapping a client name to an IMAP mailstore name. The sample is for illustrative purposes only. You should modify it to meet the needs of your installation before placing the sample in a production environment. Store your customized exit on the TCPMAINT 198 disk as **IMAPAUTH EXEC**.

IMAP Authentication Exit Processing

With the IMAP authentication exit enabled, the exit is called for the following requests:

- **0 (Initialization or Init)**. Establish a connection between the IMAP server and the IMAP authentication server. The response from the authentication exit indicates which requests the exit supports. The exit must support **Init** and **Shutdown** requests. Support for other requests is optional.
- **1 (Shutdown)**. The IMAP server is shutting down. The exit should also shutdown and log off.
- **2 (Pre-authorization or PreAuth)**. Determine if an IP address that has just connected to the IMAP server is pre-authorized. If the connection is pre-authorized, the IMAP server sends the client a "PREAUTH" greeting, indicating that the connection has already been authenticated by external means and thus no LOGIN command is needed.
- **3 (Login)**. Allow or disallow a user LOGIN command. The exit is passed a user name and password.

IMAP Authentication Exit

- **4 (Administrative lookup mapping or Map).** Map a client user name to an IMAP mailstore name. Mapping is used by the new mail arrival routine and various administration commands. If the Login exit request is not supported, mapping is also done by the Login command.

IMAP Authentication Parameter List

Table 86. IMAP Authentication Exit Parameter List

Offset in Decimal	Len	Type	Description
Input (through QueueSendReply to IMAPAuthRequestQ)			
+0	1	Int	Request code
+1	3	—	Reserved
+4	4	Int or char	Reply key
+8	156	Char	Request string, dependent on request (See IMAPAPI H for the formal definition of the structure format. See IMAPAUTH SAMPEXEC for an informal example of parsing the structures.)
Output (through QueueReply)			
+0	4	Int or char	Reply key
+4	4	Int	Return code
+8	4	Int	Reason code
+12	16	Char	Reply string, dependent on request (See IMAPAPI H for the formal definition of the structure format. See IMAPAUTH SAMPEXEC for an informal example of parsing the structures.)

IMAP Authentication Parameter Descriptions

Request code

The reason the exit was called. Valid codes are:

- 0 Initialization (Init)
- 1 Shutdown
- 2 Pre-authorization (PreAuth)
- 3 Login
- 4 Administrative mapping lookup (Map)

Reply key

A four-byte value used as the key for replies. The request code is used as the key when the request is sent to the exit. The exit must move the reply key value from the request structure to the reply structure and use it as the key on the reply.

Request string

See IMAPAPI H for the formal definition of the structure format. See IMAPAUTH SAMPEXEC for an informal example of parsing the structures.

Return code

An integer. See "Return Codes from the IMAP Authentication Exit" on page 381.

Reason code

An integer. There are no reason codes defined. The exit can define them as it sees fit. Reason codes have no affect on the server's handling of a reply (which

is based solely on the return code), but they will be included in any messages the server issues relating to a reply from the exit.

Reply string

See IMAPAPI H for the formal definition of the structure format. See IMAPAUTH SAMPEXEC for an informal example of parsing the structures.

Return Codes from the IMAP Authentication Exit

Table 87. Return codes from the IMAP authentication exit

Request	Return code	Description
0 (Initialization)	0	Accepted. There is a connection between the IMAP server and the IMAP authentication server.
	any other return code	The IMAP server is prevented from starting.
1 (Shutdown)	any return code	The value of the return code is irrelevant to the reply to this request. The server validates that it is one of the four architected return codes, but, other than that, it ignores the return code. Even though the server is shutting down, the exit must still respond to this request (as it must do to all requests).
2 (Pre- authorization)	0	Accept. A valid SFS ID ¹ has been returned. An “* PREAUTH” response is sent to the client indicating it is preauthenticated and does not need to do a LOGIN command. If the SFS ID is not valid, the IMAP server continues as if Reject had been returned.
	4	Defer. The server's default behavior determines whether the connection is preauthenticated or not. The server's default behavior is to accept all connections and send an “* OK” response to the client, indicating commands will be accepted but the client must LOGIN in order to enter the authenticated state.
	8	Reject. The request to preauthenticate this connection is rejected. An “* OK” response is sent to to the client indicating commands will be accepted but the client must LOGIN in order to enter the authenticated state.
	12	Terminate. This connection is not to be accepted. An “* BYE” response will be sent to the client and then the socket will be closed.

IMAP Authentication Exit

Table 87. Return codes from the IMAP authentication exit (continued)

Request	Return code	Description
3 (Login)	0	Accept. The user ID and password the IMAP server passed to the exit are valid and a valid SFS ID ¹ for that user ID has been returned. If it is not valid, the IMAP server continues as if Reject had been returned.
	4	Defer. The user ID is mapped using the IMAP server default (taking up to 8 characters of the first token and placing them in uppercase). The password is then validated for that user ID using the means established before IMAP was told to use the exit (either CP or an external security manager).
	8	Reject. The user ID, password, or both are not valid. The IMAP server rejects the LOGIN command by sending a tagged "NO" response to the client, but the client can continue to send more commands on this connection (for example, try the login again).
	12	Terminate. The user ID, password, or both are not valid. The LOGIN command is rejected by sending a tagged "NO" response to the client, immediately followed by an "* BYE" and the socket is closed.
4 (Administrative mapping lookup)	0	Accept. The user ID was successfully mapped and a valid SFS ID ¹ has been returned. If the SFS ID is not valid, the IMAP server continues as if Reject had been returned.
	4	Defer. The user ID is mapped according to the IMAP server's default behavior of taking up to 8 characters of the first token and placing them in uppercase.
	8	Reject. If the map request is <ul style="list-style-type: none"> • For new mail arrival, the file being processed will be transferred to the bad file ID handler. • For an administrative command, the command will fail with an invalid user name error. • A result of a client LOGIN command, a tagged "NO" is sent to the client, thus causing the the LOGIN command to fail. The client can continue to send commands. This client LOGIN case can happen only if, during the initial server-exit handshake, the exit indicated it did not support Login requests, but did support map requests.
	12	Terminate. For new mail arrival and administrative commands, this return code is treated the same as Reject. If the map request was a result of a LOGIN command, the LOGIN command is rejected by sending a tagged "NO" to the client, immediately followed by an "* BYE", and the socket is closed.

1. A valid SFS ID is

- A user ID that is less than or equal to 8 uppercase characters
- An enrolled IMAP user (except when called by the Admin ENROLL command, in which case the user ID must be a valid SFS ID that is not yet enrolled in the IMAP SFS server).

Chapter 12. Remote authorization and auditing through LDAP

Remote authorization allows resource managers that do not reside on z/VM or resource managers that reside on z/VM as a guest to centralize authorization decisions using RACF® through the z/VM LDAP server. Two services are provided by the z/VM LDAP server that enable audit and authorization requests to be resolved using RACF Security Server for z/VM. These services are provided through LDAP extended operations. This same capability exists on both z/OS and z/VM. For remote authorization calls to z/VM, the request comes in the form of a DER-encoding of the ASN.1 syntax. The following sections provide details on these types of remote authorization and auditing requests.

Note that this information describes remote authorization and audit specifically. For full details on auditing controls in z/VM, see *z/VM: RACF Security Server Auditor's Guide*.

Using remote authorization and auditing

An application or resource manager that uses the **Remote authorization** or **Remote auditing** extended operations must be able to generate requests, send it through the network to the appropriate z/VM LDAP server and interpret the response from the server. The following steps represent the typical sequence of events that are specific to the **Remote authorization** or **Remote auditing** extended operations:

1. The authenticated user must resolve to a SAF or RACF identity that is allowed to perform the authorization check or remote auditing request. The following binds in the z/VM LDAP server can resolve to a SAF or RACF identity:
 - Simple bind to the ICTX plug-in with using an authorized `racfid=userid,cn=ictx` bind distinguished name. If the RACF user ID begins with a number sign (#), it must be preceded by a backslash (\) escape character. Number sign characters in other positions of the user ID do not need to be escaped. For example:
`racfid=\#user#id,cn=ictx`
 - Simple bind to the SDBM backend. See SDBM authorization in *z/VM: TCP/IP Planning and Customization* for more information.
 - LDBM native authentication bind. Native authentication allows the use of an LDBM entry but the password or password phrase is stored in SAF. See “Native authentication” in *z/VM: TCP/IP Planning and Customization* for more information.
 - SASL EXTERNAL certificate bind where the certificate is mapped to a SAF or RACF user. See “Setting up for SSL/TLS” in *z/VM: TCP/IP Planning and Customization* . for more information about mapping certificates to users.
2. The application must build a DER-encoded extended operation request having the defined ASN.1 syntax that is specific to the **Remote authorization** or **Remote auditing** extended operation request. That request can then be included with the LDAP handle and the specific request OID on the LDAP client application call, such as `ldap_extended_operation_s()`, to build the LDAP message and send it to the server.
3. The z/VM LDAP server receives the request and routes it to the ICTX plug-in, where it is decoded and processed. The ICTX plug-in verifies the correct syntax and the authority of the requester before invoking the SAF authorization check

Remote authorization and auditing

or audit service to satisfy the request. The result of the SAF service is a DER-encoded response that the LDAP server returns.

4. The application must decode the response to interpret the results. A nonzero **LdapResult** code indicates that the request was not processed by the ICTX plug-in. A nonzero **LdapResult** is accompanied by a reason code message in the response that might provide additional diagnostic information.

Note: A zero **LdapResult** code does not necessarily imply the request was processed successfully (or for authorization, that a user has the specified access). It does, however, indicate that an extended operation responseValue was returned. The application should verify that the ICTX responseCode within the responseValue indicates success (0). A nonzero responseCode indicates one or more request items resulted in errors (or unauthorized users). The application should check the MajorCode within each response item to determine which returned failures. The application should be aware that ICTX may not return a response item corresponding to each request item in the event of a severe error, such as an error encountered in the extended operation encoding.

The application can send as many requests as needed throughout a single bound session, and should unbind from the z/VM LDAP server when it has finished processing ICTX plug-in requests.

Setting up authorization for working with remote services

After the user successfully authenticated and issued the appropriate extended operation, the bound user must then have the appropriate authority to use the underlying SAF callable services.

For the **Remote authorization** extended operation, the bound user must have at least READ access to the FACILITY class profile IRR.LDAP.REMOTE.AUTH to check the user's own access to a resource. To check access of another user, the user must have at least UPDATE access to FACILITY class profile IRR.LDAP.REMOTE.AUTH.

For example:

```
RDEFINE FACILITY IRR.LDAP.REMOTE.AUTH UACC(NONE)
PERMIT IRR.LDAP.REMOTE.AUTH CLASS(FACILITY) ID(BINDUSER) ACCESS(UPDATE)
SETROPTS RACLIST(FACILITY) REFRESH
```

For the **Remote audit** extended operation, the bound user must have at least READ access to the FACILITY class profile IRR.LDAP.REMOTE.AUDIT.

For example:

```
RDEFINE FACILITY IRR.LDAP.REMOTE.AUDIT UACC(NONE)
PERMIT IRR.LDAP.REMOTE.AUDIT CLASS(FACILITY) ID(BINDUSER) ACCESS(READ)
SETROPTS RACLIST(FACILITY) REFRESH
```

Remote authorization extended operation

The **Remote authorization** extended operation request results in calls to the RACROUTE REQUEST=AUTH SAF service. The results of the RACROUTE REQUEST=AUTH service are returned to the caller. For more information about RACROUTE REQUEST=AUTH, see *z/VM: Security Server RACROUTE Macro Reference*.

The **Remote authorization** extended operation request must contain the DER-encoding of the ASN.1 syntax. The request OID is 1.3.18.0.2.12.66. The following is the **Remote authorization** extended operation request syntax:

```
requestValue ::= SEQUENCE {
    requestVersion      INTEGER,
    itemList            SEQUENCE of
        item            SEQUENCE {
            itemVersion  INTEGER,
            itemTag      INTEGER,
            userOrGroup  OCTET STRING,
            resource     OCTET STRING,
            class        OCTET STRING,
            access       INTEGER,
            logString    OCTET STRING
        }
    }
}
```

Where:

requestValue

The name for the entire sequence of authorization request data.

requestVersion

The format of the request value. Version 1 indicates a user authorization request; each individual item in the `itemList` is an authorization request for a RACF user ID. Version 2 indicates a user authorization or a group authorization request; each individual item in the `itemList` is an authorization request for either a RACF user ID or a RACF group ID.

itemList

A sequence of one or more items, which allows for multiple authorization checks within a single ICTX request. The size of the entire encoded `requestValue` is limited to 16 million bytes unless your encoding routine or LDAP client imposes a stricter limit. If `requestVersion` is 2, the `itemList` can be a mixture of user authorization and group authorization items.

item A sequence of data that represents a single authorization check.

itemVersion

The format of the individual item. Version 1 indicates an authorization request for a RACF user ID. Version 2 indicates an authorization request for a RACF group ID.

itemTag

An integer that is set by the client for each request item and echoed in each response item. Its purpose is to assist the client in correlating multiple request responses, and has no influence on the authorization logic or logging.

userOrGroup

If `itemVersion` is 1, a RACF user ID whose authority is being checked. Its length cannot exceed 8 characters. If the length is zero, the user value defaults to the user ID associated with the bind user.

If `itemVersion` is 2, a RACF group ID whose authority is being checked. Its length must be from 1 and 8 characters. Optimizations that are used when performing a user ID authorization check are not available when performing a group ID authorization check. For this reason, it is likely that group authorization check executes more slowly than user ID authorization checks.

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This field must be specified in uppercase, because RACF user and group names are uppercase, and the remote authorization service does not convert lowercase characters to uppercase.

resource

A name to be matched against a RACF profile for authorization checking. The string may not include blank characters. Its length may be from 1 to the maximum RACF profile length defined for the specified class.

class A defined RACF general resource class. It cannot be DATASET, USER, or GROUP. Its length must be from 1 to 8 characters.

If you are checking authorization to resources protected by profiles in a grouping/member class, specify the member class name in the remote authorization request. To obtain accurate results in this case, ensure that the administrator issued SETROPTS RACLIST for the member class.

access The level of authority requested. It must be one of the following integer values:

X'01' READ
X'02' UPDATE
X'03' CONTROL
X'04' ALTER

logString

Any character data from 0 to 200 characters in length. It is appended to an ICTX-defined string in the SMF log record.

The following is the ASN.1 syntax for the **Remote authorization** extended operation. The response OID is 1.3.18.0.2.12.67.

```
responseValue ::= SEQUENCE {
    responseVersion      INTEGER,
    responseCode         INTEGER,
    itemList             SEQUENCE of
        item             SEQUENCE {
            itemVersion  INTEGER,
            itemTag       INTEGER,
            majorCode    INTEGER,
            minorCode1   INTEGER,
            minorCode2   INTEGER,
            minorCode3   INTEGER
        }
}
```

Where:

responseValue

The name for the entire sequence of authorization response data.

responseVersion

The format of the response value. Version 1 is the only supported format.

responseCode

The greatest error encountered while processing the request. See Table 88 on page 387 for more details on supported responseCodes.

itemList

A sequence of one or more items, which allows for multiple authorization results within a single ICTX response.

item A sequence of data that represents the results from a single authorization check.

itemVersion

The format of the individual item. Version 1 is the only supported format.

itemTag

An integer echoed from the corresponding request `itemTag`. The purpose of the `itemTag` is to assist the client in correlating multiple request responses. `itemTag` has no influence on the authorization logic or logging.

majorCode

An integer value representing the result of the authorization check. See Table 89 for more details on error major codes.

minorCode1

Additional details about the error. See Table 90 on page 388 for more details on error minor codes.

minorCode2

Additional details about the error.

minorCode3

Additional details about the error.

Remote authorization extended operation response codes

Use the following table to understand the response codes generated from the remote authorization response the remote authorization processing. The `responseCode` represents the greatest error encountered. You might experience situations where a request item generates an error that is not reflected in the `responseCode` because that value is overridden by a higher-severity error.

Table 88. Remote authorization responseCodes

ResponseCode (decimal)	Meaning
0	All request items were processed successfully
28	Empty item list. No items are found within the <code>itemList</code> sequence of the extended operation request, so no response items are returned.
61-70	The specified <code>requestVersion</code> is not supported. Subtract 60 from the value to determine the highest <code>requestVersion</code> that the server supports. <code>responseCode</code> 61 indicates the server supports version 1 requests only. <code>responseCode</code> 62 indicates that the highest supported request level is 2.
other	Errors or warnings encountered while processing one or more request items. The value represents the highest <code>majorCode</code> in the set of all response items. Verify the major and minor codes returned for each item.

Table 89. Remote authorization majorCodes

MajorCode (decimal)	Meaning	Comment
0	Authorized	The user has the requested access to the resource.

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Table 89. Remote authorization majorCodes (continued)

MajorCode (decimal)	Meaning	Comment
2	Warning mode	The user has the requested access because warning mode is enabled for the resource. Warning mode is a feature of RACF that allows installations to try out security policies. Installations can define a profile with the WARNING attribute. When RACF performs an authorization check by using the profile, it logs the event (if there are audit settings) and allows the authorization check to pass successfully. The log records can be monitored to ensure that the new policy is operating as expected before putting the policy into production by turning off the WARNING attribute.
4	Undetermined	No decision is made. The specified resource is not protected by RACF, or RACF is not installed.
8	Unauthorized	The user does not have the requested access to the resource.
12	RACROUTE error	The RACROUTE REQUEST=AUTH service returned an unexpected error. Compare the returned minor codes with the SAF and RACF codes documented in <i>z/VM: Security Server RACROUTE Macro Reference</i> .
16	Request value error	A value specified in the extended operation request is incorrect or unsupported. Check the returned minor codes to narrow the reason.
20	Request encoding error	A decoding error was encountered indicating the extended operation request contains non-compliant DER encoding, or does not match the documented ASN.1 syntax.
24	Insufficient authority	The requestor does not have sufficient authority for the requested function. The user ID associated with the LDAP bound user must have the appropriate access to the FACILITY class profile IRR.LDAP.REMOTE.AUTH.
100	Internal error	An internal error was encountered within the ICTX plug-in.

Table 90. Remote authorization minorCodes

MinorCode (decimal)	MinorCode Meaning
0-14	minorCode1- the SAF return code minorCode2 - the RACF return code minorCode3 - the RACF reason code

Table 90. Remote authorization minorCodes (continued)

MinorCode (decimal)	MinorCode Meaning
16-20	minorCode1 is the extended operation request parameter number within the item. 0 - item sequence 1 - itemVersion 2 - itemTag 3 - user 4 - resource 5 - class 6 - access 7 - logString
	minorCode2 value indicates one of the following: 32 - incorrect length 36 - incorrect value 40 - encoding error
	minorCode3 has no defined meaning.
24-100	minorCodes1, minorCode2, and minorCode3 do not have a defined meaning.

Remote authorization audit controls

The auditor can specify whether to log access attempts that are based on user, class, resource, or any criteria as described in *z/VM: RACF Security Server Auditor's Guide*. The SMF TYPE 80 records that are generated can be unloaded by using the IRRADU00 utility.

Remote auditing extended operation

The **Remote auditing** extended operation request must contain the DER-encoding of the ASN.1 syntax. The request OID is 1.3.18.0.2.12.68. The following is the **Remote auditing** extended operation request syntax:

```
requestValue ::= SEQUENCE {
    requestVersion      INTEGER,
    itemList            SEQUENCE of
        item            SEQUENCE {
            itemVersion  INTEGER,
            itemTag      INTEGER,
            linkValue    OCTET STRING SIZE(8),
            violation    BOOLEAN,
            event        INTEGER,
            qualifier    INTEGER,
            class        OCTET STRING,
            resource     OCTET STRING,
            logString    OCTET STRING,
            dataFieldList SEQUENCE of
                dataField SEQUENCE {
                    type    INTEGER,
                    value   OCTET STRING
                }
        }
}
```

Where:

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| **requestValue**
| The name for the entire sequence of audit request data.

| **requestVersion**
| The format of the request value. Version 1 is the only currently supported
| format.

| **itemList**
| A sequence of one or more items, allowing multiple audit records to be
| written with a single ICTX request. You should limit the size of the entire
| encoded RequestValue to 16 million bytes; however, your encoding routine
| or LDAP client might impose a stricter limit.

| **item** A sequence of data that represents a single audit record.

| **itemVersion**
| The format of the individual item. Version 1 is the only currently
| supported format.

| **itemTag**
| An integer that is set by the client for each request item and
| echoed in each response item. Its purpose is to assist the client in
| correlating multiple request responses. The itemTag value does not
| influence the audit processing, and does not appear in the audit
| record.

| **linkValue**
| 8 bytes of data that is used to mark related audit records. Specify 8
| bytes of zero (X'00') if no such marking is needed.

| **violation**
| A boolean value that indicates whether the event represents a
| violation (nonzero ~ TRUE) or not (zero ~ FALSE). The value is
| used in the audit logging decision.

| **event** An integer 1 - 7 that identifies the security event type. The possible
| values are:

| 1 Authentication
| 2 Authorization
| 3 Authorization Mapping
| 4 Key Management
| 5 Policy Management
| 6 Administrator Configuration
| 7 Administrator Action

| **qualifier**
| An integer 0 - 3 that describe the event result. The possible values
| are:

| 0 Success
| 1 Information
| 2 Warning
| 3 Failure

| **class** A defined RACF general resource class that might be used for

audit logging determination. It cannot be DATASET, USER, or GROUP. Its length must be from 0 to 8 characters.

resource

A name that might be matched against a RACF profile in the specified class for audit logging determination. Its length may be from 0 to 246 characters.

logString

Any character data from 0 to 200 characters in length. It is appended to an ICTX-defined string in the SMF log record.

dataFieldList

A sequence of type and value pairs that will be logged as SMF relocates. Any number of relocates might be included, but the audit service limits the total amount of this relocate data to 20 kilobytes per record.

dataField

A sequence of data that represents a single relocate section in an audit record.

type An integer 100 to 114 corresponding to a defined relocate number. The possible values are:

- 100 SAF identifier for bind user
- 101 Requester's bind user identifier
- 102 Originating security domain
- 103 Originating registry / realm
- 104 Originating user name
- 105 Mapped security domain
- 106 Mapped registry / realm
- 107 Mapped user name
- 108 Operation performed
- 109 Mechanism / object name
- 110 Method / function used
- 111 Key / certificate name
- 112 Caller subject initiating security event
- 113 Date and time security event occurred
- 114 Application specific data
- 115 Identifier for the client submitting the remote audit request
- 116 Version of the client submitting the remote audit request

value Character data of the associated type that is included in the audit record.

The following is the ASN.1 syntax for the **Remote auditing** extended operation response. The response OID is 1.3.18.0.2.12.69.

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```
responseValue ::= SEQUENCE {
    responseVersion      INTEGER,
    responseCode         INTEGER,
    itemList             SEQUENCE of
                        SEQUENCE{
                            itemVersion      INTEGER,
                            itemTag          INTEGER,
                            majorCode        INTEGER,
                            minorCode1       INTEGER,
                            minorCode2       INTEGER,
                            minorCode3       INTEGER
                        }
}
```

Where:

responseValue

The name for the entire sequence of audit response data.

responseVersion

The format of the response value. Version 1 is the only supported format.

responseCode

The greatest error encountered while processing the request. See Table 91 on page 393 for more details about supported responseCodes.

itemList

A sequence of one or more items, which allows for multiple audit results within a single ICTX response.

item A sequence of data that represents the results from a single audit request.

itemVersion

The format of the individual item. Version 1 is the only supported format.

itemTag

An integer that is echoed from the corresponding request `itemTag`. The purpose of the `itemTag` is to assist the client in correlating multiple request responses. The `itemTag` does not influence the audit processing, and does not appear in the audit record.

majorCode

An integer value representing the result of the audit request. See Table 92 on page 393 for more details about error major codes.

minorCode1

Additional details about the error. See Table 93 on page 394 for more details about error minor codes.

minorCode2

Additional details about the error.

minorCode3

Additional details about the error.

Remote auditing extended operation response codes

Use the following table to understand the response codes that are generated from the remote auditing response. The `responseCode` represents the greatest error encountered. You might experience situations in which a request item generates an error that is not reflected in the `responseCode`, because that value is overridden by a higher-severity error.

Table 91. Remote auditing responseCodes

ResponseCode (decimal)	Meaning
0	All request items were processed successfully.
28	Empty item list. No items are found within the itemList sequence of the extended operation request, so no response items are returned.
61-70	The specified requestVersion is not supported. Subtract 60 from the value to determine the highest requestVersion that the server supports. responseCode 61 indicates that the server supports version 1 requests only.
other	Errors or warnings that are encountered while processing one or more request items. The value represents the highest majorCode in the set of all response items. Verify the major and minor codes returned for each item.

Table 92. Remote auditing majorCodes

MajorCode (decimal)	Meaning	Comment
0	Success	The event is logged successfully.
2	Warning mode	<p>The event is logged, and warning mode is set for the specified resource. Warning mode is a feature of RACF that allows installations to try out security policies. Installations can define a profile with the WARNING attribute. When RACF performs an authorization check by using the profile, it logs the event (if there are audit settings) and allows the authorization check to pass successfully. The log records can be monitored to ensure that the new policy is operating as expected before putting the policy into production by turning off the WARNING attribute.</p> <p>A remote client resource manager using the remote audit service might simulate RACF warning mode logic after submitting an audit request for a failing authorization event. If the majorCode in the response item indicates the matching resource profile has the warning mode set, the remote client resource manager might allow the check to pass successfully.</p>
3	Logging not required	The event is not logged because no audit controls are set to require it.

Remote authorization and auditing

Table 92. Remote auditing majorCodes (continued)

MajorCode (decimal)	Meaning	Comment
4	Undetermined	The event is not logged. The conditions suggested by the following minorCode combinations might be intentional administrator settings: 4,0,0 - RACF is not installed or not active 8,8,8 - UAUDIT is not set, and class is not active or not RACLISTed 8,8,12 - UAUDIT is not set, class is active and RACLISTed, and a covering resource profile is not found
8	Unauthorized	The user does not have authority for the audit service. The userid associated with the LDAP server must have at least READ access to the FACILITY class profile IRR.RAUDITX.
12	Audit error	The audit service returned an unexpected error. Record the returned minor codes and contact your service representative.
16	Request value error	A value specified in the extended operation request is incorrect or unsupported. Check the returned minor codes to narrow the reason.
20	Request encoding error	A decoding error was encountered indicating the extended operation request contains non-compliant DER encoding, or does not match the documented ASN.1 syntax.
24	Insufficient authority	The requestor does not have sufficient authority for the requested function. The user ID associated with the LDAP bound user must have at least READ access to the FACILITY class profile IRR.LDAP.REMOTE.AUDIT.
100	Internal error	An internal error was encountered within the ICTX plug-in.

Table 93. Remote auditing minorCodes

MinorCode (decimal)	MinorCode Meaning
0-12	minorCode1- the SAF return code minorCode2 - the RACF return code minorCode3 - the RACF reason code

Table 93. Remote auditing minorCodes (continued)

MinorCode (decimal)	MinorCode Meaning
16-20	<p>minorCode1 is the extended operation request parameter number within the item.</p> <ul style="list-style-type: none"> 0 - item sequence 1 - itemVersion 2 - itemTag 3 - linkValue 4 - violation 5 - event 6 - qualifier 7 - class 8 - resource 9 - logstring 10 - dataFieldList sequence 11 - dataField sequence 12 - type 13 - value
	<p>minorCode2 value indicates one of the following:</p> <ul style="list-style-type: none"> 32 - incorrect length 36 - incorrect value 40 - encoding error
	<p>minorCode3 has no defined meaning.</p>
24-100	<p>minorCodes1, minorCodes2, and minorCodes3 do not have defined meaning.</p>

Remote audit controls

The auditor can enable logging for all remote audit events by setting UAUDIT for the RACF user ID associated with the z/VM LDAP server. To narrow the set of events logged, the auditor may set SETROPTS LOGOPTIONS for the matching class or set AUDIT/GLOBALAUDIT for the matching resource profile. To do this, the auditor must know the class and resource specified by the application submitting the remote audit requests. The SMF Unload utility can then be used to unload the generated SMF type 83 subtype 4 records.

SMF Record Type 83 subtype 4 records

The remote audit service logs events as SMF Type 83 subtype 4 records that can be unloaded by using the IRRADU00 utility. Each logged event has a unique event code with a corresponding event code qualifier, or value that indicates whether the event succeeded, resulted in warning or failure, or was logging event information. The event codes are described in the following table:

Table 94. Remote audit event codes

Event	Command / Service
1	Authentication
2	Authorization
3	Authorization mapping
4	Key management

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Table 94. Remote audit event codes (continued)

Event	Command / Service
5	Policy management
6	Administrator configuration
7	Administrator action

The following table describes the event code qualifiers:

Table 95. Remote audit event code qualifiers

(Common) Event Code Qualifier Dec (Hex)	Description	(Common) Relocate type sections
0	Successful request or authorization.	Common relocates, 100-114
1	Event information.	Common relocates, 100-114
2	Not a failure, but might warrant investigation. For authorization event, grace period might be in effect.	Common relocates, 100-114
3	Unsuccessful request; unauthorized.	Common relocates, 100-114

The following are the remote audit specific extended relocates:

Table 96. Event-specific fields for remote audit events

Relocate	XML Tag	SQL field name	Type	Length	Position		Comments
					Start	End	
100	localUser	SAF_LOCAL_USER	Char	8	3000	3007	SAF identifier for bind user
101	bindUser	SAF_BIND_USER	Char	256	3010	3265	Requesters bind user identifier
102	domain	SAF_DOMAIN	Char	512	3268	3779	Originating security domain
103	regName	SAF_REG_NAME	Char	256	3782	4037	Originating registry / real m
104	regUser	SAF_REG_USER	Char	256	4040	4295	Originating user name
105	mapDomain	SAF_MAP_DOMAIN	Char	512	4298	4809	Mapped security domain
106	mapRegName	SAF_MAP_REG_NAME	Char	256	4812	5067	Mapped registry / realm
107	mapRegUser	SAF_MAP_REG_USER	Char	256	5070	5325	Mapped user name
108	action	SAF_ACTION	Char	64	5328	5391	Operation performed
109	object	SAF_OBJECT	Char	64	5394	5457	Mechanism / object name
110	method	SAF_METHOD	Char	64	5460	5523	Method / function used

Table 96. Event-specific fields for remote audit events (continued)

Relocate	XML Tag	SQL field name	Type	Length	Position		Comments
					Start	End	
111	key	SAF_KEY	Char	256	5526	5781	Key / certificate name
112	subjectName	SAF_SUBJECT_NAME	Char	256	5784	6039	Caller subject initiating security event
113	dateTime	SAF_DATE_TIME	Char	32	6042	6073	Date and time security event occurred
114	otherData	SAF_OTHER_DATA	Char	2048	6076	8123	Application specific data
115	clientID	SAF_CLIENT_ID	Char	16	8126	8141	Identifier for client submitting remote audit request.
116	clientVer	SAF_CLIENT_VER	Char	8	8144	8151	Version of client submitting remote audit request.

Remote authorization and auditing

Chapter 13. Building an LDAP Server Plug-in

This topic explains how to build an LDAP server plug-in on z/VM and explains differences between the z/VM implementation and the IBM Tivoli® Directory Server for z/OS implementation. For details on the plug-in application service routines, see *z/OS: IBM Tivoli Directory Server Plug-in Reference for z/OS*.

An LDAP server plug-in is a software module that extends the capabilities of your directory server.

Plug-ins are dynamically loaded into the LDAP server's virtual machine when the server is started. Once the plug-ins are loaded, the server calls the functions in a shared library by using function pointers.

A server frontend listens to the wire, receives and parses requests from clients, and then processes the requests by calling an appropriate database backend function. A server backend reads and writes data to the database containing the directory entries.

If the frontend fails to process a request, it returns an error message to the client; otherwise, the backends are searched for the appropriate backend to process the request. If a backend is found to process the request, it is passed to the backend. If a backend is not found to process the request, the plug-ins are searched for an appropriate plug-in to process the request. If a backend is called, it must return a message to the client. If a plug-in is called, it must return a message to the client. The frontend, backend, or the plug-in can return a message to the client, but only one can return the message.

The following types of plug-ins are supported by LDAP:

pre-operation

A plug-in that is executed before a client request is processed; for example, a plug-in that checks for a new entry before the new entry is added to a directory.

post-operation

A plug-in that is executed after a client request is processed; for example, a plug-in that audits clients after they bind to the server.

client-operation

A plug-in that is called to process a client request.

Each plug-in is a separate dynamic link library (DLL) that is loaded by the LDAP server. The `SLAPI_PL H` include file defines the various structures and service routine prototypes that are available to the plug-in, and the service functions are provided in a DLL load module. The `GLDSLP31 TEXT` side file defines the plug-in import definitions for this DLL. The `SLAPI_PL H` and `GLDSLP31 TEXT` files are on the `TCPMAINT 591` disk.

The LDAP server **plugin** configuration option is used to define a plug-in to the LDAP server. See "plugin" in *z/VM: TCP/IP Planning and Customization*. The option has three required parameters and one optional parameter:

1. The plug-in type: `preOperation`, `clientOperation`, or `postOperation`
2. The plug-in DLL name.

3. The name of the plug-in initialization routine, which is called during LDAP server initialization
4. Optional parameters that the plug-in can retrieve.

For example:

```
plugin postOperation PLUGSAMP plugin_init "auditFile"
```

Steps for writing an LDAP plug-in

To build an LDAP plug-in:

1. Design and write the plug-in initialization routine and SLAPI service functions.

The plug-in initialization routine must register the following that are supported by the plug-in:

- Service functions
- Message types
- Distinguished name suffixes
- Extended operation object identifiers.

Return code 0 must be returned when successful and non-zero when not successful. The plug-in initialization routine receives as input, the plug-in parameter block (**Slapi_PBlock**) and returns an integer as the return value. An example of an initialization routine prototype:

```
int plugin_init ( Slapi_PBlock * pb );
```

Note: For this example, the name `plugin_init` would be the initialization routine name used with the **plugin** configuration option.

2. When writing the SLAPI service functions that implement the plug-in design, see *z/OS: IBM Tivoli Directory Server Plug-in Reference for z/OS* for application service routines to use and for defined prototypes. You can also see `SLAPI_PL H` for defined prototypes.
3. Decide on any input parameters for the plug-in.
Plug-in input parameters can be retrieved using the `SLAPI_PLUGIN_ARGC` or `SLAPI_PLUGIN_ARGV` parameters with the **slapi_pblock_get()** service routine.
4. Include `SLAPI_PL H`, which contains defined SLAPI data structures and prototypes.
5. Export the plug-in initialization routine.
6. Compile the plug-in code into object files.
7. Bind the plug-in object files with the LDAP server `GLDSLP31 TEXT` side file.
8. Ensure the plug-in DLL module is on a CMS minidisk or directory accessible by the LDAP server.
9. Edit and add the **plugin** configuration option to the LDAP server configuration file. See “plugin” in *z/VM: TCP/IP Planning and Customization*.
10. Restart the LDAP server.

You may want to program trace statements to follow processing flow in the plug-in. The trace macro, **SLAPI_TRACE()**, is provided in `SLAPI_PL H` to assist in tracing. This macro uses the **slapi_trace()** service routine, described in *z/OS: IBM Tivoli Directory Server Plug-in Reference for z/OS*. For example:

```
SLAPI_TRACE((LDAP_DEBUG_PLUGIN, "PLUGSAMP", "Entered."));
```

A sample plug-in showing several examples of using SLAPI service routines is in file PLUGSAMP CSAMPLE on the TCPMAINT 591 disk.

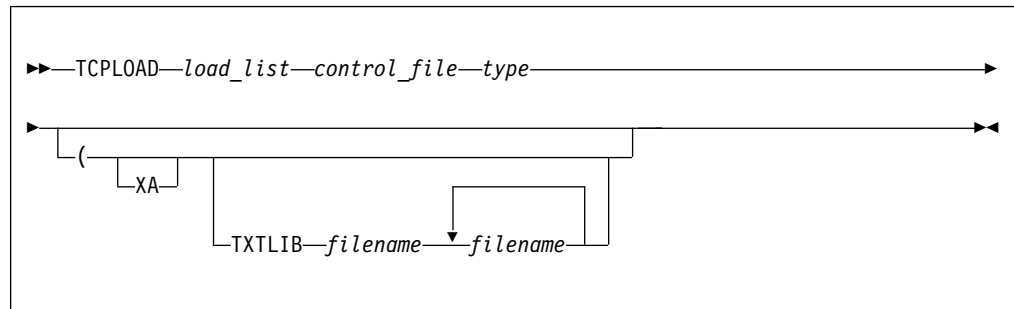
Note about LDAP support on z/VM

When referring to *z/OS: IBM Tivoli Directory Server Plug-in Reference for z/OS*, be aware of the following:

- z/VM does not support the DB2® back-end.
- z/VM does not support the 64-bit DLL.
- The z/OS term “address space” is equivalent to “virtual machine” on z/VM.

Appendix A. TCPLOAD EXEC

The TCPLOAD EXEC is provided to generate an executable module from your compiled program. When running TCPLOAD, all disks containing object files must be accessed as extensions of the A-disk. The TCPLOAD EXEC generates a module when given a list of text file names and a control file.



Parameter

Description

load_list

Specifies the file name of a file with the file type LOADLIST that contains file names to be included in the load module. The first line in the *load_list* specifies the name of the main object module. Subsequent lines specify additional object modules to be included in the load module.

control_file

Specifies the *control_file*, which determines the file types of text files according to the standard update identifier procedure.

type

Specifies the *type* parameter as one of the following:

C Includes SCEELKED, CMSLIB, RPCLIB, TCPASCAL, TCPLANG, COMMTXT, and CLIB txtlibs.

C-ONLY

Includes SCEELKED, RPCLIB, COMMTXT, CMSLIB, and CLIB txtlib.

PASCAL

Includes TCPASCAL, TCPLANG, and COMMTXT txtlibs. PASCAL is the default for the *type* parameter.

XA

Specify this option if the application requires storage above the 16Mb line. The application will be generated RMODE ANY and AMODE 31. Pascal applications will require the GLOBAL LOADLIB TCPRTLIB command be issued before being run.

TXTLIB

Specifies the TXTLIB option, which allows you to specify up to 50 *filenames* that will be added to the GLOBAL TXTLIB command.

See Table 3 on page 32 for a list of the files necessary for each application.

If TCPLOAD is not used, you must global the appropriate TXTLIB files.

Using TCPLOAD

The following example describes how to use TCPLOAD to generate an executable module from object files.

1. Create a file with file type LOADLIST, which contains all the object (TEXT) files to be linked. For example, `l1istfn loadlist`.
2. Create a control file with file type CNTRL, which contains the list of TEXT file types. For example, `ctrlfn cntrl`.
3. Invoke the TCPLOAD command, as shown in the following example.

```
TCPLOAD l1istfn ctrlfn C (TXTLIB mylib1 mylib2
```

Where:

- `l1istfn` is the LOADLIST file name
- `ctrlfn` is the control file name
- `C` is the language of the main program
- `TXTLIB` is the keyword that specifies the libraries to link
- `mylib1` and `mylib2` are the libraries to link.

The following is an example of how to create an executable module from a list of object files. In the example, `OBJ1`, `OBJ2`, `OBJ3`, `OBJ4`, and `OBJ5` are TEXT files created by compiling C programs, and `MYLIB1` and `MYLIB2` are libraries.

1. Create the file `SAMPLE LOADLIST` that lists the object files:

```
OBJ1  
OBJ2  
OBJ3  
OBJ4  
OBJ5
```

2. Create the file `TEST CNTRL` with the following:

```
TEXT
```

3. Invoke TCPLOAD with the following command:

```
TCPLOAD SAMPLE TEST C (TXTLIB MYLIB1 MYLIB2
```

This creates the executable file `SAMPLE MODULE`.

Appendix B. Pascal Return Codes

When using Pascal procedure calls, check to determine whether the call has been completed successfully. Use the SayCalRe function (see “SayCalRe” on page 79) to convert the ReturnCode parameter to a printable form.

The SayCalRe function converts a return code value into a descriptive message. For example, if SayCalRe is invoked with the integer constant BADlengthARGUMENT, it returns the message buffer length specified. For a description of Pascal return codes and their equivalent message text from SayCalRe, see Table 97.

Most return codes are self-explanatory in the context where they occur. The return codes you see as a result of issuing a TCP/UDP/IP request are in the range -128 to 0. For more information, see the Explanatory Notes at the end of Table 97.

Table 97. Pascal Language Return Codes

Return Code	Numeric Value	Message Text
OK	0	OK.
ABNORMALcondition ¹	-1	Abnormal condition during inter-address communication. (VMCF. RC= <i>nm</i> User= <i>xxxxxxx</i>)
ALREADYclosing	-2	Connection already closing.
BADlengthARGUMENT	-3	Invalid length specified.
CANNOTsendDATA ²	-4	Cannot send data.
CLIENTrestart	-5	Client reinitialized TCP/IP service.
CONNECTIONalreadyEXISTS	-6	Connection already exists.
DESTINATIONunreachable	-7	Destination address is unreachable.
ERRORinPROFILE	-8	Error in profile file; details are in <i>StackID.TCPEERROR</i> .
FATALerror ³	-9	Fatal inter-address communications error. (VMCF. RC= <i>nm</i> User= <i>xxxxxxx</i>)
HASnoPASSWORD	-10	No password in RACF directory.
INCORRECTpassword	-11	TCPIP not authorized to access file.
INVALIDrequest	-12	Invalid request.
INVALIDuserID	-13	Invalid user ID.
INVALIDvirtualADDRESS	-14	Invalid virtual address.
KILLEDbyCLIENT	-15	You aborted the connection.
LOCALportNOTavailable	-16	The requested local port is not available.
MINIDISKinUSE	-17	File is in use by someone else and cannot be accessed.
MINIDISKnotAVAILABLE	-18	File not available.
NObufferSPACE ⁴	-19	No more space for data currently available.

Pascal Return Codes

Table 97. Pascal Language Return Codes (continued)

Return Code	Numeric Value	Message Text
NOMoreINCOMINGdata	-20	The foreign host has closed this connection.
NONlocalADDRESS	-21	The internet address is not local to this host.
NOoutstandingNOTIFICATIONS	-22	No outstanding notifications.
NOsuchCONNECTION	-23	No such connection.
NOtcpIPservice	-24	No TCP/IP service available.
NOTyetBEGUN	-25	Not yet begun TCP/IP service.
NOTyetOPEN	-26	The connection is not yet open.
OPENrejected	-27	Foreign host rejected the open attempt.
PARAMlocalADDRESS	-28	TcpOpen error: invalid local address.
PARAMstate	-29	TcpOpen error: invalid initial state.
PARAMtimeout	-30	Invalid time-out parameter.
PARAMunspecADDRESS	-31	TcpOpen error: unspecified foreign address in active open.
PARAMunspecPORT	-32	TcpOpen error: unspecified foreign port in active open.
PROFILEnotFOUND	-33	TCPIP cannot read profile file.
RECEIVEstillPENDING	-34	Receive still pending on this connection.
REMOTEClose	-35	Foreign host unexpectedly closed the connection.
REMOTEReset	-36	Foreign host aborted the connection.
SOFTWAREerror	-37	Software error in TCP/IP!
TCPipSHUTDOWN	-38	TCP/IP service is being shut down.
TIMEOUTconnection	-39	Foreign host is no longer responding.
TIMEOUTopen	-40	Foreign host did not respond within OPEN time-out
TOOmanyOPENS	-41	Too many open connections already exist.
UNAUTHORIZEDuser	-43	You are not authorized to issue this command.
UNEXPECTEDsyn	-44	Foreign host violated the connection protocol.
UNIMPLEMENTEDrequest	-45	Unimplemented TCP/IP request.
UNKNOWNhost	-46	Destination host is not known.
UNREACHABLEnetwork	-47	Destination network is unreachable.
UNSPECIFIEDconnection	-48	Unspecified connection.
VIRTUALmemoryTOOsmall	-49	Client virtual machine has too little storage.
WRONGsecORprc	-50	Foreign host disagreed on security or precedence.

Table 97. Pascal Language Return Codes (continued)

Return Code	Numeric Value	Message Text
YOURend	-55	Client has ended TCP/IP service.
0resources	-56	TCP cannot handle any more connections now.
UDPlocalADDRESS	-57	Invalid local address for UDP.
UDPunspecADDRESS	-59	Address unspecified when specification necessary.
UDPunspecPORT	-60	Port unspecified when specification necessary.
UDPzeroRESOURCES	-61	UDP cannot handle any more traffic.
FSENDstillPENDING	-62	FSend still pending on this connection.
DROPPEDbyOPERATOR	-79	Connection dropped by operator.
ERRORopeningORreadingFILE	-80	Error opening or reading file.
FILEformatINVALID	-81	File format invalid.
CANNOTreadFILE	-85	A file used by the operation cannot be read. The file may not exist, or it may be a file mode 0 file.
CANNOTwriteFILE	-86	A file used by the operation cannot be written to. The file may not exist, or it may be a file mode 0 file.
TLsnotAVAILABLE	-87	The SSL server is currently not available.
LABELnotRECOGNIZED	-88	The security server is available but the label is not recognized.
LABELnotPERMITTED	-89	The security server is available but the user is not authorized to use the label specified.
KEYRINGnotRECOGNIZED	-90	The security server is available but the keyring is not recognized.
KEYRINGnotPERMITTED	-91	The security server is available but the user is not authorized to use the keyring specified.
ALREADYsecured	-92	The request to secure the connection failed. The connection is already secure.
STATICALLYsecured	-93	The request to dynamically secure the connection failed. The connection is already statically secured.
CONNECTIONnotSECURE	-94	The request to close a secure connection failed. The connection is not secure.
SSLhandshakeINprogress	-95	The request cannot be made at this time. There is an SSL handshake currently in progress on this connection.

Pascal Return Codes

Table 97. Pascal Language Return Codes (continued)

Return Code	Numeric Value	Message Text
MIXEDaddresses	-96	A mixture of IPv4 and IPv6 addresses have been specified in the Status6InfoType record, this is not allowed.
IPv6connection	-97	An IPv4 function has been issued against an IPv6 connection, the data returned is not valid.
SSLnotRESPONDING	-98	A QueryTLS request was made to the SSL server but the server is not responding.
BACKlevelSSL	-99	The current SSL server is backlevel and does not support TLS negotiated security.
TCPipALREADYstarted	-101	TCP/IP services have already been started.

Explanatory Notes

1. ABNORMALcondition

The actual VMCF return code is available in the external integer variable LastVmcfCode, and is included in the output of SayCalRe if called immediately after the error is detected.

2. CANNOTsendDATA

Cannot send data on this connection because the connection state is invalid for sending data.

3. FATALerror

The actual VMCF return code is available in the external integer variable LastVmcfCode, and is included in the output of SayCalRe if called immediately after the error is detected.

4. NObufferSPACE

Applies to this connection only. Space may still be available for other connections.

Appendix C. C API System Return Codes

This appendix provides a reference for system calls. Table 98 provides the system-wide message numbers set by the system calls. These message numbers are contained in the compiler file `ERRNO.H` and in the TCP file `TCPERRNO.H`.

Table 98. System Return Codes

Message	Code	Description
EPERM	1	Permission denied.
ENOENT	2	No such file or directory.
ESRCH	3	No such process.
EINTR	4	Interrupted system call.
EIO	5	I/O error.
ENXIO	6	No such device or address.
E2BIG	7	Argument list too long.
ENOEXEC	8	Exec format error.
EBADF	9	Bad file number.
ECHILD	10	No children.
EAGAIN	11	No more processes.
ENOMEM	12	Not enough memory.
EACCES	13	Permission denied.
EFAULT	14	Bad address.
ENOTBLK	15	Block device required.
EBUSY	16	Device busy.
EEXIST	17	File exists.
EXDEV	18	Cross device link.
ENODEV	19	No such device.
ENOTDIR	20	Not a directory.
EISDIR	21	Is a directory.
EINVAL	22	Invalid argument.
ENFILE	23	File table overflow.
EMFILE	24	Too many open files.
ENOTTY	25	Inappropriate device call.
ETXTBSY	26	Text file busy.
EFBIG	27	File too large.
ENOSPC	28	No space left on device.
ESPIPE	29	Illegal seek.
EROFS	30	Read only file system.
EMLINK	31	Too many links.
EPIPE	32	Broken pipe.
EDOM	33	Argument too large.

C API System Return Codes

Table 98. System Return Codes (continued)

Message	Code	Description
ERANGE	34	Result too large.
EWouldBlock	35	Operation would block.
EINPROGRESS	36	Operation now in progress.
EALREADY	37	Operation already in progress.
ENOTSOCK	38	Socket operation on non-socket.
EDESTADDRREQ	39	Destination address required.
EMSGSIZE	40	Message too long.
EPROTOTYPE	41	Protocol wrong type for socket.
ENOPROTOOPT	42	Protocol not available.
EPROTONOSUPPORT	43	Protocol not supported.
ESOCKTNOSUPPORT	44	Socket type not supported.
EOPNOTSUPP	45	Operation not supported on socket.
EPFNOSUPPORT	46	Protocol family not supported.
EAFNOSUPPORT	47	Address family not supported by protocol family.
EADDRINUSE	48	Address already in use.
EADDRNOTAVAIL	49	Cannot assign requested address.
ENETDOWN	50	Network is down.
ENETUNREACH	51	Network is unreachable.
ENETRESET	52	Network dropped connection on reset.
ECONNABORTED	53	Software caused connection abort.
ECONNRESET	54	Connection reset by peer.
ENOBUFS	55	No buffer space available.
EISCONN	56	Socket is already connected.
ENOTCONN	57	Socket is not connected.
ESHUTDOWN	58	Cannot send after socket shutdown.
ETOOMANYREFS	59	Too many references: cannot splice.
ETIMEDOUT	60	Connection timed out.
ECONNREFUSED	61	Connection refused.
ELOOP	62	Too many levels of symbolic loops.
ENAMETOOLONG	63	File name too long.
EHOSTDOWN	64	Host is down.
EHOSTUNREACH	65	No route to host.
ENOTEMPTY	66	Directory not empty.
EPROCLIM	67	Too many processes.
EUSERS	68	Too many users.
EDQUOT	69	Disc quota exceeded.

Table 98. System Return Codes (continued)

Message	Code	Description
ESTALE	70	Stale NFS file handle.
EREMOTE	71	Too many levels of remote in path.
ENOSTR	72	Device is not a stream.
ETIME	73	Timer expired.
ENOSR	74	Out of streams resources.
ENOMSG	75	No message of desired type.
EBADMSG	76	Trying to read unreadable message.
EIDRM	77	Identifier removed.
EDEADLK	78	Deadlock condition.
ENOLCK	79	No record locks available.
ENONET	80	Machine is not on the network.
ERREMOTE	81	Object is remote.
ENOLINK	82	Link has been severed.
EADV	83	Advertise error.
ESRMNT	84	Srmount error.
ECOMM	85	Communication error on send.
EPROTO	86	Protocol error.
EMULTIHOP	87	Multihop attempted.
EDOTDOT	88	Cross mount point.
EREMCHG	89	Remote address changed.

C API System Return Codes

Appendix D. Well-Known Port Assignments

This appendix lists the well-known port assignments for transport protocols TCP and UDP, and includes port number, keyword, and a description of the reserved port assignment. You can also find a list of these well-known port numbers in the ETC SERVICES file.

TCP Well-Known Port Assignments

Table 99 lists the well-known port assignments for TCP.

Table 99. TCP Well-Known Port Assignments

Port Number	Keyword	Reserved for	Services Description
0		reserved	
5	rje	remote job entry	remote job entry
7	echo	echo	echo
9	discard	discard	sink null
11	systat	active users	active users
13	daytime	daytime	daytime
15	netstat	Netstat	who is up or Netstat
19	chargen	ttytst source	character generator
21	ftp	FTP	File Transfer Protocol
23	telnet	Telnet	Telnet
25	smtp	mail	Simple Mail Transfer Protocol
37	time	timeserver	timeserver
39	rlp	resource	Resource Location Protocol
42	nameserver	name	host name server
43	nicname	who is	who is
53	domain	name server	domain name server
57	mtp	private terminal access	private terminal access
77	rje	netrjs	any private RJE service
79	finger	finger	finger
87	link	ttylink	any private terminal link
95	supdup	supdup	SUPDUP Protocol
101	hostname	hostname	nic hostname server, usually from SRI-NIC
109	pop	postoffice	Post Office Protocol
111	sunrpc	sunrpc	Sun remote procedure call
113	auth	authentication	authentication service
115	sftp	sftp	Simple File Transfer Protocol
117	uucp-path	UUCP path service	UUCP path service
119	untp	readnews untp	USENET News Transfer Protocol
123	ntp	NTP	Network Time Protocol

Well-Known Port Assignments

Table 99. TCP Well-Known Port Assignments (continued)

Port Number	Keyword	Reserved for	Services Description
160–223		reserved	
512	REXEC	REXEC	Remote Execution Protocol
514	RSH	RSHELL	Remote Shell Service
712	vexec	vice-exec	Andrew File System authenticated service
713	vlogin	vice-login	Andrew File System authenticated service
714	vshell	vice-shell	Andrew File System authenticated service
2001	filesrv		Andrew File System service
2106	venus.itc		Andrew File System service, for the Venus process

UDP Well-Known Port Assignments

Table 100 lists the well-known port assignments for UDP.

Table 100. UDP Well-Known Port Assignments

Port Number	Keyword	Reserved for	Services Description
0		reserved	
5	rje	remote job entry	remote job entry
7	echo	echo	echo
9	discard	discard	sink null
11	users	active users	active users
13	daytime	daytime	daytime
15	netstat	Netstat	Netstat
19	chargen	ttytst source	character generator
37	time	timeserver	timeserver
39	rlp	resource	Resource Location Protocol
42	nameserver	name	host name server
43	nicname	who is	who is
53	domain	nameserver	domain name server
67	bootpd	BOOTP	BOOTP Daemon
75			any private dial out service
77	rje	netrjs	any private RJE service
79	finger	finger	finger
111	sunrpc	sunrpc	Sun remote procedure call
123	ntp	NTP	Network Time Protocol
160–223		reserved	
520			RouteD and MPROUTE using Rip
531	rxd-control		rxd control port
2001	rauth2		Andrew File System service, for the Venus process
2002	rfilebulk		Andrew File System service, for the Venus process

Table 100. UDP Well-Known Port Assignments (continued)

Port Number	Keyword	Reserved for	Services Description
2003	rfilesrv		Andrew File System service, for the Venus process
2018	console		Andrew File System service
2115	ropcons		Andrew File System service, for the Venus process
2131	rupdsrv		assigned in pairs; bulk must be srv +1
2132	rupdbulk;		assigned in pairs; bulk must be srv +1
2133	rupdsrv1		assigned in pairs; bulk must be srv +1
2134	rupdbulk1;		assigned in pairs; bulk must be srv +1

Well-Known Port Assignments

Appendix E. Related Protocol Specifications

IBM is committed to industry standards. The internet protocol suite is still evolving through Requests for Comments (RFC). New protocols are being designed and implemented by researchers, and are brought to the attention of the internet community in the form of RFCs. Some of these are so useful that they become a recommended protocol. That is, all future implementations for TCP/IP are recommended to implement this particular function or protocol. These become the *de facto* standards, on which the TCP/IP protocol suite is built.

Many features of TCP/IP for z/VM are based on the following RFCs:

RFC	Title	Author
768	<i>User Datagram Protocol</i>	J.B. Postel
791	<i>Internet Protocol</i>	J.B. Postel
792	<i>Internet Control Message Protocol</i>	J.B. Postel
793	<i>Transmission Control Protocol</i>	J.B. Postel
821	<i>Simple Mail Transfer Protocol</i>	J.B. Postel
822	<i>Standard for the Format of ARPA Internet Text Messages</i>	D. Crocker
823	<i>DARPA Internet Gateway</i>	R.M. Hinden, A. Sheltzer
826	<i>Ethernet Address Resolution Protocol: or Converting Network Protocol Addresses to 48.Bit Ethernet Address for Transmission on Ethernet Hardware</i>	D.C. Plummer
854	<i>Telnet Protocol Specification</i>	J.B. Postel, J.K. Reynolds
856	<i>Telnet Binary Transmission</i>	J.B. Postel, J.K. Reynolds
857	<i>Telnet Echo Option</i>	J.B. Postel, J.K. Reynolds
877	<i>Standard for the Transmission of IP Datagrams over Public Data Networks</i>	J.T. Korb
885	<i>Telnet End of Record Option</i>	J.B. Postel
903	<i>Reverse Address Resolution Protocol</i>	R. Finlayson, T. Mann, J.C. Mogul, M. Theimer
904	<i>Exterior Gateway Protocol Formal Specification</i>	D.L. Mills
919	<i>Broadcasting Internet Datagrams</i>	J.C. Mogul
922	<i>Broadcasting Internet Datagrams in the Presence of Subnets</i>	J.C. Mogul
950	<i>Internet Standard Subnetting Procedure</i>	J.C. Mogul, J.B. Postel
952	<i>DoD Internet Host Table Specification</i>	K. Harrenstien, M.K. Stahl, E.J. Feinler
959	<i>File Transfer Protocol</i>	J.B. Postel, J.K. Reynolds
974	<i>Mail Routing and the Domain Name System</i>	C. Partridge
1009	<i>Requirements for Internet Gateways</i>	R.T. Braden, J.B. Postel
1013	<i>X Window System Protocol, Version 11: Alpha Update</i>	R.W. Scheifler
1014	<i>XDR: External Data Representation Standard</i>	Sun Microsystems Incorporated
1027	<i>Using ARP to Implement Transparent Subnet Gateways</i>	S. Carl-Mitchell, J.S. Quarterman
1032	<i>Domain Administrators Guide</i>	M.K. Stahl

RFCs

RFC	Title	Author
1033	<i>Domain Administrators Operations Guide</i>	M. Lottor
1034	<i>Domain Names—Concepts and Facilities</i>	P.V. Mockapetris
1035	<i>Domain Names—Implementation and Specification</i>	P.V. Mockapetris
1042	<i>Standard for the Transmission of IP Datagrams over IEEE 802 Networks</i>	J.B. Postel, J.K. Reynolds
1055	<i>Nonstandard for Transmission of IP Datagrams over Serial Lines: SLIP</i>	J.L. Romkey
1057	<i>RPC: Remote Procedure Call Protocol Version 2 Specification</i>	Sun Microsystems Incorporated
1058	<i>Routing Information Protocol</i>	C.L. Hedrick
1091	<i>Telnet Terminal-Type Option</i>	J. VanBokkelen
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Appendix F. Abbreviations and Acronyms

The following abbreviations and acronyms are used throughout this book.

AIX	Advanced Interactive Executive
ANSI	American National Standards Institute
API	Application Program Interface
APPC	Advanced Program-to-Program Communications
APPN	Advanced Peer-to-Peer Networking
ARP	Address Resolution Protocol
ASCII	American National Standard Code for Information Interchange
ASN.1	Abstract Syntax Notation One
AUI	Attachment Unit Interface
BFS	Byte File System
BIOS	Basic Input/Output System
BNC	Bayonet Neill-Concelman
CCITT	Comite Consultatif International Telegraphique et Telephonique. The International Telegraph and Telephone Consultative Committee
CLIST	Command List
CMS	Conversational Monitor System
CP	Control Program
CPI	Common Programming Interface
CREN	Corporation for Research and Education Networking
CSD	Corrective Service Diskette
CTC	Channel-to-Channel
CU	Control Unit
CUA	Common User Access
DASD	Direct Access Storage Device
DBCS	Double Byte Character Set
DLL	Dynamic Link Library
DNS	Domain Name System
DOS	Disk Operating System
DPI	Distributed Program Interface
EBCDIC	Extended Binary-Coded Decimal Interchange Code
EISA	Enhanced Industry Standard Adapter
ESCON	Enterprise Systems Connection Architecture
FAT	File Allocation Table
FTAM	File Transfer Access Management
FTP	File Transfer Protocol
FTP API	File Transfer Protocol Applications Programming Interface
GCS	Group Control System
GDDM	Graphical Data Display Manager
GDDMXD	Graphics Data Display Manager Interface for X Window System
GDF	Graphics Data File
HPFS	High Performance File System
ICMP	Internet Control Message Protocol
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPL	Initial Program Load
ISA	Industry Standard Adapter
ISDN	Integrated Services Digital Network

Abbreviations and Acronyms

ISO	International Organization for Standardization
IUCV	Inter-User Communication Vehicle
JES	Job Entry Subsystem
JIS	Japanese Institute of Standards
JCL	Job Control Language
LAN	Local Area Network
LAPS	LAN Adapter Protocol Support
LCS	IBM LAN Channel Station
LDAP	Lightweight Directory Access Protocol
LPQ	Line Printer Query
LPR	Line Printer Client
LPRM	Line Printer Remove
LPRMON	Line Printer Monitor
LU	Logical Unit
MAC	Media Access Control
Mbps	Megabits per second
MBps	Megabytes per second
MCA	Micro Channel Adapter
MIB	Management Information Base
MIH	Missing Interrupt Handler
MILNET	Military Network
MHS	Message Handling System
MTU	Maximum Transmission Unit
MVS	Multiple Virtual Storage
MX	Mail Exchange
NCP	Network Control Program
NDIS	Network Driver Interface Specification
NFS	Network File System
NIC	Network Information Center
NLS	National Language Support
NSFNET	National Science Foundation Network
OS/2	Operating System/2®
OSA	Open Systems Adapter
OSF	Open Software Foundation, Inc.
OSI	Open Systems Interconnection
OSIMF/6000	Open Systems Interconnection Messaging and Filing/6000
OV/MVS	OfficeVision/MVS
OV/VM	OfficeVision/VM
PAD	Packet Assembly/Disassembly
PC	Personal Computer
PCA	Parallel Channel Adapter
PDN	Public Data Network
PDU	Protocol Data Units
PING	Packet Internet Groper
PIOAM	Parallel I/O Access Method
POP	Post Office Protocol
PROFS™	Professional Office Systems
PSCA	Personal System Channel Attach
PSDN	Packet Switching Data Network
PU	Physical Unit
PVM	Passthrough Virtual Machine
RACF	Resource Access Control Facility
RARP	Reverse Address Resolution Protocol
REXEC	Remote Execution
REXX	Restructured Extended Executor Language

Abbreviations and Acronyms

RFC	Request For Comments
RIP	Routing Information Protocol
RISC	Reduced Instruction Set Computer
RPC	Remote Procedure Call
RSCS	Remote Spooling Communications Subsystem
SAA	Systems Application Architecture®
SBCS	Single Byte Character Set
SFS	Shared File System
SLIP	Serial Line Internet Protocol
SMIL	Structure for Management Information
SMTP	Simple Mail Transfer Protocol
SNA	Systems Network Architecture
SNMP	Simple Network Management Protocol
SOA	Start of Authority
SPOOL	Simultaneous Peripheral Operations Online
SQL	IBM Structured Query Language
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TSO	Time Sharing Option
TTL	Time-to-Live
UDP	User Datagram Protocol
VGA	Video Graphic Array
VM	Virtual Machine
VMCF	Virtual Machine Communication Facility
VM/ESA	Virtual Machine/Enterprise System Architecture
VMSES/E	Virtual Machine Serviceability Enhancements Staged/Extended
VTAM®	Virtual Telecommunications Access Method
WAN	Wide Area Network
XDR	eXternal Data Representation

Abbreviations and Acronyms

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For a list of z/VM terms and their definitions, see *z/VM: Glossary*.

The z/VM glossary is also available through the online z/VM HELP Facility, if HELP files are installed on your z/VM system. For example, to display the definition of the term “dedicated device”, issue the following HELP command:
`help glossary dedicated device`

While you are in the glossary help file, you can do additional searches:

- To display the definition of a new term, type a new HELP command on the command line:

```
help glossary newterm
```

This command opens a new help file inside the previous help file. You can repeat this process many times. The status area in the lower right corner of the screen shows how many help files you have open. To close the current file, press the Quit key (PF3/F3). To exit from the HELP Facility, press the Return key (PF4/F4).

- To search for a word, phrase, or character string, type it on the command line and press the Clocate key (PF5/F5). To find other occurrences, press the key multiple times.

The Clocate function searches from the current location to the end of the file. It does not wrap. To search the whole file, press the Top key (PF2/F2) to go to the top of the file before using Clocate.

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See the following publications for additional information about z/VM. For abstracts of the z/VM publications, see *z/VM: General Information*, GC24-6193.

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z/VM Base Library

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- *z/VM: DFSMS/VM Diagnosis Guide*, GC24-6182
- *z/VM: DFSMS/VM Messages and Codes*, GC24-6183
- *z/VM: DFSMS/VM Planning Guide*, SC24-6184
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- *Open Systems Adapter-Express Customer's Guide and Reference*, SA22-7935
- *Open Systems Adapter-Express Integrated Console Controller User's Guide*, SA22-7990
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- *z/VM: RACF Security Server Command Language Reference*, SC24-6213

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- *z/VM: RACF Security Server General User's Guide*, SC24-6215
- *z/VM: RACF Security Server Macros and Interfaces*, SC24-6216
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- *z/VM: RACF Security Server System Programmer's Guide*, SC24-6219
- *z/VM: Security Server RACROUTE Macro Reference*, SC24-6231

Remote Spooling Communications Subsystem Networking for z/VM

- *z/VM: RSCS Networking Diagnosis*, GC24-6223
- *z/VM: RSCS Networking Exit Customization*, SC24-6224
- *z/VM: RSCS Networking Messages and Codes*, GC24-6225
- *z/VM: RSCS Networking Operation and Use*, SC24-6226
- *z/VM: RSCS Networking Planning and Configuration*, SC24-6227

Prerequisite Products

Device Support Facilities

- *Device Support Facilities: User's Guide and Reference*, GC35-0033

Environmental Record Editing and Printing Program

- *Environmental Record Editing and Printing Program (EREP): Reference*, GC35-0152
- *Environmental Record Editing and Printing Program (EREP): User's Guide*, GC35-0151

Other TCP/IP Related Publications

This section lists other publications, outside the z/VM V6.4 library, that you may find helpful.

- *TCP/IP Tutorial and Technical Overview*, GG24-3376
- *TCP/IP Illustrated, Volume 1: The Protocols*, SR28-5586
- *Internetworking with TCP/IP Volume I: Principles, Protocols, and Architecture*, SC31-6144

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Product Number: 5741-A07

Printed in USA

SC24-6239-05

