TCP/IP [2]

Transmission Control Protocol/Internet Protocol (TCP/IP) is an integrated networking protocol suite developed by the U. S. Department of Defense (DoD) for the Defense Data Network (DDN). The TCP/IP implementation described in this section is for the UNICOS operating system, running on all Cray Research systems. This implementation is compatible with other network communications products that comply with the DoD TCP/IP specifications. It allows Cray Research systems to be added to any established TCP/IP network and provides many networks and users with access to Cray Research systems.

The following hardware and software are minimum requirements for installing and operating TCP/IP:

- A Cray Research system running the UNICOS operating system.
- Network media, such as a Cray FEI-3 front-end interface, a Network Systems Corporation (NSC) Data Exchange (DX) or Data Exchange Extended Chassis (DXE) adapter, a Fiber Distributed Data Interface (FDDI), or a Cray High Performance Parallel Interface (HIPPI).

  Note: The required network media differs based on the type of Cray Research system you have.

- At least one other host in the network that supports DoD standard TCP/IP protocols.

This section provides you with the information you need to install and maintain TCP/IP. It is assumed that you have a working knowledge of your particular Cray Research system and the UNICOS operating system.

The following topics are discussed:

- TCP/IP basics
  - Details of Internet addressing, including hardware address resolution and subnet addressing
  - Name and address mapping process
  - Routing of data through gateways to its final destination
- Configuration for GigaRing, Model E (IOS-E), and Model V (IOS-V) based systems

  - Physical network media through which Cray Research systems interface with other systems
  - Directions for configuring TCP/IP (with or without the use of the UNICOS installation and configuration menu system (ICMS)). For more information on the use of the UNICOS ICMS, see *UNICOS System Configuration Using ICMS*, publication SG–2412.
- Network tuning
- Troubleshooting
- Trace facility
- Security administration basics

2.1 TCP/IP Basics

Cray Research systems operate in environments in which communication with computer systems in other networks is necessary. Communication among these computers is possible through a technology that connects the diverse systems and allows each to access the other. This technology, known as *internetworking*, provides gateways through which the data can travel. The standards that specify the details of how these computers communicate, called Transmission Control Protocol/Internet Protocol (TCP/IP), were developed by the U. S. Department of Defense (DoD) Advanced Research Project Agency. This collection of individual networks in government, military, university, and industry installations is called the *TCP/IP Internet*, or simply the *internet*.

This section presents the aspects of TCP/IP that you must know to administer the Cray Research system on the Internet. The following aspects are described:

- Internet structure
- Network hardware
- Internet addressing
- Hardware addressing
- Routing of information

2.1.1 Internet Structure

A computer network consists of two or more computers (also known as *hosts*) that are connected to each other by network technology such as an NSC HYPERchannel, a Cray FEI-3 front-end interface, an FDDI, or a Cray High Performance Parallel Interface (HIPPI). This type of connection is known as a *direct connection* and creates a network known as a *local area network (LAN)*. An *internetwork* consists of two or more interconnected LANs, which can be interconnected by either a host or a router. Hosts and routers that interconnect LANs are known as *gateways*.

Internet technology allows communication between networks (for example, a gateway receives a packet of data from a computer on one network and sends it to a computer on another network). Figure 1 shows gateway `G` connected to both networks `A` and `B`. Gateway `G` receives packets of data from any host on network `A` (dotted lines represent hosts) and transfers them to network `B`. Likewise, gateway `G` receives packets of data from any host on network `B` and transfers them to network `A`.

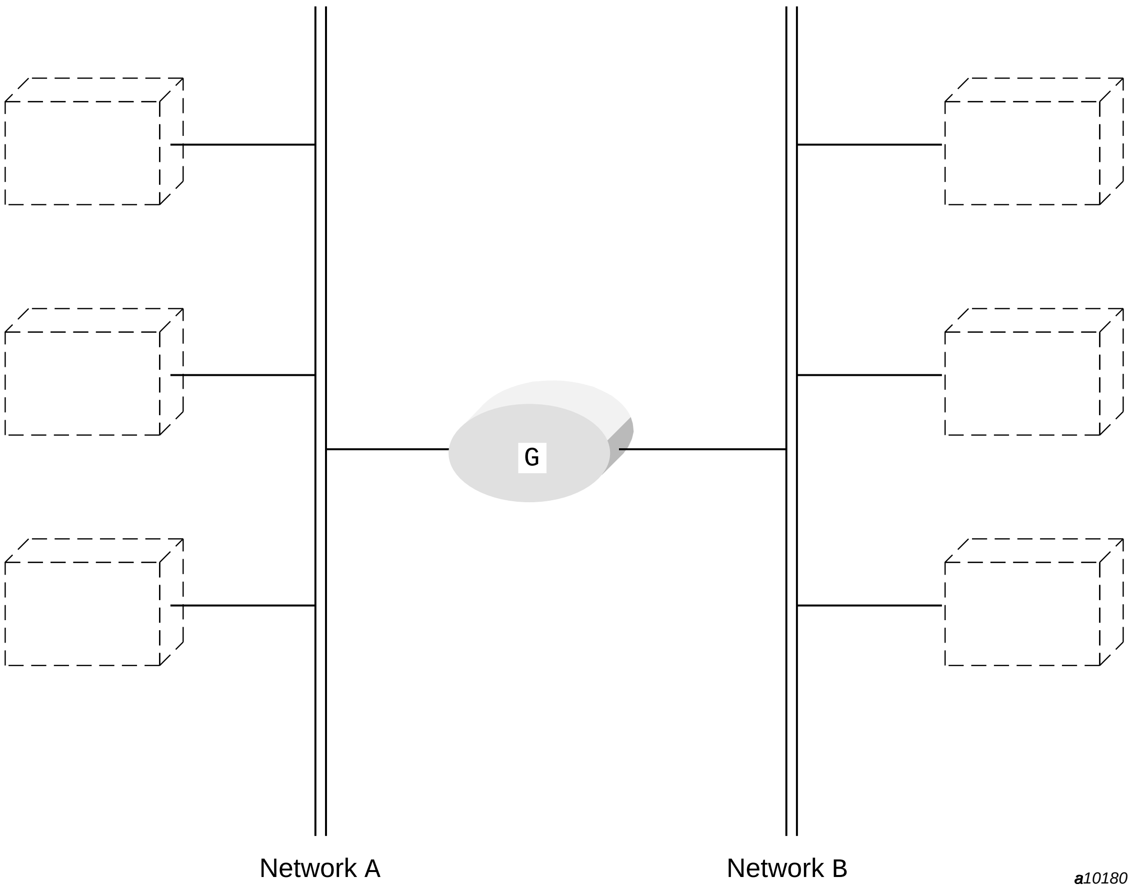


Figure 1. Two networks interconnected by gateway G

Typical internetworks are more complex than the one depicted in Figure 1, page 6. Packets are sometimes routed through numerous gateways before arriving at the designated destination. Sometimes decisions have to be made as to the most efficient route to take. Consider the internetwork in Figure 2. Dotted lines represent hosts.

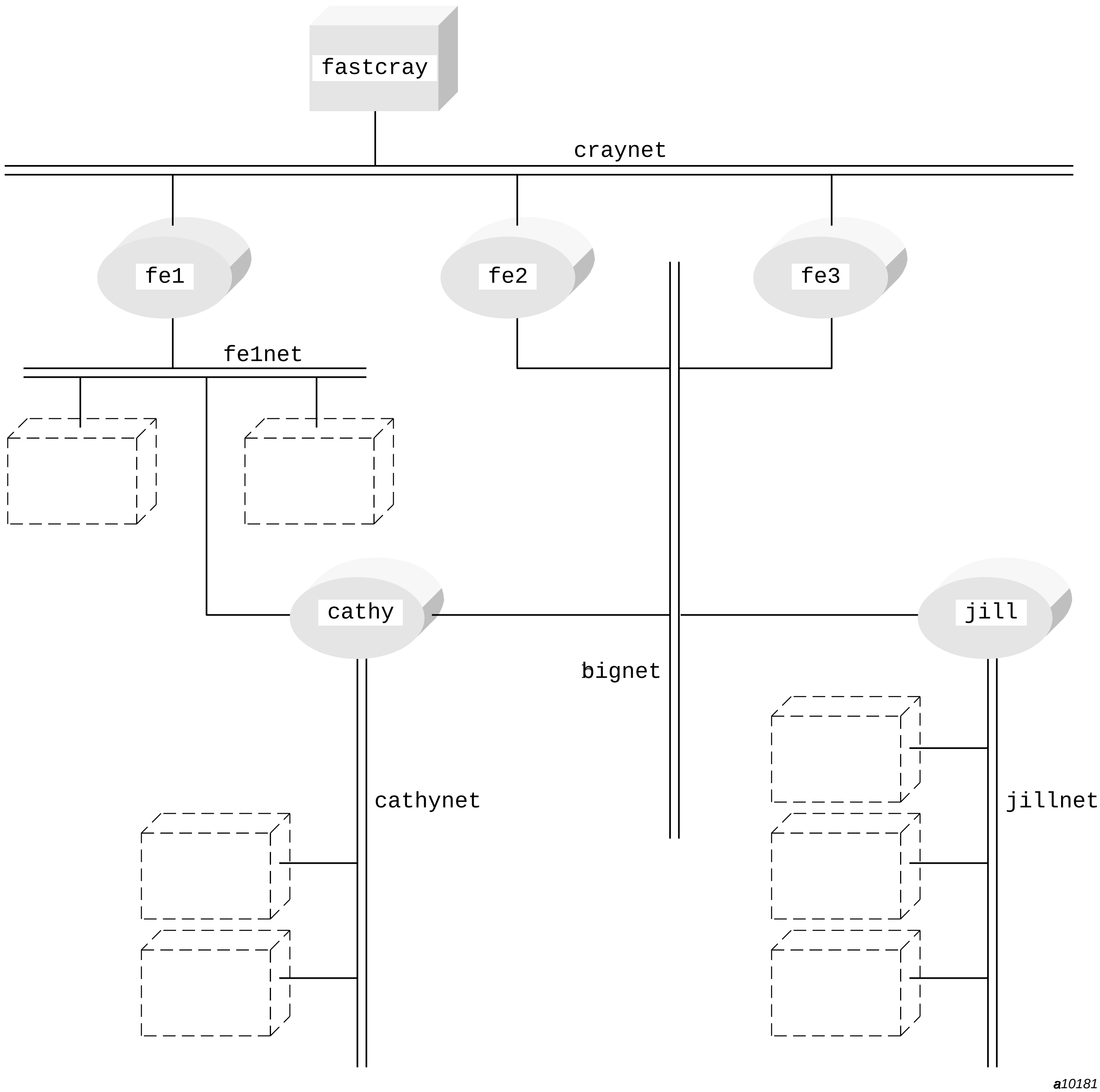


Figure 2. Several interconnected networks

Notice, for example, the choices for routes that a host on the `jillnet` network would have when trying to send data to the `craynet` network. Data could be routed through `fe2` or `fe3` to `craynet`, or through `cathy`, to the `fe1nt` network, and then through `fe1` to `craynet`. Planning the route that data will take to get from one network to another is the job of the administrator. See Section 2.1.4, page 15, for information on how this process works. See Section 2.3.3, page 154, for a discussion of how route selection can affect network performance.

2.1.2 Internet Addressing

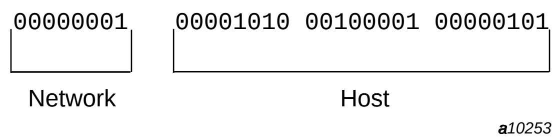
The technology that allows hosts to interface with Cray Research systems requires that two types of addresses be specified: Internet and hardware. This section discusses Internet addressing; the following section discusses hardware addressing.

TCP/IP provides an addressing system in which each host on the internetwork is assigned at least one 32-bit address. This address is used for communication among the hosts in the internetwork and is known as the *Internet address*. Each host has as many Internet addresses as it has network interfaces. Those hosts with more than one network interface can be used as gateways. For example, the gateway called `cathy` in Figure 2, page 7, has three different Internet addresses because it interfaces with `cathynet`, `bignet`, and `fe1net`. Gateways `fe1`, `fe2`, `fe3`, and `jill` each have two Internet addresses. The hosts shown inside the networks have only one Internet address each because they are connected to only one network.

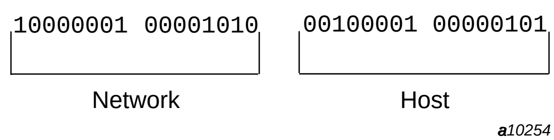
The Internet address consists of two main parts: the part that identifies the network to which the host is connected, and the unique part that identifies the host.

2.1.2.1 Address Classes

TCP/IP provides four types of addresses to accommodate the diversity of Internet structures. Class A addresses are assigned for networks that consist of more than 65,534 hosts. The high-order 8 bits identify the network; the remaining 24 bits identify the host. The first bit of a class A address is always `0`. The following Internet address is a class A address:



Class B addresses are assigned to internetworks that consist of from 254 to 65,534 hosts. The high-order 16 bits identify the network; the remaining 16 bits identify the host. The first and second bits of a class B address are always `10`. The following Internet address is a class B address:



Class C addresses are assigned to internetworks that consist of fewer than 254 hosts. The high-order 24 bits identify the network; the remaining 8 bits identify the host. The first three bits of a class C address are always `110`. The following Internet address is a class C address:

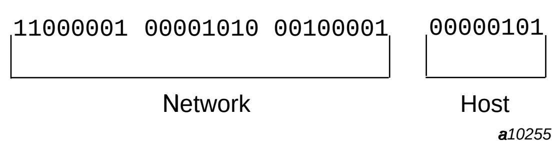
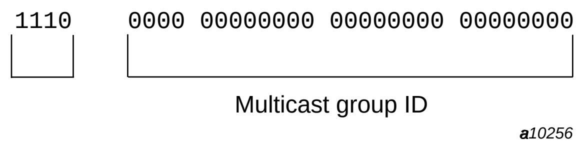


Table 1, page 9summarizes the characteristics of class A, B, and C addresses.

Table 1. Characteristics of class A, B, and C addresses

Address class	Maximum hosts/network	Maximum unique networks
A	16,777,214	126
B	65,534	16,382
C	254	2,097,150

Class D addresses are assigned to IP multicast group addresses. A multicast address is used when sending an IP datagram to a group of hosts that belong to a specific multicast group. A multicast group address is the combination of the high-order four bits `1110` and the multicast group ID (the remaining 28 bits). The following Internet address is a class D address:



When written in decimal notation, these addresses range from 224.0.0.0 through 239.255.255.255. Some multicast group addresses are assigned as well-known addresses by the Internet Assigned Number Authority (IANA). These are called permanent host groups. For example, the address for the permanent host group that includes all routers on a specified subnet is 224.0.0.2. See RFC 1700 for more information about permanent host groups.

2.1.2.2 Subnet and Supernet Addressing

Some sites have numerous networks. If each network were assigned a different network identifier, the routing process would become difficult. *Subnet addressing* allows numerous networks to appear to the routing process to be part of the same network. This standard is defined by RFC 950. See Section 2.1.4, page 15, for details of the routing process.

Subnet addressing uses part of the host portion of the Internet address to designate subnetworks. Consider the class B address in the previous example. Ordinarily, the last 16 bits specify the host identifier. With subnetting, you can take part of the host portion to identify subnetworks and use the remaining part of the host portion to identify hosts on the subnetworks. For example, you could use the first 3 bits of the host portion to identify subnetworks. Using only 3 bits, you can identify as many as six different networks (`001`, `010`, `011`, and so on). Bits `000` and `111` are reserved. The other 13 bits could then be used to identify the hosts on the various subnetworks. You could identify as many as 8190 hosts per subnetwork this way.

The bits of the host identifier part of an Internet address can be divided in whatever manner is necessary to identify your particular network structure. For example, if you need more subnetworks, you can use more bits to identify the subnetworks and fewer to identify the hosts.

If it is necessary to choose subnet addressing for your site, you must also choose a 32-bit subnet mask to identify your network. This mask shows which part of an Internet address identifies the network (including the subnetwork) and which identifies a host. The mask must contain 1's to represent the bits that identify the network portion and 0's to represent the bits that identify the host portion. For example, suppose your site has been assigned the following class C address:

```
11000000 00001001 00101000 00000000
```

Assume that you need to choose a subnet mask to identify the network and host portions of this address. You know that the left three octets of the mask will be all 1's, signifying that the first three octets are the network portion (class C addresses always take 24 bits to identify the network portion). Because you are going to use part of the host portion (rightmost octet) to identify the subnetwork, some of the bits will be 1's, and some will be 0's in the last octet of the mask. How much of this octet you use to identify the subnetwork and how much you use to identify the hosts depends on the structure of your network. For example, if you needed to identify six physical subnetworks, you would set the first 3 bits of this octet to 1's. You would set the rest of the bits to 0's, to identify them as host bits. Those 5 bits could identify up to 30 hosts on each of the subnetworks. Your subnet mask would be as follows:

```
11111111 11111111 11111111 11100000
```

Maybe you have only two subnetworks to be identified. In that case, your subnet mask would be as follows:

```
11111111 11111111 11111111 11000000
```

With this subnet mask, you could identify up to 62 hosts on each network.

You must specify this mask in the `netmask` argument of the `ifconfig`(8) command. An example of using the `netmask` argument is shown on Section 2.2.9.6.2, page 117.

As the Internet continues to grow, the phenomenon of supernetting is starting to become more common. Supernetting is the reverse of subnetting. In it, a block of adjacent network addresses lying on a power-of-two boundary are combined into a single, larger network. For example, 16 class C network addresses are shown below:

```
11000000 00001001 00101000 00000000
11000000 00001001 00101000 00000000
11000000 00001001 00101000 00000000
11000000 00001001 00101000 00000000
```

These could be combined into a supernet for a site which needed an address space somewhere between those of a class B and a class C network.

For more information on supernetting, see RFC 1519.

2.1.2.3 Decimal Notation

For ease of use, Internet addresses are usually expressed as four decimal integers, separated by decimal points. Each decimal integer represents one octet of the 32-bit address. For example, the Internet address

```
10000001 00001010 00100001 00000101
```

would be expressed as follows in decimal notation:

```
129.10.33.5
```

A class A address (which always begins with a high-order binary 0) is recognized as any Internet address whose decimal notation begins with an integer in the range 0 to 127. A class B address (which always begins with a high-order binary 10) is recognized as any Internet address whose decimal notation begins with an integer in the range 128 to 191. A class C address (which always begins with a high-order binary 110) is recognized as any Internet address whose decimal notation begins with the integer in the range of 192 through 223.

Subnet masks can also be expressed as 4 decimal-separated numbers. The subnet masks in the previous examples would be expressed as 255.255.255.224 and 255.255.255.192, respectively.

2.1.2.4 Mapping Internet Addresses to Names

Because it is easier to remember a name than an Internet address, Internet protocol has provided a means by which you can assign names to all Internet hosts. To do so, create the `/etc/hosts` file or use the domain name service and create the `/etc/resolv.conf` file and enter the Internet addresses and corresponding names or aliases. See Section 2.2.4.1, page 31, or Section 2.2.8.3, page 81, for more details on the `/etc/hosts` file and the domain name service, respectively). Subsequently, when a user issues a command and uses a name instead of an Internet address, the appropriate database is searched, and the name is matched with the corresponding Internet address.

2.1.3 Hardware Addressing

Network hardware and the associated device drivers are protocol-independent. Therefore, the hardware cannot use Internet addresses to get the data to its remote destination.

The device drivers write hardware addresses (not Internet addresses) into the hardware message header. TCP/IP uses Internet addresses, however, to obtain hardware addresses. This section describes three methods for determining the destination's hardware address, given its Internet address. This process is called *hardware address resolution*.

2.1.3.1 Using the Address Resolution Protocol (ARP)

Address resolution protocol (ARP) is a dynamic address resolution protocol. Broadcast LAN media, such as Ethernet and FDDI, support ARP. ARP allows a host to find the physical address of a target host on the same physical network, given only the target host's Internet address. When a host that is connected to a broadcast type network wants to resolve an Internet address such as 128.150.30.10, it broadcasts a special packet (ARP request) that asks the host with Internet address 128.150.30.10 to respond with its physical (hardware) address (for example, 00-00-95-40-00-30). All hosts on the LAN receive the request, but only the host that recognizes its Internet address sends a reply that contains its physical address. ARP is used on Cray FDDI and Ethernet interfaces to implement the address resolution needed to map the 32-bit Internet address (logical address) to a 48-bit FDDI/ Ethernet hardware address (physical address).

ARP is a caching protocol; to avoid repeated use of the protocol, it maintains a cache of recently learned Internet-to-physical address mappings. For more information about ARP, see RFC 826.

2.1.3.2 Using a Configuration File—Model E and Model V Systems Only

For each type of Cray network hardware used in the internetwork, you can create a configuration file, in which you supply specific information about the hardware. In this file, you include Internet addresses and corresponding hardware addresses. (If you have created the `/etc/hosts` file, you can use names instead of Internet addresses.)

For Model E and Model V based systems, this configuration file is commonly referred to as the `/etc/hycf.` *name* file, or just the `hycf` file.

The `hycf` file is used as input to the `hyroute`(8) command, which does the actual mapping of the Internet addresses to the network hardware addresses (see Section 2.2.6.4, page 46, for details on the `hycf` file and the `hyroute` command). The `hycf` file information supplied to the `hyroute` command is the information that TCP/IP uses to build the message header (including the physical destination address and the logical destination address). Use this method if you want to control or customize any information in the message header. For HYPERchannel connections, because of the information that must be specified, you must use this method.

2.1.3.3 Using a Configuration File—GigaRing Based Systems Only

For each type of Cray network hardware used in the internetwork, you can create a configuration file, in which you supply specific information about the hardware. In this file, you include Internet addresses and corresponding hardware addresses. (If you have created the `/etc/hosts` file, you can use names instead of Internet addresses.)

The HIPPI `arp` file has the following format: `/etc/ghippi`*X*`.arp`

where *X* is the ordinal of the HIPPI interface. The `arp` file is used by `/etc/initif`, which performs `arp -s`.

The GigaRing `arp` file has the following format: `/etc/grX.arp`

where *X* is the ordinal of the GigaRing interface.

To use `arp` on a HIPPI or GigaRing interface, enter permanent ARP entries in the ARP table with the `arp -s` command. ATM interface configuration is done in the `atm.pvc` file. It is not necessary to configure an `arp` entry for interface names on FDDI or Ethernet.

2.1.3.4 Using the Internet Address—Model E and Model V Based Systems Only

If you do not create a `hycf` file, TCP/IP constructs the hardware address, as well as other control information, from the third and fourth octets of the Internet address, as follows:

- The third octet is interpreted as the physical destination (byte 4 of the message header).
- The fourth octet is interpreted as the logical destination (byte 5 of the message header).

For example, if the Internet address were 128.123.10.8, the message header `physical destination address` field would be 10; the message header `logical destination address` field would be 8.

2.1.4 Routing of Information

routing is the process of finding a path or route for data to travel from source to destination. This section describes *static routing*, in which the administrator plans the most efficient route for the data. *dynamic routing* is an automatic process in which the routes are chosen by use of the `gated`(8) command. See Section 2.2.8.1, page 65, for a description of dynamic routing.

If the source address and the destination address are a part of the same network, the route is considered *direct*. If the source and the destination are on different networks, gateways must be used between them. These routes are considered *indirect*. In some indirect Internet configurations, the path from source to destination is obvious, as shown in Figure 3.

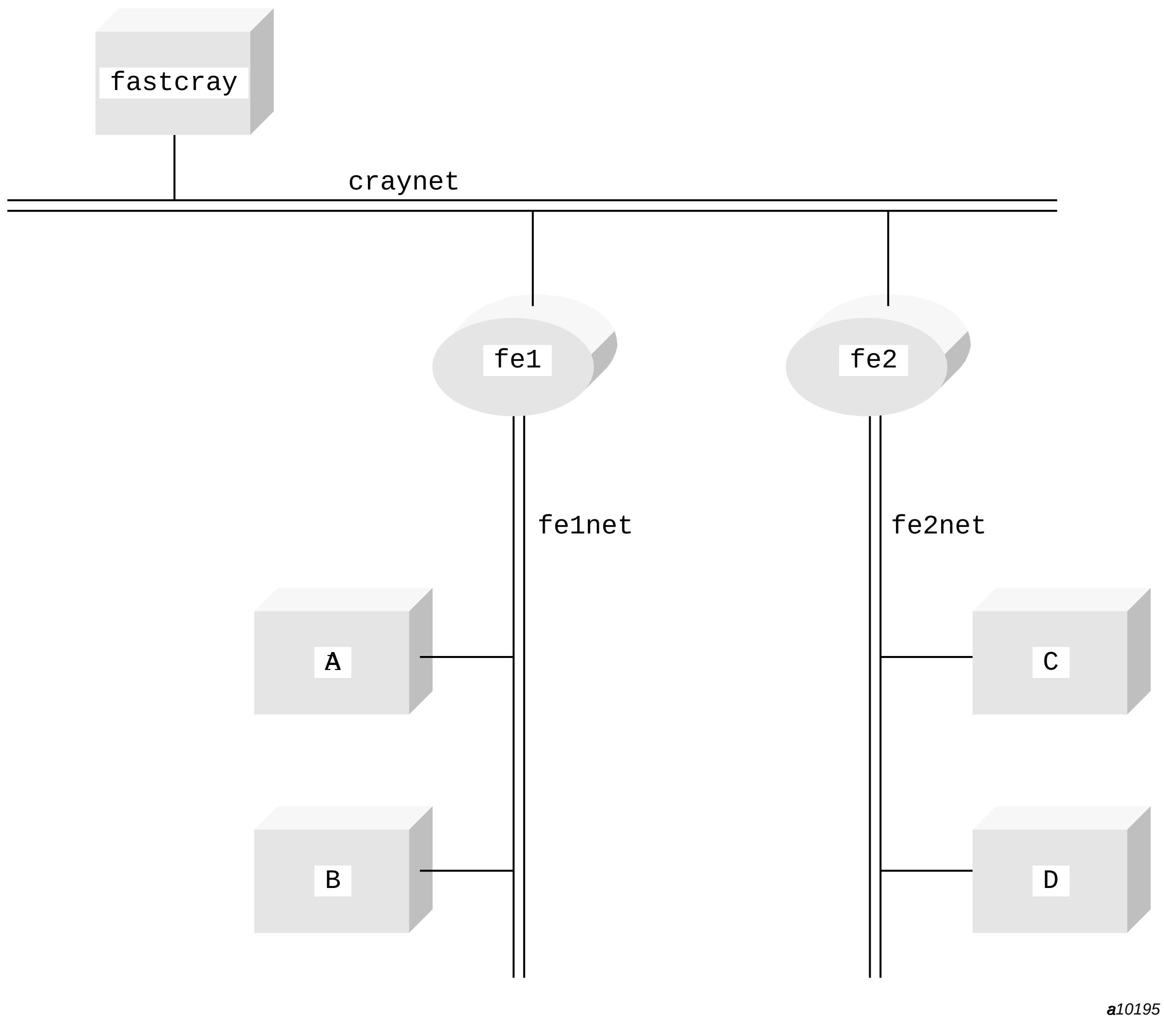


Figure 3. Internet configuration with obvious paths

If data is to be sent between network `craynet` and host `A` or host `B`, it must be routed through gateway `fe1`. If data is to be sent between `craynet` and host `C` or host `D`, it must be routed through gateway `fe2`. However, in Figure 4, the paths that the data must take to reach network `craynet` are not so obvious. Any of the hosts in `bignet` can have data routed through gateway `fe1` or `fe2`.

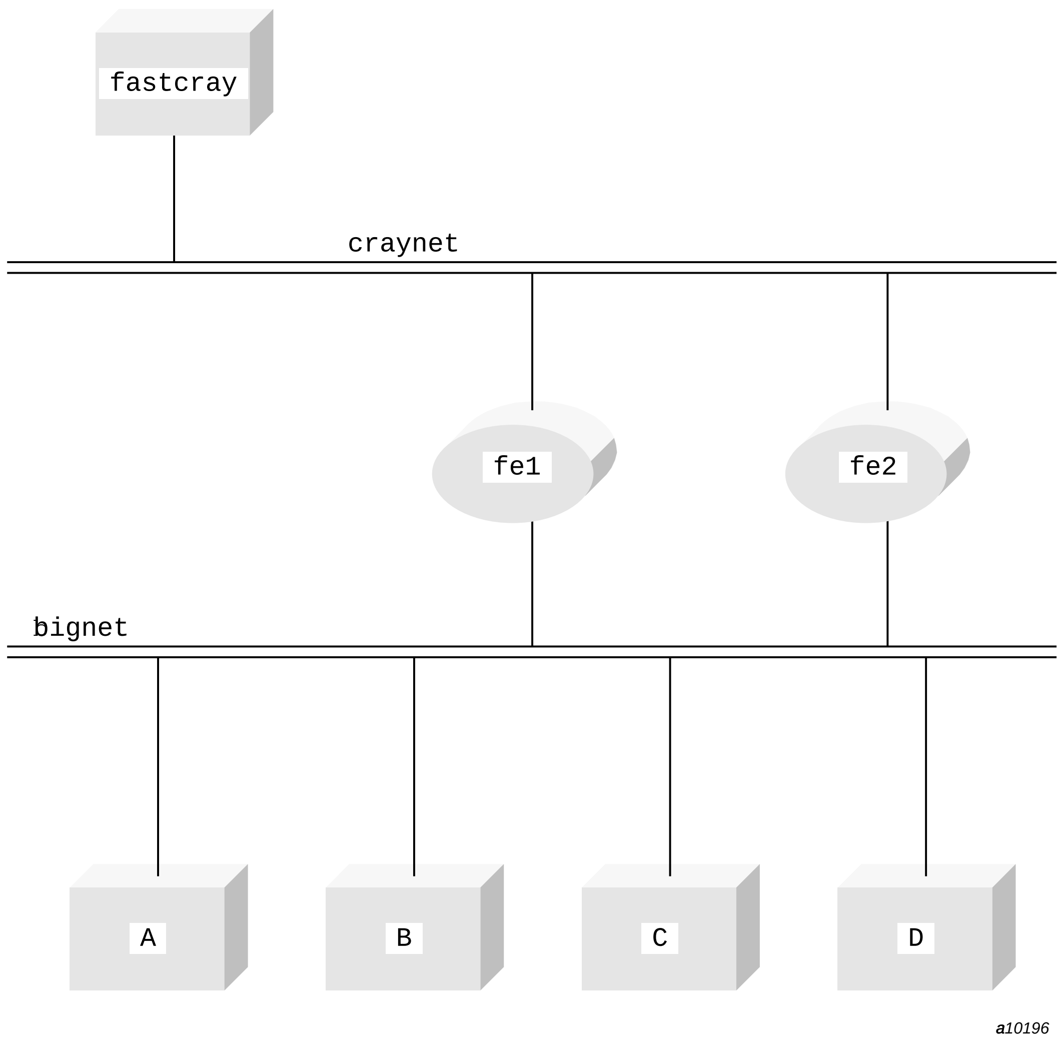


Figure 4. Internet configuration with alternative paths

2.1.4.1 Routing Procedure

As an administrator, you must determine the proper routing information, based on the configuration of your networks, for each host that is not directly connected to the Cray Research system. For example, if you were administering the internetwork shown in Figure 4, you would first determine which hosts will use which gateways to communicate with the `craynet` network. You might decide that hosts A and B will use gateway fe1, and hosts C and D will use gateway fe2. The routing information you would supply for each host would indicate the first gateway through which the data must travel to reach craynet. Each pass through a gateway is known as a *hop*.

If there is more than one local network to which gateways are connected, you must also specify a network route for each gateway. You can also specify default gateways to provide paths for the hosts or networks that have no alternative gateways to use.

Data is sent through the internetwork in pieces known as *datagrams*. When a host is ready to send a datagram to another host, the destination Internet address is included in the datagram, and the adapter encapsulates the datagram into a unit of data known as a *network packet*. A network packet can travel only between directly connected hosts.

In Figure 5, a datagram is routed from host A in network bignet to the craynet network.

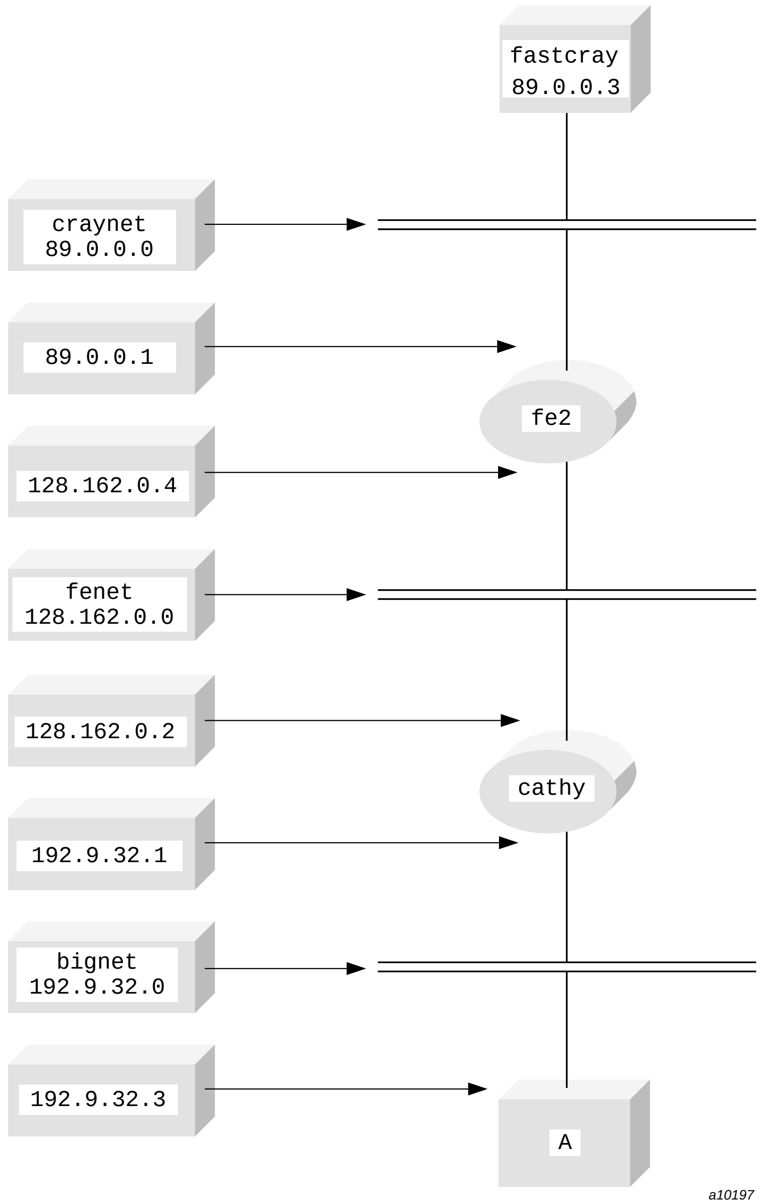


Figure 5. Routing procedure example

When host `A` (address 192.9.32.3) is ready to send a datagram to the `craynet` network (network address 89.0.0.0), the routing information for host `A` reveals that, for datagrams going to network 89.0.0.0, the first hop is gateway `cathy` (address 192.9.32.1). Although the ultimate destination is for a host on `craynet`, a packet is built and sent to `cathy` 's address. This is as far as this packet can go. When the packet reaches address 192.9.32.1, the datagram is stripped from the packet. The destination address in the datagram is checked against `cathy'`s routing information. `cathy` 's information reveals that, for datagrams going to network 89.0.0.0, the first hop is gateway `fe2` (address 128.162.0.4). The datagram is put into a new packet, with the destination address specified as `fe2` 's address. When the packet reaches address 128.162.0.4, the datagram is again stripped from the packet. The routing information for `fe1` reveals a direct route (no hops) to network 89.0.0.0. The datagram is put into yet another packet, and the packet is sent to the destination host.

2.1.4.2 Routing Algorithm

You specify routes by creating kernel data structures known as *routing tables*. Routing tables contain *destination/gateway* pairs; *destination* is the destination of the datagram, and *gateway* is the gateway to be used for the next hop. A gateway can be either a host or an adapter. The example in the previous section is based on a routing algorithm that the routing software uses to find a match between a datagram's destination address and an address found in the destination field of the routing table. When the match is found, the corresponding gateway is used as the destination for the packet.

The algorithm is as follows:

1. If the destination address of the datagram exactly matches any of the destination addresses in the host-specific routes of the routing table, return the first such match.

2. Otherwise, if the network portion of the destination address of the datagram matches any of the destination network addresses in the network routes in the routing table, return the first such match.

3. Otherwise, if a default route is available, return that route.

4. Otherwise, there is not enough information to route the packet, and an error is returned to the sender. If this occurs, user programs receive either a `Host unreachable` or a `Network unreachable` error message.

2.1.4.3 Routing Tables

A route for each network interface connected to a host is the only information that the routing software needs to route data through the network. This information is contained in the routing tables. Routes for directly connected networks are set up automatically when an interface is initialized (see Section 2.2, page 23). However, the system administrator must set up routing tables on all hosts that will be communicating with host networks that are not directly attached. Each host has a start-up script, which is used to configure network interfaces and initialize routing information whenever the system is initialized. On many systems, the administrator places `route`(8) commands in the start-up script to place the proper routing information in the routing tables when the start-up script is executed.

The `/etc/staticrts` start-up script supplied with the UNICOS system takes a slightly different approach, requiring the system administrator to place the proper routing information in the `/etc/gated.conf` file, from which it will be extracted and used to initialize the routing tables when the `/etc/staticrts` script is executed.

Assume that you are the network administrator for the internetwork segment shown in Figure 6. Routing tables must be set up for hosts `A`, `B`, `C`, `D`, `E`, and `F`, and between `smallnet` and `bignet`. It is your job to determine the routing of data from these hosts to the Cray Research system (`fastcray`). (See Section 2.3, page 128, for details on selecting the most efficient routes.) The `bignet` network has four hosts, and network `smallnet` has only two. If all data coming from `bignet` and going to network `craynet` is routed through gateway `G2`, gateway `G2` might be too busy, and routing might become unnecessarily slow. Therefore, to minimize the load on gateway `G2`, you can decide to route data from hosts `A`, `B`, and `D` through gateway `G2`, and to route data from host `C` through gateway `G1`.

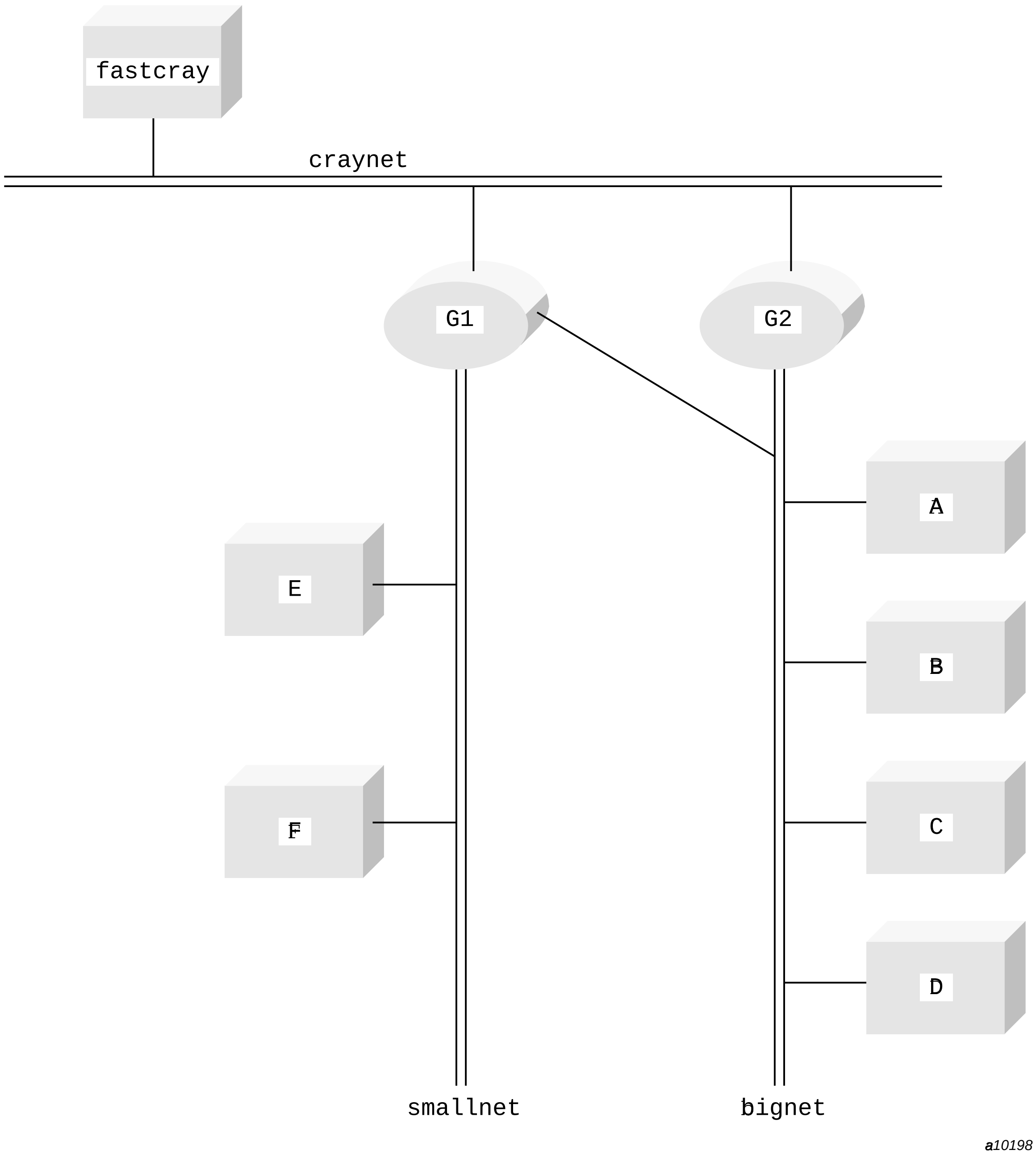


Figure 6. Routing table example

The following list shows the routing tables set up from the `route` commands for each host on the internetwork shown in Figure 6, page 22:

Host	Routing table
A	`route add craynet G2`
	`route add smallnet G1`
B	`route add craynet G2`
	`route add smallnet G1`
C	`route add default G1`
D	`route add craynet G2 route add smallnet G1`
E	`route add default G1`
F	`route add default G1`
`fastcray`	`route add smallnet G1`
	`route add bignet G2`
	`route add C G1`

The routing tables set up for hosts `A`, `B`, and `D` specify that gateway `G2` will be used for network `craynet` destinations, and gateway `G1` will be used for `smallnet` destinations. The routing table for host `C` specifies that, no matter what the destination, data from host `C` will be routed to gateway `G1`. The routing tables for hosts `E` and `F` also indicate that gateway `G1` will be used for all routing. Hosts `E` and `F` have no other choice. The routing table for `fastcray` is set up so that the route it uses to send data to each host is the same route that the host uses to send data to `fastcray`.

2.2 Configuring TCP/IP

This section describes the configuration of TCP/IP in a UNICOS environment. It describes the system components that are configurable, and it discusses methods for configuring them. The following steps are described:

- Configuring the TCP kernel code (determining and setting mbufs, and configuring other kernel parameters by using the `netvar`(8) and `sysctl`(2) commands)
- Setting up network-wide configuration files (`/etc/hosts` and `/etc/networks`)

- Setting up local system configuration files (`/etc/services`, `/etc/shells`, `/etc/hosts.equiv`, `/etc/config/spnet.conf`, `/etc/protocols`, and `/etc/config/interfaces`)
- Configuring network interfaces and daemons
- Performing start-up procedures
- Using the `telnet linemode` feature
- Assisting users in setting up environments (tab settings, `$HOME/.netrc`, `$HOME/.rhosts`, and `bftp`)

If you are planning to run the UNICOS security feature on your Cray Research system, refer to Section 2.6.3, page 224, for additional kernel configuration.

If you are also planning to tune your system, refer to Section 2.3, page 128.

2.2.1 Configuration Issues

This section describes several instances in which the configuration you choose will affect the general operation of your TCP/IP networking software. Some of these considerations involve choices among different methods by which the software can accomplish something (such as looking up host name and address information); others involve general policy considerations affecting the configuration of your network (such as the selection of appropriate Internet addresses).

2.2.1.1 Looking up Host Names and Addresses

The underlying TCP/IP protocol suite identifies and communicates with all hosts by their numeric Internet addresses. If the software that implements the protocols allowed users to specify hosts by only numeric Internet addresses, however, keeping track of which numeric address referred to which host would become a tremendous burden on users (not to mention system administrators). To avoid this problem and to make networking easier to use, the TCP/IP software allows for central lookup of host names for conversion into the numeric Internet addresses used by the underlying protocols. (It is easier to remember names than to remember numbers.) UNICOS TCP/IP provides two separate configuration methods to allow the software to map between Internet addresses and host names. The method you choose for your system configuration has a large impact on the networking capabilities provided to your system's users.

Note: These host address look-up methods are contained in library routines common to all TCP/IP networking software; no software needs recompilation, regardless of the configuration you choose.

The first method of mapping between host addresses and names is to place the host addresses and names in the static text file `/etc/hosts`, as described in Section 2.2.4.1, page 31. The advantage to using the `/etc/hosts` file is simplicity; the information your users are seeking resides in one, easy-to-find and easy-to-fix file. The disadvantage is that the `/etc/hosts` file on your Cray Research system is merely a local copy of information that must be consistent across all hosts on your networks; it is very easy for the information in your `/etc/hosts` file to become out-of-date because of changes that occur to remote networks at your site (for example, the addition of a new host, or a changed name of a host).

The second method is to use the Internet domain name service, the configuration of which is described in Section 2.2.8.3, page 81. The domain name service is a distributed collection of name servers on various hosts; these servers answer requests for information about mappings between host addresses and names. That is, the UNICOS TCP/IP software requests that a server (either on your local Cray Research system or a remote system, according to your configuration) supply the address for a given host name, and the server responds with the information (possibly after consulting other name servers).

Note: The use of the domain name service is not allowed for the Cray ML-Safe configuration of the UNICOS system.

The disadvantages of using the domain name service are that using this service is more complex than relying on one `/etc/hosts` file (and, therefore, somewhat more complex to administer) and that relying on name servers configured by other administrators for information about those administrators' remote hosts and networks introduces the risk of incorporating mistakes from other administrators' information.

The advantages of using the domain name service are that, despite the complexity of the domain name service, relying on it for information about changes to remote hosts and networks is a lot less work than repeatedly updating the `/etc/hosts` file by hand; also, your Cray Research system users can access more remote hosts more conveniently and without administrator intervention.

However, the use of the domain name service for your host name and address lookup does not completely eliminate the need for an `/etc/hosts` file. Because the domain name service uses the underlying TCP/IP protocols to ask information of and receive information from other name servers, system startup can be a problem if the domain name service is requested to resolve a host name that is necessary for network initialization (for example, the name of a local interface to be configured up) before the networks have, in fact, been initialized. Thus, even when using the domain name service, you must have in your `/etc/hosts` file the names of any hosts referred to during your start-up procedure. Typically, this list includes, at a minimum, all the hosts in the network access list (NAL) and workstation access list (WAL), the names of any local interfaces, and the names of any remote systems for which you will be configuring routing information.

In summary, relying on `/etc/hosts` for your Cray Research system should be adequate for sites with smaller networks administered by one central authority. However, if your Cray Research system will be attached to the Internet or some other larger collection of networks that are supported by many different administrators, the use of the domain name service will provide more reliably consistent host name and address mapping than will the use of an `/etc/hosts` file alone.

2.2.1.2 Selection of Internet Addresses

If you are connecting your Cray Research system to an existing TCP/IP network, Internet addresses have already been established for the networks at your site; also, there is likely to be an established list of host names and addresses for configuration of your `/etc/hosts` file, or one or more existing domain name servers on various hosts on the network to resolve host names and address for your system.

If, however, you are establishing a new TCP/IP network to which to attach your Cray Research system, you must use a new network address. The UNICOS TCP/IP software places no specific policy restrictions on the network numbers you use for the addresses on any specific networks at your site; technically, you can choose any number you want for a new network address. However, choosing a network number in such a haphazard manner introduces the risk of conflicting network numbers if your site decides to connect its TCP/IP networks to those of another site.

To avoid conflicts of this type, a central administration center exists for official Internet network addresses. To request official network addresses for any networks at your site, send your request to the following location:

Network Solutions, Inc.

505 Huntmar Park Drive

Herndon, VA 22070

Attn: InterNic Registration Service

The email address is RS.INTERNIC.NET. The telephone number is (800)365-3642. See RFC 1400 for further information.

(In practice, sites with several local networks will typically request one official network address for the site and differentiate among local networks by establishing a different subnet address for each one, not by giving each local network its own official network address.)

Note: Because it is often very difficult to foresee the future needs of a given networking installation, Cray Research strongly recommends that you secure official Internet addresses from the InterNic for any TCP/IP networks at your site, even if you have no current plans to connect your site to any outside networks. This small precaution will prevent the trouble of converting your network's Internet addresses if your site should decide to connect to the Internet in the future.

2.2.2 Configuring the TCP/IP Kernel Code

This section describes the steps you must take to determine and set segments of a special memory pool (*mbufs*), and to specify other kernel parameters through the use of the `netvar`(8) facility. See Section 2.3.2.1, page 134, for a more detailed description of mbufs.

2.2.2.1 Determining the Number of Mbufs Needed

To determine the number of mbufs to allocate, you must consider the following factors:

- Whether HIPPI is being used as a TCP/IP interface. HIPPI does not achieve its peak performance with TCP/IP unless you use large kernel buffers (`TCP_SNDBUF` and `TCP_RCVBUF` socket options) and expanded windows (`TCP_WINSHIFT` socket option). UNICOS `ftp` and `ftpd` facilities automatically use these to maximize file transfer throughput.

Note: For Model E and Model V based systems, define a minimum of 1800 mbufs for each HIPPI interface configured for TCP/IP; for GigaRing based systems, define a minimum of 4000 mbufs for each HIPPI interface configured for TCP/IP.

- Mbufs are incremented by 4000. See Section 2.2.2.2.1, page 29 for a table showing the number of mbufs required to `ifconfig` each interface type.
- Number of routing entries in the routing table (for Model E and Model V based systems, each entry requires 1 mbuf; for GigaRing based systems, each entry requires 2 mbufs.). See Section 2.1.4, page 15, for a description of routing tables.
- Number of active sockets (for Model E and Model V based systems, each requires 3 mbufs for the life of the connection; for GigaRing based systems, each requires 2 mbufs for the life of the connection). See Section 2.3.2.1.4, page 141, for a description of sockets.
- Number of UNICOS network file system (NFS) user ID maps configured (approximately 150 mbufs for each).
- On systems running the UNICOS security feature, the number of NAL, WAL, and Internet Protocol Security Options (IPSO) map entries (each requires 1 mbuf).

These factors account for a small, but fixed pool of mbufs. Additional mbufs are required to handle transient peaks, packet headers, data queued for input or output to active connections, and file transfer and remote shell connections. To avoid a setting that is too low, you should set your number of mbufs to 50% above the minimum estimate. For more information on selecting the number of mbufs to allocate, see Section 2.3.2.1.3, page 136.

2.2.2.2 Setting the Number of Mbufs

To set the number of mbufs, perform the following steps:

1. If you are using the UNICOS ICMS to configure your kernel, consult the `Configure System -> Kernel configuration` menu for the item that sets the appropriate number of mbufs.

   If you are not using the UNICOS ICMS to configure your kernel, set (or change) the value of the `TCP_NMBSPACE` parameter in the `/usr/src/uts/cf/config.h` file to the appropriate number of mbufs.

Either method sets the number of mbufs, which will be allocated at system initialization time for TCP/IP use. You cannot change the size of this pool while the system is running.

2. Issue the `nmake`(1) command from the `/usr/src/uts/cf` directory (for CRAY J90 systems, the `/usr/src/uts` directory). This recompiles the module with the new mbuf value and links a new kernel.

3. Issue the following command from the `/usr/src/uts/cf` or `/usr/src/uts` directory:

```
nmake installsys
```

This installs the newly built kernel with the new number of mbufs in the root directory.

2.2.2.2.1 Mbuf Requirements—for GigaRing Based Systems Only

1. The following shows the number of mbufs required to `ifconfig` each interface type:

Interface	mbufs required
ATM	2000
Ethernet	500
FDDI	1000
HIPPI	4000
GigaRing	4000

2.2.2.3 Specifying Other Kernel Variables

You can use either the `netvar`(8) or `sysctl`(8) command to set or change other kernel networking variables, such as the TCP/IP `send` and `receive` space, while the system is up and running. At system start-up time, the default `tcpstart`(8) script, which is supplied with the UNICOS system, uses `netvar`(8) to initialize kernel variables to values you select (see Section 2.2.9.2, page 112, for details).

2.2.3 Security Configuration Parameters for Networking

Security configuration parameters for the UNICOS operating system are set in the kernel parameters and `config.h` file. For information on installing and configuring the UNICOS system, see *UNICOS System Configuration Using ICMS*, publication SG–2412.

The following are the security configuration parameters for networking:

Parameter	Description

NFS_SECURE_EXPORT_OK

Flag indicating whether information on a secure file system can be exported over NFS. A *secure file system* refers to a file system that has been explicitly marked as secure by labelit(8) or mkfs(8). This configuration parameter is retained for compatibility with the UNICOS operating system.

If NFS_SECURE_EXPORT_OK is enabled (set to 1), remote access to secure file systems will be allowed. If NFS_SECURE_EXPORT_OK is disabled (set to 0), remote access to secure file systems is prohibited.

It is recommended that sites use a setting of 1 for all configurations of the UNICOS operating system.

The default setting is 1. There is no required ML-Safe setting.

NFS_REMOTE_RW_OK

Flag indicating whether remotely mounted NFS file systems can be mounted as read/write or whether they must always be read-only. If NFS_REMOTE_RW_OK is enabled (set to 1), remotely mounted NFS file systems may be mounted read/write or read-only. If NFS_REMOTE_RW_OK is disabled (set to 0), all remotely mounted NFS file systems are mounted read-only.

The default setting is 1. There is no required ML-Safe setting.

SECURE_NET_OPTIONS

A bit mask of flags that may contain the following bits. It allows a site to configure certain global networking options. standard

Bit name	Value	Description
NETW_STRICT_B1	00001	Restrict network label ranges so that NAL entries must either specify an IP security option or a single label for a remote host.
NETW_SOCK_COMPAT	00002	Automatically make all sockets set up by a privileged process multilevel sockets.
NETW_RCMD_COMPAT	00004	Allow traditional processing of .rhosts and hosts.equiv.

The default setting is 6 (NETW_SOCK_COMPAT | NETW_RCMD_COMPAT).

The 1 (NETW_STRICT_B1) bit is required for the Cray ML-Safe configuration of the UNICOS system.

2.2.4 Setting up Network-wide Configuration Files

This section describes the configuration and format of the /etc/hosts and /etc/networks files, which map Internet addresses to host and network addresses, respectively. Because the Internet addresses listed in these files must be consistent across all hosts on the affected networks, many sites maintain master copies of these files (maintained by a central administrator), and when necessary, distribute updated copies to all of the systems that are based on the UNIX system and attached to their networks. This administrative technique is much simpler than relying on the individual administrators of each host to make changes to the files manually; thus, it is particularly recommended for sites with many networked hosts. However, if you ever need to modify the contents of your /etc/hosts or /etc/networks file directly, you must adhere to the formats specified in the following section.

2.2.4.1 The /etc/hosts File

The /etc/hosts file is a text file that associates each Internet address with one or more host names. See "Looking up host names and addresses," Section 2.2.1.1, page 24, for information on setting up the /etc/hosts file. There should be one entry in the /etc/hosts file (that is, one Internet address) for each network interface on each host of the networks that are accessible to your

Cray Research system. The `gethost`(3) library routines, which are compiled into the TCP/IP software, consult the entries in the `/etc/hosts` file to map a host name supplied by the user to an Internet address (and vice versa).

If you are using the UNICOS ICMS to configure your Cray Research system, you can disable the appropriate portion of the UNICOS ICMS and manually update the `/etc/hosts` file. This would be appropriate for a site at which the `/etc/hosts` file for all systems that are based on the UNIX system is maintained by a central administrator and distributed to your Cray Research system. To complete the disable procedure, consult the `Configure System -> Configurator automation options` menu for the correct entry to use to automate the host address configuration.

If you decide to use the UNICOS ICMS to configure your `/etc/hosts` file, the `Configure System -> Network configuration -> General network configuration -> Host address configuration` menu lets you specify the remote hosts that are accessible to your Cray Research system, and it generates an `/etc/hosts` file from the information you supply.

If you decide not to use the UNICOS ICMS to configure your `/etc/hosts` file, or if you are not using the UNICOS ICMS for your configuration at all, you must follow the guidelines in this section to edit the `/etc/hosts` file directly to specify the remote hosts that are accessible to your Cray Research system.

The following is an example of an `/etc/hosts` file:

```
# /etc/hosts
# TCP/IP hosts file
#
127.0.0.1     localhost   loopback
89.0.0.0x3    r-n-d       rocky
89.0.0.4      support     bullwinkle      bw
89.00.0.5     cray-a      peabody
192.9.0.5     cray-b      boris
35.01.0.11    star
51.0.0.1      accounts
```

Use the following format rules for creating the `/etc/hosts` file:

- Begin each line with an Internet address. Each segment of the address can be expressed in decimal, octal, or hexadecimal format. Octal segments are preceded by 0; hexadecimal segments are preceded by 0x. In the previous example, the fourth segment of the address for host `r-n-d` is in hexadecimal format; the second segment of the address for host `cray-a` is in octal format; the second segment of the address for host `star` is in octal format; all other segments are in decimal format. Each Internet address must appear on a separate line.

- Follow the Internet address by at least one blank space or tab.
- Look at the official host name in the field following the Internet address. Ensure that the host name does not exceed 63 characters and contains only alphanumeric characters or the minus sign with the first character alphanumeric.
- Allow the host name to be followed by blank space and one or more aliases. In the previous example, host `support`, which has Internet address 89.0.0.4, has the two aliases, `bullwinkle` and `bw`.
- Always use the Internet address for the loopback test (see "The `hit`(8) command" and Section 2.4.1.1.3, page 177, for details of the loopback test). In the previous example, the Internet address 127.0.0.1 for `localhost` is used for the loopback test.

  Note: In the Cray ML-Safe configuration of the UNICOS system, special steps must be taken to run the `hit`(8) command (see *General UNICOS System Administration*, publication SG–2301, for more details on non-TCP software and UNICOS security).

- Add comment lines to the file by preceding the comments with a #. You can enter comments on a separate line, with a # as the first character, or on part of a line. Any data following a # and contained on the same line as the # is considered a comment.
- If you insert multiple entries for a single remote host, the first entry is used.

For improved performance, you can also create `/etc/hosts.bin`, a binary equivalent of the `/etc/hosts` file that can be searched more rapidly. If this binary file is present, it is used instead of the `/etc/hosts` file to discover the Internet address for a given host name. Use the `mkbinhost`(8) command to create the `/etc/hosts.bin` file. If you are using the default `tcpstart` script, this file is created automatically when the system is initialized.

2.2.4.2 The `/etc/networks` File

The `/etc/networks` file is a text file that associates names with networks that are accessible to your Cray Research system by using the network portion of the Internet addresses of the hosts on each network. (This is referred to as the *network number* of the network.) You can choose not to provide any mapping between network numbers and network names (that is, you can decide not to provide an /etc/networks file). If you do not provide an /etc/networks file, however, all references to networks in your configuration (typically as an argument to the route(8) command as part of the NAL and WAL configurations, or in the output of the netstat(1B) command) must be by network number, and not by name. If you do provide an /etc/networks file, the getnet(3) library routines, which are compiled into the TCP/IP software, consult the entries in the /etc/networks file to map a network name that is supplied by the user to a network number (and vice versa).

If you are using the UNICOS ICMS to configure your Cray Research system, you can disable the appropriate portion of the UNICOS ICMS and manually update the /etc/networks file. This would be appropriate for a site at which the /etc/networks file for all systems that are based on the UNIX system is maintained by a central administrator and distributed to your Cray Research system. To complete the disable procedure, consult the Configure System -> Configurator automation options menu for the correct entry to use to automate the network address configuration.

If you decide to use the UNICOS ICMS to configure your /etc/networks file, the Configure System -> Network configuration -> General network configuration -> Network address configuration menu lets you specify the networks that are accessible to your Cray Research system, and it generates a /etc/networks file from the information you supply.

If you decide not to use the UNICOS ICMS to configure your /etc/networks file, or if you are not using the UNICOS ICMS for your configuration at all, you must follow the guidelines in this section to edit the /etc/networks file directly to specify the networks that are accessible to your Cray Research system.

The following is an example of an /etc/networks file:

```
# /etc/networks
# TCP/IP networks file
#
loopback   127          # Class A network
craynet1   128.162.1    # Class B subnetted network
craynet2   128.162.2    #
ether1     128.162.3    r-n-d     research
```

Use the following format conventions for creating or changing the network file:

- Use the first field of every line as the official network name. The network name must not exceed 63 characters and must contain only alphanumeric characters and the minus sign with the first character alphanumeric.

Follow the network name by blank space (that is, by any number of spaces or tabs).

- Note that the second field contains the network portion of an Internet address, which can be in decimal, octal, or hexadecimal format. (Ensure that each network number appears on a separate line.)
- Follow the network number by a blank space and one or more aliases. In the previous example, network `ether1`, which has network number 128.162.3, has the two aliases `r-n-d` and `research`.
- Remember that the `/etc/networks` file is searched sequentially. If there are multiple entries for one network, the first entry is used.
- Use network number 127 for loopback processing. Because loop-back processing is used to test the network, you should never use the official network name as an alias for `loopback`.
- Add comment lines to the file by preceding the comments with a #. Enter comments on a separate line, with a # as the first character, or on part of a line. Any data following a # and contained on the same line as the # is considered a comment.

2.2.5 Setting up Local System Configuration Files

The configuration files that are described in the following section must be configured if your site uses the facility that the file represents.

2.2.5.1 The `/etc/services` File

The `/etc/services` file is a text file that associates the name of a service with the protocol and standard port number that are used by the daemon that provides the service. The default `/etc/services` file that is supplied with the UNICOS system lists the Internet-standard protocols and ports for many services. Therefore, you should never need to modify an existing entry. However, it might be appropriate to add information about new services that are local to your site.

If you are using the UNICOS ICMS to configure your Cray Research system, you can disable the appropriate portion of the UNICOS ICMS and manually update the `/etc/services` file. To do so, consult the `Configure System -> Configurator automation options` menu for the correct entry to use to automate the services configuration.

If you decide to use the UNICOS ICMS to configure your /etc/services file, the Configure System -> Network configuration -> General network configuration -> Networking services configuration menu lets you specify the services available on your Cray Research system, and it generates an /etc/services file from the information you supply.

If you decide not to use the UNICOS ICMS to configure your /etc/services file (or if you are not using the UNICOS ICMS at all), you can add services by editing the /etc/services file directly and then running the rsvportbm(8) command. This command prevents servers that use the bindresvport(3) and rresvport(3) library routines from using the ports reserved in the /etc/services file.

The /etc/services file contains the following information:

- Official service name
- Port number (see Assigned Numbers, RFC 1010)
- Slash (/)
- Protocol name (currently TCP, UDP, or OSI)
- Aliases of the service

The following is a sample network services file:

```
# /etc/services
# Network Services, Internet style
echo         7/tcp
echo         7/udp
netstat     15/tcp
ftp         21/tcp
telnet      23/tcp
smtp        25/tcp      mail
hostnames  101/tcp      hostname
sunrpc     111/tcp
sunrpc     111/udp
# Host specific functions
tftp        69/udp
finger      79/tcp
# UNIX specific services
ntp        123/udp
exec       512/tcp
login      513/tcp      log
shell      514/tcp      sh
```

```
ntalk      518/udp
printer    515/udp
nqs        607/tcp
```

2.2.5.2 The /etc/shells File

The /etc/shells file is a text file that contains a list of shells that are associated with user accounts. The ftpd(8) program on the Cray Research system consults the list of shells in this file (by using the getusershell(3) library routine). If the login shell of an account to which someone is trying to log in through ftp(1B) does not appear in the /etc/shells file, ftpd(8) does not permit the login. If this file does not exist on your Cray Research system, it is because only accounts that list the standard shell (/bin/sh) or the C shell (/bin/csh) as their login shell are permitted to access the Cray Research system by using ftp(1B) to transfer files.

If you are using the UNICOS ICMS to configure your TCP/IP software, consult the Configure System -> Network configuration -> TCP/IP configuration -> Shells menu to supply the list of shells for the /etc/shells file.

If you are not using the UNICOS ICMS to configure your TCP/IP software, or if you are not using the UNICOS ICMS at all, you must edit the /etc/shells file directly.

The following shows a sample file that enables accounts that list the standard, C, and Korn shells as their login shell to access files on the Cray Research system by using ftp(1B).

```
# /etc/shells
# List of acceptable shells for chsh/passwd -s
# Ftpd will not allow users who do not have one of these
#     shells to connect
#
/bin/sh
/bin/csh
/bin/ksh
```

2.2.5.3 The /etc/hosts.equiv File

The TCP/IP /etc/hosts.equiv file is an optional file that provides host access permission information. The presence of a remote host's name in this file grants access to users on that host who have the same account name on the local host without requiring them to enter a password.

Note: The implications of `/etc/hosts.equiv` are different when you are running UNICOS security. See Section 2.6, page 218, for more details.

Following is an example of a `hosts.equiv` file:

```
# hosts.equiv
twg                   # Allows access to users from twg who have
                      # accounts on the local host
cray1     - steve     # Allows all users from cray1 except steve
cray2     mark        # Allows user mark to access all accounts on the
                      # local host
```

Use the following format conventions for creating or changing the `/etc/hosts.equiv` file:

- Begin each remote host's name on a separate line.
- Follow the host name by a blank space and the login name of any user on the host. The specified user can access all user accounts except root on the local host. Use a minus sign (`-`) in the second field to deny access to specific users.
- Use the wildcard character (*) in either field to match any user or host name.

  Note: It is a security risk to use the wildcard character. For example, the wildcard character in the second field allows all users on the remote host to access all user accounts on the local Cray host. Do not use the wildcard character without a thorough understanding of its implications.

The `rlogind`(8), `rshd`(8), and `rexecd`(8) daemon processes use this file; therefore, listing a remote host in `/etc/hosts.equiv` allows users of that remote host to access the local host through the r-series commands.

Note: You can prohibit users on all remote hosts from using the r-series commands by commenting out the references to r-series daemons (`rshd`, `rlogind`, `rexecd`, and so on) in the `/etc/inetd.conf` file. See Section 2.2.8.7, page 102, for more information.

Users from remote hosts who have accounts on the local host are automatically logged in and given execution privileges if their login names are the same on both the remote host and the local host. (Users can set up `$HOME/.rhosts` files in their home directories on the local host to allow automatic login and access to their accounts, even if the login names are different on the Cray Research system and the remote host.)

When using the `rlogin`(1B) program or `rexec`(3) library routine, users are prompted for their login names, and possibly their passwords, when the contents of the `.rhosts` file requires it. When using the `rcp`(1) or `rsh` (see `remsh`(1B)) program, users are denied access if neither `/etc/hosts.equiv` nor `$HOME/.rhosts` is configured. See the *TCP/IP Network User's Guide*, publication SG–2009 for the format of entries in the `.rhosts` file.

A user with the login name `root` on the remote host can log in as `root` on the Cray Research system only when listed in the Cray Research system `.rhosts` file. You must carefully set up the `/etc/hosts.equiv` and `/.rhosts` files to minimize security risks.

The r-series programs (`rlogin`(1B), `rsh`(1B), `rcp`(1B), and `rexec`(3)) work only between hosts that run under operating systems that are based on a UNIX operating system. These programs provide automatic user authentication and automatically pass terminal information to the remote host by using the following procedure:

1. If the user is not root, the server searches `/etc/hosts.equiv` for the remote host's name.
2. If the host name is not found, the server searches for the user's login name in `/etc/passwd`.
3. If the login name is found, the user's `.rhosts` file is checked.
4. If the remote host name and remote user name are contained in the `.rhosts` file, the user is immediately logged in to the local host.

Warning: Using the second field of the `/etc/hosts.equiv` file is a security risk if `NETW_RCMD_COMPAT` is also enabled. The first field is a remote system name; the second field is an optional user name. For any remote system (`R`) and any user (`U`) that are listed in the first and second fields of the `/etc/hosts.equiv` file, `U` can log in to any local account, except `root`, from `R`, without using a password.

When `NETW_RCMD_COMPAT` is used, automatic authentication is a security risk because passwords are not checked if a user's local login and local host name are listed in the remote `.rhosts` file. For example, a user with the login name `joan` on any remote host that is in `/etc/hosts.equiv` is allowed automatic login to local account `joan`.

Another network security problem involves the function of the second field in the `/etc/hosts.equiv` file (when `NETW_RCMD_COMPAT` is running). After a remote host name, you can enter the user name of any user on the remote host. Then, when the `-l` *username* option is entered with any of the r-series commands, the user in the /etc/hosts.equiv entry has automatic login and file access to the accounts of every user on the local host except root.

For example, suppose you enter the following line in the /etc/hosts.equiv file on the local host:

```
twghost  mark
```

User mark can then enter the following command from host twghost:

```
$  rlogin  runcray  -l  steve
```

User steve now has automatic login and file access to the accounts of every user on the local host except root.

2.2.5.4 The /etc/protocols File

The /etc/protocols file is a text file that associates the name of a protocol in the Internet protocol suite with the protocol number (and one or more aliases). The default /etc/protocols file that is supplied with the UNICOS system contains a standard list of protocols and, therefore, might not need to be modified. However, it might be appropriate to add information about new protocols that are local to your site.

If you are using the UNICOS ICMS to configure your TCP/IP software, you can disable the appropriate portion of the UNICOS ICMS and manually update and configure the /etc/protocols file. To do so, consult the Configure System -> Configurator automation options menu for the correct entry to use to automate the protocols configuration.

If you are using the UNICOS ICMS to configure your /etc/protocols configuration file, the Configure System -> Network configuration -> TCP/IP configuration -> Protocols menu lets you specify the protocols available on your Cray Research system, and it generates a proper /etc/protocols file from the information you supply.

If you are not using the UNICOS ICMS to configure your /etc/protocols file, or if you are not using the UNICOS ICMS at all, you can add protocols by editing the /etc/protocols file directly. For each protocol listed in the file, there should be one line containing the official protocol name, the protocol number, and any aliases for the protocol name. The items are separated by any number of blanks or tab characters (or both). A comment is identified by a #.

The following is an example /etc/protocols file:

```
# /etc/protocols

ip      0     IP     # internet protocol, pseudo protocol number
icmp    1     ICMP   # internet control message protocol
tcp     6     TCP    # transmission control protocol
udp     17    UDP    # user datagram protocol
```

2.2.6 Configuring Network Interfaces—Model E and Model V Systems Only

The following section describe the following steps that you must take to configure each Cray Research system interface on the network:

1. Define the hardware devices
2. Name the Cray interface
3. Choose an Internet address
4. Create the `hycf` file, if needed

Note: Before you begin the steps presented in this section, ensure that all of the hardware diagnostic tests have been performed and that all of the hardware is functioning properly. Consult the appropriate vendor documentation for specific diagnostic information.

If you are using the UNICOS ICMS for configuration, you can use the `Configure System -> Network configuration -> TCP/IP configuration -> Configure interfaces` menu to configure your interfaces.

2.2.6.1 Defining Hardware Devices

Defined hardware devices for Cray Research systems are as follows:

- Model E systems

  Hardware devices for Model E systems are defined in the `network` section of the `~cri/os/uts/param` file on the OWS-E or the `/etc/config/param` on the Cray mainframe. Following is a sample `param` file for a Cray Research Model E system:

```
network {
      .
      .
      .
```

```
        npdev   0 {
                 iopath {
                     cluster 0;
                     eiop 0;
                     channel 030;
                 }
                 np_spec FEI3;
         }
       .
       .
       .

         hidev   0 {
                 iopath {
                     cluster 0;
                     eiop 3;
                     channel 030;
                 }
                 logical path 0 {
                         flags 00;
                         I_field 00;
                         ULP_id 00;
                 }
                 flags 00;
                 input;
                 device type PS_32;
}
```

- CRAY J90 Model V systems

  Hardware devices for CRAY J90 systems are defined in the `network` section of the `/sys/param` file. The `/sys/param` file is located on the console disk for CRAY J90 systems. The HIPPI interface is not defined in this file because it is detected during the boot sequence. Following is a sample `param` file for a Cray Research Model V system:

```
network {
     ...
     endev   0 {
             iopath { cluster 1; eiop 0; channel 020; }
     }

     fddev   0 {
             iopath { cluster 2; eiop 0; channel 040; }
```

```
        }
      atmdev  0 {
              iopath { cluster 0; eiop 0; channel 020; }
        }
      atmdev  1 {
              iopath { cluster 3; eiop 0; channel 020; }
      }
      ...
}
```

2.2.6.2 Naming the Cray Interface

The interface name, which TCP/IP uses to access a given hardware device, consists of two parts. The first part, which is the interface name prefix, indicates the type of hardware. The second part, which is the number of the interface name (also known as the *interface number*), identifies the physical device.

2.2.6.2.1 Interface Name Prefix

The interface name prefix is derived from the UNICOS driver that controls the hardware device. This prefix indicates the major number that TCP/IP uses when it defines the character special device for the given hardware. Following is a list of the prefixes and a description of the associated interfaces:

Prefix	Type of interface
`en`	Ethernet interface on CRAY J90 systems. Shown as `endev` in the `param` file.
`fd`	FDDI interface on Model E systems. Shown as the `fddev` hardware device entry in the `/etc/config/param` file.
`fddi`	FDDI interface on CRAY J90 systems. Shown as `fddev` in the `param` file.
`hi`	HIPPI interface on Model E and CRAY J90 systems. Shown as the `hidev` hardware device entry in the `/etc/config/param` file (for Model E systems only).
`np`	Low-speed HYPERchannel interface on Model E systems. Shown as the `npdev` hardware device entry in the `/etc/config/param` file.

`atm` — Asynchronous Transfer Mode (ATM) interface on CRAY J90 systems.

`bbgx:atmx` — ATM interface on Model E systems.

The following matrix summarizes the prefixes that Cray Research systems support:

Cray Research systems	Supported prefixes						
	`en`	`fd`	`fddi`	`hi`	`np`	`atm`	`bbgx:atmx`
IOS Model E		x		x	x		x
CRAY J90 model V	x		x	x		x	

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2.2.6.2.2 Interface Numbers

Interface numbers for hardware devices are derived from the order in which the hardware device entries appear in the files in which they are defined.

On Model E systems, the interface number for hardware devices is derived from the order in which the hardware device entry appears in the `network` section of the `param` file. This number is used to distinguish interfaces of the same type.

The following example shows the `network` section of a `param` file:

```
network {
      .
      .
      .
       npdev   0 {
                iopath {
                    cluster 0;
                    eiop 0;
                    channel 030;
                }
                np_spec FEI3;
        }

        npdev   1 {
                iopath {
```

```
                    cluster 0;
                    eiop 0;
                    channel 032;
                }
                np_spec N130X;

        hidev   0 {
                iopath {
                    cluster 0;
                    eiop 3;
                    channel 030;
                }
                logical path 0 {
                        flags 00;
                        I_field 00;
                        ULP_id 00;
                }
                flags 00;
                input;
                device type PS_32;
}

        hidev   1 {
                iopath {
                    cluster 0;
                    eiop 3;
                    channel 032;
                }
                logical path 0 {
                        flags 00;
                        I_field 00;
                        ULP_id 00;
                }
                flags 00;
                output;
                device type PS_32;
}
```

The interface names for this example are as follows:

```
np0
np1
hi0
hi1
```

2.2.6.3 Choosing an Internet Address

Each interface on your system must have an Internet address. The network and subnet parts of the Internet address of the interface must correspond to the Internet address of the network to which the interface is attached. The host portion of the address can be selected by using the preferred administrative practices for your site. (Some sites have a central network administrator who determines the new Internet addresses for new systems and interfaces; other sites let the individual system administrator decide.)

When you are choosing an Internet address for an interface that is attached to a new TCP/IP network, see Section 2.2.4, page 31, for guidelines.

2.2.6.4 Creating the `hycf` File

> **Note:** For software loopback interfaces, direct FDDI interfaces, Ethernet interfaces, and ATM interfaces, it is not necessary to create an `hycf` file.

If you are using the UNICOS ICMS for configuration, you can use the `Configure System -> Network configuration -> TCP/IP configuration -> Configure hardware addresses` menu to create and maintain the `hycf.` *name* file. The information you put in this file is used as input to the `hyroute`(8) command, which initializes the interface with hardware address information. This configuration file, sometimes known as the `hycf` file, varies according to the type of network hardware used, as shown in the following sections.

2.2.6.4.1 NSC Low-speed Connections

> **Note:** CRAY J90 systems support NSC boxes if you connect to a HYPERchannel network A400, N400, or DX adapter.

Use the following format when you create the `hycf` file for NSC low-speed connections:

connection hostname hardware_address `ff00 0 [`*mtu*`];`

connection — Type of connection. The `direct` parameter indicates that the host is connected to the same HYPERchannel trunk as the Cray Research system. The `gateway` parameter indicates that the host resides on a remote HYPERchannel trunk that is connected to the local trunk.

> **Note:** If the connection is type `gateway`, the fields that follow *hostname* must contain the names of hosts that are connected to the bridge. These hosts must be defined as direct hosts in this `hycf` file and must precede the gateway definition.

hostname — Host name that appears in the `/etc/hosts` file, or Internet address that is expressed in decimal notation.

hardware_address — Host's 16-bit HYPERchannel address in hexadecimal format.

The most significant octet (byte) is the physical unit address that is configured within the network adapter hardware or firmware. Consult the documentation for your adapter for the best way to retrieve this information.

The least significant octet is the logical address. This corresponds to the low-level device driver's logical path. By convention, logical path 5 is used for TCP/IP. However, the system administrator can choose any value. The only restriction is that the logical address chosen must be unique with respect to all protocols that use the device.

The install tool does not support an alternate logical path for TCP/IP. To use a logical path other than 5, you must manually create the TCP/IP nodes. To do so, use the following command:

`mknod` *name* `c 35` *(npdev* `*16)` + *logical path*

The *npdev* variable indicates the low-speed device ordinal. The parameter *name* should be `/dev/comm/tcp` *xxxx* where *xxxx* is the four-digit octal representation of the minor device number. For example, to create a TCP/IP node for logical path 3 on device ordinal 1, you would use the following command:

```
mknod /dev/comm/tcp0023 c 35 19
```

The hardware address is included in the packet that is sent on the network to the destination host. The adapter that is attached to the destination host recognizes that the packet should be passed to the destination host by the physical unit address part of the hardware address. When the destination host processes the packet, the destination protocol is chosen based on the logical address. That is, the physical unit address tells which adapter box on the HYPERchannel should process the packet, and the logical address tells which protocol in the destination machine will process the incoming packet.

For example, suppose that you are setting the *hardware_address* field for a Cray Research system that has an adapter with physical unit address 0x52. Also assume that TCP/IP is configured to open logical path 5 for that device. The *hardware_address* field for that computer is 5205.

`ff00` HYPERchannel control number in hexadecimal format (trunks to try, control bits).

`0` Access code. This number must be 0.

mtu Maximum transmission unit. The largest amount of data that can be sent to the host in one packet. The default is 4144. See Section 2.3.1, page 128, for details on specifying *mtu*.

The following is an example of an `hycf` file for NSC low-speed connections. Note that some of the connections do not use logical path 5 for TCP/IP.

```
# Configuration table for the hyroute command for NSC low-speed
# connections
#
#direct          MACH-NAME   TO                          MTU
direct           cray2       c605     ff00      0        4144;
direct           cray1       c205     ff00      0        4144;
direct           wilbur      12c1     ff00      0        4144;
direct           orville     2200     ff00      0        4144;
direct           wk01        2605     ff00      0        4144;
direct           wk02        4623     ff00      0        4144;
direct           wk03        4400     ff00      0        4144;
direct           wk04        4402     ff00      0        4144;
```

2.2.6.4.2 FEI-3 or VAXBI Connections

Note: CRAY J90 systems do not support FEI-3 connections.

Use the following format when creating the `hycf` configuration file for FEI-3 or VAXBI connections:

`direct` *hostname dest* `ff00 0 [`*mtu*`];`

`direct`	Type of connection. `direct` indicates a direct connection between the Cray Research system and the host.
hostname	Host name that appears in the `/etc/hosts` file, or the Internet address expressed in decimal notation.
dest	Hardware address of FEI-3 or VAXBI in hexadecimal format. The leftmost 2 digits of the address must match the last field of the device's entry in the `comm_info` structure. The hardware address can be any number that is unique among the entries in the `comm_info` structure. This structure is found in the `/usr/src/uts/cf/conf.` *sn* `.c` file; *sn* refers to the serial number of a Cray Research system. The rightmost 2 digits are the logical address, and they are chosen by the system administrator. The only restriction is that they must be unique with respect to all protocols that use the device.
`ff00`	This field is unused by the Cray Research system.
`0`	This field is unused by the Cray Research system.
mtu	Maximum transmission unit. The largest amount of data that can be sent to the host in one packet. The default is 4144. See Section 2.3.1, page 128, for details on specifying *mtu*. For FEI-3 connections, *mtu* should be set to 4352. See *fy Driver Administrator's Guide*, publication SG–2132.

The following is an example of an `hycf` file for FEI-3 and VAXBI connections.

```
# Configuration table for the hyroute command for FEI-3/VAXBI connections

#direct    MACH-NAME     TO      NA      NA     MTU
direct     snq1-vme      1e02    ff00    0      4144;
direct     yafs-vme      1e03    ff00    0      4144;
```

2.2.6.4.3 HIPPI Connections

Use the following format when you create the `hycf` file for the HIPPI connections:

`direct` *hostname ifield readdev writedev* [*mtu*];

`direct` Type of connection. `direct` indicates a direct connection between the Cray Research system and the host.

hostname Host name that appears in the `/etc/hosts` file, or Internet address expressed in decimal notation.

ifield HIPPI I-field value for connection to this host (hexadecimal notation). The I-field is typically used to make a HIPPI connection through one or more HIPPI crossbar switches. The I-field is used by the switch(es) to determine the path that is required to complete the connection. In the most simple case, the I-field contains the camp-on bit plus the port number to which the host is connected. The camp-on bit is bit 2**24 (0x01000000). This bit directs the switch to keep trying to make the connection until the connection is completed or the source abandons the connection attempt. The Cray Research HIPPI TCP/IP implementation is designed to be used with the camp-on bit if a switch that supports this feature is present. Some switches support additional routing implementations in which the destination address is not a simple port number but is instead a value that the switch converts into one or more port numbers. Consult the switch manufacturer's documentation for details on constructing an appropriate I-field.

The I-field is significant even when no switch is present. If two systems are directly connected, you must still specify an I-field for both systems: the system you are currently configuring and the system to which you are connected. Each I-field must be unique. If they are equal, TCP/IP traffic is not sent over the physical interface and all operations fail. The camp-on bit is not significant for connections in which no switch is present.

If a double-wide (64-bit) HIPPI connection can be made between two systems, the I-field must include bit 2**28 (0x10000000) for the driver to make use of this capability. If this bit is not set in the I-field, data is sent in 32-bit mode even though the 64-bit capability exists. Only the IOS–E can be configured to support the 64-bit HIPPI interface. Some switches and HIPPI fiber optic channel extenders offer 64-bit capability as well. If a switch offers both 64-bit and 32-bit capabilities, the `hycf` file should use the double-wide bit for hosts to which a 64-bit connection can be made. If a host has double-wide capability, but another host is only 32-bit capable, the entry for this host should not have the double-wide bit set. The driver ensures that the connection is made in the appropriate mode on a per-packet basis. The double-wide bit is also significant in the case in which no switch is present.

readdev Minor device number (in hexadecimal format) of the character special device that TCP/IP will open for reading. See "Selecting `readdev` and `writedev` values," Section 2.2.6.4.4, page 52, for more information.

writedev Minor device number (in hexadecimal format) of the character special device that TCP/IP will open for writing. See "Selecting `readdev` and `writedev` values," Section 2.2.6.4.4, page 52, for more information.

mtu Maximum transmission unit. The largest amount of data to send to the host in one packet. The default is 16496. See Section 2.3.1, page 128, for details on specifying *mtu*.

The following is an example of an `hycf` file for HIPPI connections:

```
#
#                       NSC PS32 HIPPI Switch
#
#                                  Minor number
#        Hostname       I-field      In     Out      MTU
#      ------------     --------    ----    ----    -----
direct sn1001-hippi     03000000    0060    0070    4352  ; # Port 0
direct sn1701-hippi     03000001    0020    0030    4352  ; # Port 1
direct sn1601-hippi     03000002    0020    0030    4352  ; # Port 2
direct uss-hippi        03000003    0020    0030    4352  ; # Port 3
direct sn1061-hippi     03000004    0020    0030    4352  ; # Port 4
```

2.2.6.4.4 Selecting `readdev` and `writedev` Values

The read and write minor device numbers, `readdev` and `writedev`, determine the logical path that will be opened and provide the mapping to physical HIPPI channels for this interface. A range of 16 minor numbers maps to each physical HIPPI channel. Minor numbers 0 through 15 map to the first channel, numbers 16 through 31 map to the second and so on. The path number is the remainder of the minor number divided by 16. For example, minor number 0 is path 0, as is minor number 16. Minor number 1 is path 1 on the first HIPPI channel. Minor number 17 is path 1 on the second HIPPI channel (17 mod 16 equals 1).

Path 0 is the dedicated path; other paths are shared paths. The dedicated path can be opened only if no shared paths are currently open. Opening the dedicated path prevents the subsequent opening of shared paths on that channel. TCP/IP requires only one path and can be brought up on either the dedicated path or on a shared path. If TCP/IP is brought up on a shared path, user programs with appropriate privilege can share the HIPPI channel by opening character special device files. It should be noted that user programs can interfere with TCP/IP traffic, causing performance degradation. You should ensure the proper functioning of applications that you allow to share the HIPPI channel with TCP/IP. Among other things, these applications must adhere to the HIPPI-FP standard for HIPPI packet formation. They must use an upper-level protocol identifier (ULP-ID) other than 4; TCP/IP uses 4. If TCP/IP is brought up on a shared path, performance is slightly lower than if it is brought up on a dedicated path, even if no user program is currently active on another path.

On Model E systems and CRAY J90 systems, there is also an I/O control-only path. On this path, the `open`(2), `close`(2), and `ioctl`(2) system calls can be issued, but attempts to transfer data are rejected. Usually, this path is used for gathering statistical data from the device driver. The `xnetmon`(8) utility is an example of this type of program.

The I/O control-only path is defined as `MAXPATHS-1`. On Model E systems, `MAXPATHS` is set to the *himaxpaths* variable in the `param` file. For example, if *himaxpaths* is set to 8, path 7 becomes the I/O control-only path. On CRAY J90 systems, the `param` file is not used to configure HIPPI channels. `MAXPATHS` is always set to 16, which means that path 15 is always the I/O control-only path.

The methods of determining which physical channel is assigned to each minor number range are different for Model E systems and memory HIPPI systems.

- Model E systems

  The method for associating a minor device number range for a physical HIPPI channel on Model E systems includes making an entry in the network section of the `param` file for each physical HIPPI channel. These entries begin with `hidev`. Entry 0 (`hidev 0`) is the first HIPPI channel, `hidev 1` is the second, and so on. The first device is associated with minor numbers 0 through 15, the second with 16 through 31. Following is an example of the HIPPI portion of the network section of a Model E `param` file:

```
hidev   0 {
        iopath {
            cluster 0;
            eiop 3;
            channel 030;
        }
        logical path 0 {
                flags 00;
                I_field 00;
                ULP_id 00;
        }
        flags 00;
        input;
        device type PS_32;
}

hidev   1 {
        iopath {
            cluster 0;
            eiop 3;
```

```
                channel 032;
            }
            logical path 0 {
                    flags 00;
                    I_field 00;
                    ULP_id 00;
            }
            flags 00;
            output;
            device type PS_32;
    }

    hidev   2 {
            iopath {
                cluster 0;
                eiop 3;
                channel 034;
            }
            logical path 0 {
                    flags 00;
                    I_field 00;
                    ULP_id 00;
            }
            flags 00;
            input;
            device type P_8;
    }

    hidev   3 {
            iopath {
                cluster 0;
                eiop 3;
                channel 036;
            }
            logical path 0 {
                    flags 00;
                    I_field 00;
                    ULP_id 00;
            }
            flags 00;
            output;
            device type P_8;
    }
```

The following shows the relationship between minor device numbers and `hidev` entries (and therefore physical channel assignments) on Model E systems. This assumes that *himaxpaths* is set to 16.

Path for `hidev`	Minor number range	Dedicated path minor number	Shared paths minor number	`ioctl` only
0	0-15	0	1-14	15
1	16-31	16	17-30	31
2	32-47	32	33-46	47
3	48-63	48	49-62	63

Assume that you want to use channels 034 and 036, cluster 0, and IOP 3 for the TCP/IP interface. If you choose the dedicated path, the minor numbers for the read and the write device are 32 and 48 (0x20 and 0x30). The `hycf` entry is as follows:

```
direct sn2402-hippi     01000006       0020    0030    65448   ;
```

- CRAY J90 systems (memory HIPPI systems)

  On CRAY J90 systems, the `param` file is not used to configure HIPPI channels. The physical channel number determines the minor device number range associated with a given channel. The lowest numbered channel is the first channel (numbers 0 through 15), with higher number channels being assigned 16 minor device numbers in order. In the following example, assume that two memory HIPPI channel pairs are present:

Channel	Minor number range	Dedicated path minor number	Shared paths minor numbers	Path for `ioctl` only
064	0-15	0	1-14	15
067	16-31	16	17-30	31
0104	32-47	32	33-46	47
0107	48-63	48	49-62	63

On CRAY J90 systems, even-numbered channels are always input channels (read devices); odd numbered channels are always output channels (write devices).

A CRAY J90 system using the dedicated path for channels 064 and 067 would use minor number 0 for input and 16 (0x10) for output resulting in the following `hycf` entry:

```
direct  sn5194-hippi    01000004        0000    0010    65536   ;
```

2.2.7 Configuring Network Interfaces—GigaRing Based Systems Only

The following sections describe the following steps that you must take to configure each Cray Research system interface on the network:

1. Define the I/O node configuration
2. Name the Cray interface
3. Choose an Internet address
4. If you are running HIPPI, create an `arp` file, `ghippi#.arp`, where # is the interface number.
5. If you are running Host-to-Host GigaRing, create an `arp`file `gr#.arp`, where # is the interface number.
6. If you are running ATM, create the `atm.pvc` file.

FDDI and Ethernet automatically use the Address Resolution Protocol (ARP) to resolve internet addresses into physical addresses. ATM and HIPPI require you to configure addresses manually.

Note: Before you follow the procedures in this section, make sure that all hardware diagnostic tests have been performed, and that all hardware functions properly. Refer to the appropriate vendor documentation for supporting information and procedures.

2.2.7.1 Defining I/O Node Configuration

Hardware devices that interface with Cray Research GigaRing based systems are defined in the network portion of the `/opt/CYRIos/snSerialNumber/param` file that resides on the system workstation (SWS). Following is a sample `param` file for a Cray Research system with GigaRing I/O:

```
network {
     ...
     gether 0 {
          iopath { ring 1; node 4; channel 2; }
```

```
          maxinputs 128;
          maxoutputs 128;
     }
     gfddi 0 {
          iopath { ring 1; node 4; channel 0; }
     }
     gatm 0 {
          iopath { ring 1; node 4; channel 3; }
     }
     gr 0 {
          iopath { ring 5; node 7; }
     }
     ghippi 0 {
          iopath { ring 4; node 8; channel 0; }
          maxusers 4;
          maxinputs 80;
          maxoutputs 80;
     }
     ghippi 1 {
          iopath { ring 4; node 8; channel 1; }
          maxusers 3;
          maxinputs 80;
          maxoutputs 80;
     }
          ...
     }
```

The devices are defined according to the following parameters.

- The `iopath` ring number declares the ring the network device resides on.
- The `iopath` node number is the MPN node (for `gether`, `gfddi`, and `gatm`) or SPN node (for `ghippi`), or the local host node for `gr`.
- The `iopath` channel number is the channel on the MPN node, or SPN node.

Note that the channel number is not valid for `gr` interfaces.

An HPN-1 has two HIPPI channel pairs. The first HIPPI channel pair (the top two connectors on the back of the HPN) are channel 0. The second HIPPI channel pair (the bottom two connectors on the back of the HPN) are channel 1.

An HPN-2 has either a single 100 Mb of 200 Mb HIPPI channel pair. Both are designated as channel 0.

2.2.7.2 Naming the Cray GigaRing Interface

The interface name, which TCP/IP uses to access a given hardware device, consists of two parts. The first part, which is the interface name prefix, indicates the type of hardware. The second part, which is the number of the interface name (also known as the interface number), identifies the physical device.

2.2.7.3 Interface Name Prefix

The interface name prefix is derived from the UNICOS driver that controls the hardware device. This prefix indicates the major number that TCP/IP uses when it defines the character special device for the given hardware. Following is a list of the prefixes and a description of the associated interfaces:

Prefix	Type of interface
`gatm`	Asynchronous Transfer Mode (ATM)
`gether`	Ethernet
`gfddi`	FDDI
`ghippi`	HIPPI
`gr`	Host-to-Host GigaRing

2.2.7.4 Identifying Character Special Devices

You do not need to define character special device nodes to use TCP/IP with Ethernet, ATM, HIPPI, or FIDDI channels; the host kernel creates the I-node(s) it needs. TCP/IP is hardcoded to use user number zero. However, if you are using the HIPPI channel in "raw" mode, you must define character special device nodes.

On non-GigaRing I/O Cray HIPPI implementations, there are separate character special device files for input and output. The GigaRing I/O HIPPI "raw" character special devices are full-duplex: each device logically represents a HIPPI input and output channel. For example:

```
fd = open("/dev/ghippio/u0", O_RDWR);
/*  reades and writes use the same file descriptor (fd)  */
```

For GigaRing networking I/O, there is a single host driver for all networking interfaces; `gether`, `gfddi`, `gatm`, `gr`, and `ghippi`. The *major* device number is always 25. The *minor* device number for HIPPI character special devices for a specific interface depends on the order in which all the network devices (not just the HIPPI interfaces) are defined in the host's configuration file.

The number of character special device files for a HIPPI interface should at least match the number of users defined by maxusers in the host's configuration file. Each device file corresponds to a specific user of the interface. Multiple users can share the same HIPPI interface at the same time. The HIPPI channel can be used in "raw" mode and by TCP/IP at the same time. The maximum number of users for any networking interface is 256 (user number 0 to 255).

GigaRing character special devices have the following format:

`/dev/`*gdevicenameX*`/`*uY*

Where *X* is the HIPPI device number and ranges from 0 to # of interfaces less 1 (that is, *N*`-1`, where *N* = *number of interfaces*),
devicename is the channel type, an *Y* is the user number (or logical path) ranging from 0 to maxusers –1

For HIPPI character special device usage, there are restrictions or capabilities associated with a particular user path, i.e., a specific path is not the dedicated path or has a ULPid associated with it. If TCP/IP is being used on the HIPPI channel, it will always use user path 0 (`/dev/ghippix/u0`).

2.2.7.5 Creating HIPPI Character Special Device Nodes

You can determine the order that the networking interfaces are defined by either perusing the host's configuration file or looking at the output from `netstat -i`.

For interfaces defined in the following order, the character special device nodes for the two HIPPI interfaces are as follows:

```
Interface   maxusers   Starting minor#
---------   --------   ---------------
gether0     n/a              0
gfddi0      n/a            256
gatm0       n/a            512
gr0         n/a            768
ghippi0      4             1024
ghippi1      3             1280


mkdir /dev/ghippi0
chmod 755 /dev/ghippi0
cd /dev/ghippi0
/etc/mknod u0 c 25 1024
/etc/mknod u1 c 25 1025
```

```
/etc/mknod u2 c 25 1026
/etc/mknod u3 c 25 1027
chmod 666 u*

mkdir /dev/ghippi1
chmod 755 /dev/ghippi1
cd /dev/ghippi1
/etc/mknod u0 c 25 1280
/etc/mknod u1 c 25 1281
/etc/mknod u2 c 25 1282
chmod 666 u*
```

Warning: If, at a future time, additional networking interfaces are added to the host's configuration file, they must come after the HIPPI interface definitions. If they are placed in front of the HIPPI interface definitions, the HIPPI interface minor device numbers increase by 256 and become invalid.

2.2.7.6 Choosing an Internet Address

Each interface on your system must have an Internet address. The network and subnet parts of the Internet address of the interface must correspond to the Internet address of the network to which the interface is attached. The host portion of the address can be selected by using the preferred administrative practices for your site. (Some sites have a central network administrator who determines the new Internet addresses for new systems and interfaces; other sites let the individual system administrator decide.)

When you are choosing an Internet address for an interface that is attached to a new TCP/IP network, see Section 2.2.4, page 31, for guidelines.

2.2.7.7 Creating the `ghippi#.arp` File

Note: For software loopback interfaces, direct FDDI interfaces, Ethernet interfaces, and ATM interfaces, it is not necessary to create an `arp` file.

The information you put in this file is used as input to the `arp`(8) command, which initializes the interface with hardware address information. This configuration file, sometimes known as the `arp` file, varies according to the type of network hardware used. Each ghippi connection requires a separate `arp` file.

Use the following format when you create the `ghippi#.arp` file for HIPPI connections:

```
hostname 00:00:AA:BB:CC:DD
```

hostname
: Host name that appears in the `/etc/hosts` file, or Internet address expressed in decimal notation.

ifield (AA:BB:CC:DD)
: HIPPI I-field value for connection to this host (hexadecimal notation) where AA:BB:CC:DD corresponds to the I-field 0xAABBCCDD. The I-field is typically used to make a HIPPI connection through one or more HIPPI crossbar switches. The I-field is used by the switch(es) to determine the path that is required to complete the connection. In the most simple case, the I-field contains the camp-on bit plus the port number to which the host is connected. The camp-on bit is bit 2**24 (0x01000000). This bit directs the switch to keep trying to make the connection until the connection is completed or the source abandons the connection attempt.

Some switches support additional routing implementations in which the destination address is not a simple port number but is instead a value that the switch converts into one or more port numbers. Consult the switch manufacturer's documentation for details on constructing an appropriate I-field.

If a double-wide (64-bit) HIPPI connection can be made between two systems, the I-field must include bit 2**28 (0x10000000) for the driver to make use of this capability. If this bit is not set in the I-field, data is sent in 32-bit mode even though the 64-bit capability exists. Only HPN-2 can be configured to support the 64-bit HIPPI interface. Some switches and HIPPI fiber optic channel extenders offer 64-bit capability as well. If a switch offers both 64-bit and 32-bit capabilities, the `ghippi#.arp` file should use the double-wide bit for hosts to which a 64-bit connection can be made. If a host has double-wide capability, but another host is only 32-bit capable, the entry for this host should not have the double-wide bit set. The driver ensures that the connection is made in the appropriate mode on a per-packet basis. The double-wide bit is also significant in the case in which no switch is present.

The following is an example of a `ghippi#.arp` file for a HIPPI connection:

```
sn1001-hippi  00:00:03:00:00:00  ; # Port 0
sn1701-hippi  00:00:03:00:00:01  ; # Port 1
sn1601-hippi  00:00:03:00:00:02  ; # Port 2
uss-hippi     00:00:03:00:00:03  ; # Port 3
sn1061-hippi  00:00:03:00:00:04  ; # Port 4
```

2.2.7.8 Creating the `atm.pvc` File

The `atm.pvc` file is used for configuring the Permanent Virtual Circuit (PVC) identifiers for all GigaRing ATM interfaces.

The `spansd` implements the FORE Systems proprietary ATM signalling protocol called SPANS. The `q2931d` implements the standard UNI ATM signalling protocol. Both daemons should be in the `SYS2` group, and are `/etc/spansd` and `/etc/q2931d`, respectively.

Use the following format to create the `atm.pvc` file for ATM connections:

```
hostname ifc AAL VPI VCI QOS
```

The following is an example `atm.pvc` file for an ATM connection:

```
# hostname   ifc    AAL   VPI   VCI   QOS
# --------   ---    ---   ---   ---   ---

atmhost1     gatm   5     0     32    5000
atmhost2     gatm   5     0     32    0
```

Where:

hostname — Name of the remote host that this system communicates with over the ATM network. This name must appear in the host database (i.e., `/etc/hosts` file).

ifc	Network interface. Must be `gatm` for a GigaRing-based system.
AAL	ATM Adaption Layer Type. Defines the layer type to use when communicating with the specified host. Only AAL 5 is currently supported. Specify this number in decimal.
VPI	Virtual Path Identifier. Identifies the path to use when communicating with the specified host. The VPI is placed into each ATM cell header so that the cell can be routed through the ATM network. Currently, GigaRing ATM interfaces support only VPI 0. Specify this number in decimal.
VCI	Virtual Circuit Identifier. Identifies the circuit to use when communicating with the specified host. The VIC is placed into each ATM cell header so that the cell can be routed through the ATM network. This number should be between 32 and 1023. Consult your local network administrator to determine the VCI. Specify this number in decimal.
QOS	Quality of Service in Kb/s. Determines the peak data rate (expressed in kilobits per second) that this host will deliver ATM calls to the remote host via the GigaRing ATM interface. Placing a zero in this field disables the peak rate control feature when sending to the specified host, allowing unlimited bandwidth.

2.2.7.8.1 Creating the `gr#.arp` File

The information you put in this file is used as input to the `arp`(8) command, which initializes the interface with hardware address information. This configuration file, sometimes known as the `arp` file, varies according to the type of network hardware used. Each `gr` interface requires a separate `arp` file. There needs to be an entry in the `arp` file for each host you wish to access via the `gr` interface.

Use the following format when you create the `gr#.arp` file for Host-to-Host GigaRing interfaces:

```
hostname 00:00:00:00:AA:BB
```

hostname — Host name that appears in the `/etc/hosts` file, or Internet address expressed in decimal notation.

ifield (00:00:00:00:AA:BB) — Where *AA* is the ring number for this host (hexadecimal notation). This ring number will be the same value as that specified in the param file for this `gr` interface. (All entries in a specific `gr#.arp` file will have the same ring number.)

Where *BB* is the node number for this host (hexadecimal notation).

The following is an example of a `gr#.arp` file:

```
sn9132-gr      00:00:00:00:05:01
sn7025-gr      00:00:00:00:05:04
```

2.2.8 Configuring Daemons

The following daemons can be configured:

Daemon	Configuration
`gated`(8)	Performs dynamic routing
`lpd`(8)	Spools print files to remote printers
`named`(8)	Provides domain name service
`sendmail`(8)	Performs Simple Mail Transfer Protocol (SMTP) operations
`snmpd`(8)	Performs Simple Network Management Protocol (SNMP) operations
`ntpd`(8)	Provides mechanisms to synchronize time and coordinate time distribution
`inetd`(8)	Provides a sublist of daemons that can be started

Note: The `gated`(8), `named`(8), `snmpd`(8), and `ntpd`(8) daemons must not be configured when you are running the Cray ML-Safe configuration of the UNICOS system.

These daemons are described in the following sections.

2.2.8.1 The gated Daemon

As an alternative to the static routing that is performed by the route(8) command, the gated(8) daemon can oversee dynamic management of the routing table on the local Cray host. The gated daemon communicates with remote hosts by using one or more routing protocols. Using these protocols, gated collects information that enables it to determine and install the correct routes that it uses to achieve optimal routing for packets that originate from the local Cray host. The gated daemon has the simple ability to detect the failure of directly attached networks or gateways and to manipulate the routing table on the local Cray host to reestablish IP service to remote hosts and networks whose path to the local Cray host is affected by an unavailable network or gateway.

The gated daemon supports RFCs 1388, 1583, 1058, and parts of 1009. The specific routing protocols supported by gated are as follows:

Protocol	Description
RIP and OSPF	Two interior protocols that are used to exchange routing information within commonly administered local networks

You can configure the gated daemon independently in each of the supported protocols to supply routing information, to listen for routing information, or both. For example, the gated daemon can be configured to simultaneously listen for and supply OSPF routing information, and to only listen for RIP routing information.

2.2.8.1.1 Configuration Guidelines for gated

The actual routing protocols that you configure for the gated daemon to use on your Cray Research system depend on the routing protocols that the remote hosts and gateways use on the networks to which the system is attached. For example, if the other hosts on an attached network are using the RIP protocol to exchange routing information, the gated daemon on the local Cray Research system should also be configured to use the RIP protocol to exchange routing information. However, the following general guidelines for configuring gated apply to Cray Research systems:

- A Cray Research system can have more than one directly attached network, and it can be considered a gateway system between its directly attached networks, but it is uncommon for a Cray Research system to function intentionally as a generic gateway. A Cray Research system usually serves as an endpoint for connections to and from the system, which allows the resources of the system to be spent on user tasks rather than forwarding packets that are intended for other systems. Consequently, it is more functional to configure `gated` to provide dynamic rerouting when it encounters network or gateway failure than it is to configure `gated` to use the Cray Research system as a true gateway.

Note: The Cray Research system must not perform forwarding (that is, act as a gateway) when it is running the Cray ML-Safe configuration of the UNICOS system.

- Cray Research systems typically do not serve as exterior gateways for their local networks; therefore, they do not support Exterior Gateway Protocol (EGP) or Border Gateway Protocol (BGP) protocol information.

- The gateways on networks that are directly attached to the Cray Research system must be configured not only to send updates to the Cray Research system, but to work with the configuration on the Cray Research system, because proper dynamic routing requires cooperation among hosts to exchange routing updates. Configuring `gated` on the Cray Research system in isolation from the configuration of the gateway system is generally not sufficient to achieve optimal routing.

- Cray Research supports directly attached network media with no broadcast capability. Some routing protocol implementations rely on a broadcast capability for the local network to supply routing updates to other hosts (such as the Berkeley `routed` program, which implements RIP). Therefore, any gateway that wants to supply routing updates over a nonbroadcast media to a Cray host must be capable of being configured to supply routing updates over nonbroadcast network media. Usually, this means that the gateway has implemented the `gated` daemon as a routing protocol, but other routing protocol implementations can exist on a given gateway. Consult the documentation supplied by the vendor of your gateway system to plan your dynamic routing capabilities.

2.2.8.1.2 The `/etc/gated.conf` File

The complete format of the `/etc/gated.conf` file is described in the `gated-config`(5) man page. If you are using the UNICOS ICMS, configure this file by using the `Configure System -> Network configuration -> TCP/IP configuration -> Routing` menu. Some general guidelines for configuration of this file are as follows:

- You can specify hosts and networks in the `gated.conf` file by using either the name or the Internet address. However, if you are using the `named` daemon or the `resolv.conf` resolver library, you should use only Internet addresses in the `gated.conf` file.
- When you do not want to supply routing information to other gateways, but want `gated` only to listen for RIP updates, you must specify `nobroadcast` on the appropriate `rip` statement.
- Any gateways residing on nonbroadcast networks to which you want to supply RIP updates must be explicitly specified by the `sourcegateways` directives of the appropriate `rip` statement because of the lack of a broadcast capability on the directly attached networks.
- You can exclude the interfaces to network media that function as virtual point-to-point links, such as HIPPI or FEI-3 interfaces by using the `interface` *interface_list* `noripout` directive of the appropriate `rip` statement.
- To configure static routes, which are never removed in response to routing protocol updates, use the `static` statement.

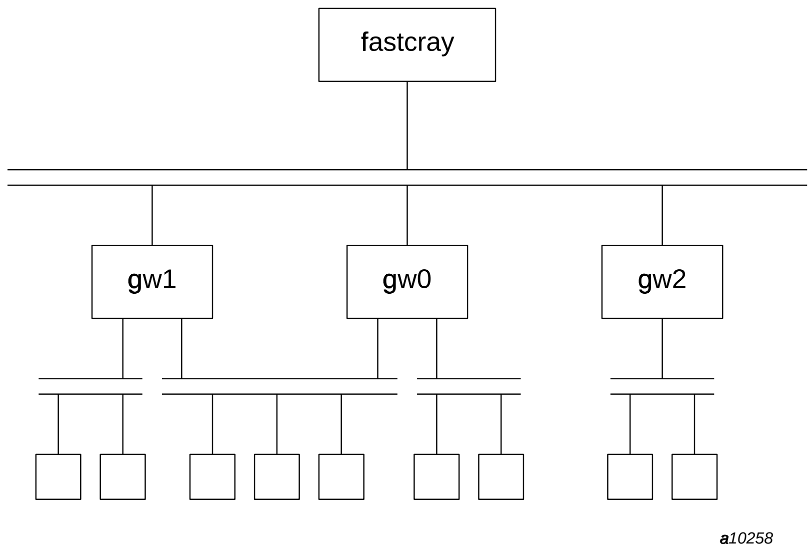
  Note: Cray Research extensions to the static route options in the `gated` configuration file provide access to all of the Cray Research proprietary routing extensions, such as per-group restricted routing, and type of service routing; see `gated-config`(5) for details.

- When a gateway on a network that is directly attached to the Cray Research system can redirect traffic by sending `ICMP REDIRECT` messages, you can specify that gateway as the gateway for the `default` route in the `static` statement.
- You can direct `gated` to listen for a specific set of hosts or networks through the use of `import` statements. Information received in routing updates about other hosts or networks is ignored. Alternatively, use of `import` statement `restrict` directives excludes a specific set of hosts or networks from consideration.
- You can limit the information that `gated` supplies to other gateways to a specific set of hosts or networks through `export` statements. Alternatively, use of `export` statement `restrict` directives causes `gated` to supply information to other gateways about all hosts or networks that are not included in the specified set.

2.2.8.1.3 gated Configuration Examples

This section contains two examples of gated configuration.

Consider the following sample network configuration:



The gateway gw0 of this network configuration serves as the default gateway for connections to the Cray Research system fastcray. Instead of sending all network traffic through this one default gateway, however, it is recommended that traffic for the networks that are attached to the other two gateways gw1 and gw2 use those gateways. (For a more complete discussion of the effect of network routing on overall network performance, see Section 2.3.3, page 154.) When gw0 can send ICMP REDIRECT messages, the following sample /etc/gated.conf file is sufficient to ensure proper maintenance of the routing tables on fastcray:

```
rip no ;

redirect yes ;

static {
default gateway gw0 ;
} ;
```

The `redirect yes` statement in this sample `gated.conf` file indicates that `fastcray` listens to `ICMP REDIRECT` messages from the gateways on its attached network and installs them in the kernel routing tables. (Conceptually, this occurs in response to an `ICMP REDIRECT` message; however, in reality, the UNICOS kernel installs the route directly, and the `redirect yes` statement prevents `gated` from removing those installed routes.)

For this configuration, when sending traffic to a host that is accessible through the `gw2` gateway, `fastcray` sends the initial packet to its default gateway `gw0`. Like any gateway, `gw0` consults its routing table and forwards the packet to gateway `gw2`, and the packet eventually reaches its destination host on one of the networks that is attached to gateway `gw2`. After forwarding the packet for delivery, gateway `gw0` determines that because `fastcray` and gateway `gw2` are both on the attached network from which gateway `gw0` received the packet, it is more efficient for `fastcray` to forward packets intended for the destination host directly to `gw2` (where gateway `gw0` would send the packets anyway). Then it sends an `ICMP REDIRECT` message to `fastcray`, informing it that packets intended for that destination host should be redirected to gateway `gw2`.

One problem with this simple configuration is that some gateway systems send a separate `ICMP REDIRECT` message for each appropriate destination host instead of sending one message for the entire network. This can possibly lead to inefficient use of system resources on the Cray Research system, because each `ICMP REDIRECT` message generates a new host-level entry in its routing table. Also, the procedure of sending an initial packet to `gw0` for redirection and processing the resultant `ICMP REDIRECT` message adds a small amount of overhead to establishing initial connections to each destination system. You can eliminate this problem by using static network routes on the Cray Research system. This can be accomplished by changing the `static` statement in the `/etc/gated.conf` file to the following:

```
static {
        default gateway gw0 ;
        othernet1 gateway gw1 ;
        othernet2 gateway gw2 ;
} ;
```

By adding static routes for `othernet1` and `othernet2`, `fastcray` sends packets for those networks directly to `gw1` and `gw2`, and it eliminates the need for `gw0` to send `ICMP REDIRECT` messages for the traffic to those networks.

The following sample network is a more complex example than the previous one:

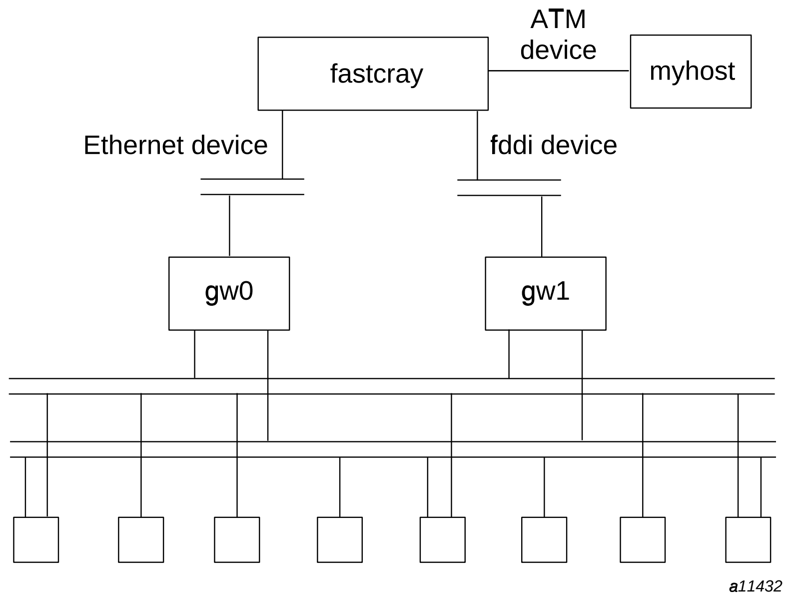


Figure 7. Sample network configuration

This network configuration might be appropriate in a situation in which a network administrator wants to provide two (or more) gateways to the Cray Research system to ensure access to the system when one gateway fails. This technique requires proper configuration of not only `gated` on the Cray Research system but also the equivalent dynamic routing programs on the directly attached gateways.

The `gated` daemon detects failure of a gateway by tracking the elapsed time since individual routes to destination hosts or networks were received in RIP updates. If 180 seconds elapse without mention of a route in a routing update, the route is deleted and considered to be in a *hold down* state. If the route is being exported, for the next 120 seconds the route is announced with a metric of infinity. This causes all listening routers to stop using this host for the route. This means that the `gated` daemon's detection of a gateway failure is implicit; when no updates are received from the failed gateway, the routes through that gateway are held down and deleted. This allows other routes to the destinations to be installed.

This method of failure detection means that unless otherwise configured, `gated` assumes that a gateway that does not send routing updates is down when in fact it might be up but not configured to send updates.

The following example is of a `/etc/gated.conf` file. This example provides a basic back-up mechanism for this network configuration when a failure of either gateway occurs.

For Model E based systems, where `np0` is an Ethernet device, `np1` is a FDDI device, and `np2` is an ATM device:

```
interfaces   {
   interface np2 passive ;

};
   rip yes {
         nobroadcast ;
         sourcegateways gw0 gw1 ;
   } ;

   export proto rip gateway gw0 {
          proto direct interface np1 np2 ;
   } ;

   export proto rip gateway gw1 {
        proto direct interface np0 np2 ;
   } ;
```

For GigaRing based systems, where `gether0` is an Ethernet device, `gfddi0` is a FDDI device, and `gatm0` is an ATM device:

```
interfaces   {
   interface gatm0 passive ;

};
   rip yes {
         nobroadcast ;
         sourcegateways gw0 gw1 ;
   } ;

   export proto rip gateway gw0 {
          proto direct interface gfddi0 gatm0 ;
   } ;

   export proto rip gateway gw1 {
        proto direct interface gether0 gatm0 ;
   } ;
```

There are several items in this example to note:

- The `interface np2/gatm0 passive` statement prevents `gated` from deleting routes to the OWS/SWS, even when it received no routing updates from the OWS/SWS.

- The two `export` statements inform each gateway of not only the interface through which `fastcray` communicates with the OWS/SWS (`np2/gatm0`), but also the interface through which the Cray Research system communicates with the other gateway. This means that each gateway recognizes the address of the other interface on the Cray Research system and forwards packets for that address directly to the Cray Research system, instead of routing them to the gateway.

- The `export` statements instruct `gated` to advertise only the other directly attached interfaces to `fastcray`. Implicitly, this means that in the routing updates it distributes, `gated` does not advertise any routes that it learned through an update from either gateway. This helps prevent `fastcray` from functioning as a generic gateway.

  For example, the following `export` statement that contains an added `proto rip` directive makes the Cray Research system function as a generic gateway by instructing `gated` to advertise routes it learned through RIP updates from either gateway and also to explicitly advertise the networks for the `np0/gether0` and `np2/gatm0` interfaces:

  For IOS–E based systems, where `np0` is an Ethernet device and `np2` is an ATM device:

  ```
  export proto rip gateway gw1 {
          proto rip ;
          proto direct interface np0 np2 ;
  } ;
  ```

  For GigaRing based systems, where `gether0` is an Ethernet device and `gfddi0` is an ATM device:

  ```
  export proto rip gateway gw1 {
          proto rip ;
          proto direct interface gether0 gfddi0 ;
  } ;
  ```

- Although this configuration provides a general backup mechanism if a gateway fails, note that this backup does not preserve connections that exist at the time of the failure. When a gateway fails, any connections that are using that gateway are severed. However, the dynamic routing capabilities of gated switch the routing to the alternate gateway, which allow users to reestablish connections to fastcray and to continue use while the cause of the gateway failure is investigated and corrected.

2.2.8.2 The lpd Daemon

When the system is initialized, the line printer daemon passes through the /etc/printcap file to obtain information about the existing printers; it prints any files that are queued. In subsequent operations, this daemon listens for and processes line printer requests that come in on port 515 (see Section 2.2.5.1, page 35).

The /etc/printcap file configures all printers that are available to users executing on the UNICOS system. The following commands provide users the indicated access to those printers defined in /etc/printcap:

Command	Description
lpq(1B)	Displays the files queued for printing.
lpr(1B)	Spools a file for printing.
lprm(1B)	Removes a file from the queue. If printing has already started on the file, it is aborted.

The following commands provide control of the state of each printer:

Command	Description
lpc(8)	Allows the super user to change the status of and control the queues for each printer.
lpd(8)	Controls the printing of all files that were spooled for printing by the lpr command.

To configure and make printers available to users running on the UNICOS system, the following steps must be performed:

1. Ensure that lpd is started during system initialization.
2. Create the /etc/printcap file, using the rules listed in the following section, " printcap file creation rules."
3. Configure the printer spool directories, as listed in the /etc/printcap file.

2.2.8.2.1 printcap File Creation Rules

This section lists the rules for creating the /etc/printcap file. A sample printcap file is shown on Section 2.2.8.2.4, page 79.

- Each line in the file defines one printer.
- All fields contained on a line define specific characteristics that are associated with the printer. Each field is delimited by a colon (:).
- Spaces are significant and taken literally, rather than ignored.
- Any data following a # and continuing to the end of the line is considered a comment.
- The first field contains a list of names by which a given printer is known to users who are executing on UNICOS. Each name in the list must be delimited by a vertical bar (|). All printer commands (lpq, lpr, lprm) accept the -P option, or use the PRINTER environment variable, to indicate a name in this list.
- The remaining fields are identified by keywords and can be arranged in any order except where otherwise indicated. If a keyword is not specified, or is followed by a @, the default value is used. The following section, "printcap file keywords," lists the available keywords.

2.2.8.2.2 printcap File Keywords

The /usr/src/net/tcp/usr/ucb/lpr/lp.local.h file contains the default value for each printcap file keyword. Only the first occurrence of a keyword appearing on any printer definition line is used. The following example printcap file is built with the lp command and defines default values.

```
/*
 * Defaults for line printer capabilities data base
 */
#define DEFLP           "lp"
#define DEFLOCK         "lock"
#define DEFSTAT         "status"
#define DEFSPOOL        "/usr/spool/lpd"
#define DEFDAEMON       "/usr/lib/lpd"
#define DEFLOGF         "/dev/console"
#define DEFDEVLP        "/dev/lp"
#define DEFRLPR         "/usr/lib/rlpr"
```

```
#define DEFBINDIR       "/usr/ucb"
#define DEFMX           1000
#define DEFMAXCOPIES    0
#define DEFFF           "\f"
#define DEFWIDTH        132
#define DEFLENGTH       66
#define DEFUID          1
```

The following keywords have the indicated meaning and default:

`ff=`
: Indicates the character string that represents a form feed to the indicated printer. This keyword is used only when the printer is defined as being locally attached.

  The `DEFFF` constant defines the form feed default value, which is set to `"\f"`.

`if=`
: Specifies the name of an input filter program that is executed for each file that is printed. Standard input to this program is set up to receive the control file, and then the actual file to be printed. Standard output is set up to go to the actual printer device entry (defined by `lp=`). This keyword is used only when the printer is defined as being locally attached.

  There is no default for this keyword; if it is not specified, no input filter is started.

`lf=`
: Specifies the log file that the `lpd` daemon creates to be used for error messages that are encountered while printing a file on the given printer or sending a file to the remote system for printing.

  The `DEFLOGF` constant defines the log file default value, which is set to `/dev/console`.

`lo=`
: Indicates the default lock file name. This file exists in the spool directory for the given printer. Its contents indicate the process ID of the daemon started up to control printing. This file also contains the control file name of the current file being printed, if one is currently active.

The file mode of the default lock file indicates whether printing is enabled (that is, if the `owner execute` bit is off), whether queuing is enabled (that is, if the `group execute` bit is off), and whether `lpd` should reorder its queue after it finishes printing the current file (that is, the `world execute` bit is on).

The `DEFLOCK` constant defines the lock file default name, which is set to `lock`. The value of the `sd=` parameter controls the path name to this file.

`lp=` Indicates the printer device to be opened when a file is requested to be printed on the indicated printer. If specified as `lp=:`, the printer is assumed to be located on a remote host.

The `DEFDEVLP` constant defines the printer device default value, which is set to `/dev/lp`.

`ma` Specifies the maximum security label allowed on this printer. This keyword is meaningful only with UNICOS security.

`mi` Specifies minimum security label allowed on this printer. This keyword is meaningful only on with UNICOS security.

Note: With UNICOS security, the `ma` and `mi` keywords define the maximum and minimum labels supported by the printer. If the printer is remote, it must be trustworthy to print between those labels, and must supply banner page and per-page human-readable labels on the printed output.

`of=` Specifies the name of an output filter program that is executed each time the `lpd` daemon starts up. If another filter program is being used with a given, locally attached printer (for example, an input filter), this output filter performs whatever processing is required by the printer between print files. If no other filter program is being used with a given, locally attached printer, this output filter also acts as an input filter (as described under the `if=` keyword).

For remote printers, standard input to this program is set up to receive control information, the print file's control file, and the actual file to be printed. Standard output is set up to go to the remote system.

There is no default for this keyword; if it is not specified, no output filter is started.

The control information passed to the output filter, when used for remote printers, is as follows:

Information	Description
`3` *number filename*	Indicates that the information following this line is the print file's control file. *number* is the size (in bytes) of the control file being sent. *filename* is the name of the control file being sent.
`2` *number filename*	Indicates that the information following this line is the actual file to be printed. *number* is the size (in bytes) of the print file being sent. *filename* is the name of the print file being sent.
`1`	Indicates that an error occurred while the current file was being read; the file is not printed. This also signifies the end of the current file.

0	Indicates the end of the file currently being sent to the remote system.

rm=
: Indicates the remote host name (or valid alias) of the host to which the printer is attached. The value specified for this keyword takes precedence over what is specified for the lp= keyword. Therefore, when this name is different from the official host name (or valid alias) of the local host, the lp= keyword is ignored, and the file is sent to the remote host.

  There is no default for this keyword; if it is not specified, the printer is assumed to be locally attached.

rp=
: Indicates the remote printer's name. This is the name by which the printer is known on the remote host (that is, one of the names in the first field of the remote host's printcap file).

  The DEFLP constant defines the remote printer name default value, which is set to lp.

sd=
: Specifies the full path name of the directory to be used for spooling files for printing. This directory also contains all of the control files (that is, the lock and status files) for the given printer.

  Note: With UNICOS security, if the printer supports a range of security labels, its spool directory must be created as a multilevel directory.

  The DEFSPOOL constant defines the path of the spool directory default value, which is set to /usr/spool/lpd.

st=
: Indicates the default status file name. This file exists in the spool file directory. Its content describes the current status of the line printer daemon (lpd) while it is running.

  The DEFSTAT constant defines the default status file's default name, which is set to status.

`tc=`
: Specifies another printer's name and is used to indicate that this printer definition also contains the list of keywords identified on the line defining the other printer. If specified, this must be the last keyword in the printer's definition; otherwise, it is ignored.

  There is no default for this keyword; if it is not specified, the printer's characteristics are assumed to be totally defined by the given line.

`tr=`
: Indicates the character string to be printed after all queued files are printed. This keyword is used only when the printer is defined as being locally attached.

  There is no default for this keyword; if it is not specified, nothing is sent to the printer when all queued files are printed.

2.2.8.2.3 Remote Printers and the UNICOS System

Remote printers that will receive output from a UNICOS system are expected to operate within the following restrictions:

- If the remote printer will print output at a single label, it is acceptable to print this labeled output on prelabeled paper.
- If the remote printer is expected to print multiple labels of output, the printer must be attached to a system that supports labeled printing.
- Any remote multilabel printer server must interpret the label of a connection on the `lpd` port as the label to be printed on the output.
- Labels printed on output must be human-readable.

As described in the previous section, the `mi` and `ma` keywords in the `/etc/printcap` entry for a particular printer define the range of labels allowed on output transmitted to that remote printer.

2.2.8.2.4 Sample `printcap` File

The following is a sample `printcap` file:

```
# Example file:  /etc/printcap
#
```

```
lp0|myprinter:rm=remote1:sd=/usr/spool/printers/lp0:
lp1|devprinter:rm=remote2:rp=ps1:sd=/usr/spool/printers/lp1:
lp2:lp=:rm=remote3:rp=hisprinter:sd=/usr/spool/printers/lp2:
lp3:lp=/dev/null:if=/etc/myfilter:sd=/usr/spool/printers/lp3:
lp4:sd=/usr/spool/printers/lp4:tc=lp3:
```

In the preceding example, each printer has the following characteristics:

- `lp0`
  - Known also as `myprinter`.
  - Attached to the remote system `remote1`.
  - Known as `lp` to `remote1` because no `lp=` keyword was specified.
  - Queues all files to be printed in the `/usr/spool/printers/lp0` directory before being sent to the remote system.
- `lp1`
  - Known also as `devprinter`.
  - Attached to the remote system `remote2`.
  - Known as `ps1` to `remote2`.
  - Queues all files to be printed in the `/usr/spool/printers/lp1` directory before being sent to the remote system.
- `lp2`
  - Attached to the remote system `remote3`.
  - Known as `hisprinter` to `remote3`.
  - Queues all files to be printed in the `/usr/spool/printers/lp2` directory before being sent to the remote system.
- `lp3`
  - Set up to execute the filter program `/etc/filter`. All files are discarded after the filter program performs its processing on them (`lp=/dev/null`).
  - Queues all files to be printed in the `/usr/spool/printers/lp3` directory before being discarded.

- lp4
  - Queues all files to be printed in the /usr/spool/printers/lp4 directory before being discarded.
  - Contains all other printer characteristics that are identical to those of lp3.

2.2.8.3 The named Daemon

Note: The use of the named daemon is not allowed with the Cray ML-Safe configuration of the UNICOS system.

As an alternative to using the /etc/hosts file, you can configure your UNICOS system to use the local domain name server, named(8), or the associated domain name resolver routines in the system library, to provide information (for example, host names and Internet numbers) about remote hosts that are accessible to the local Cray host.

Because named is not available on systems running UNICOS security during startup, every name that appears in the /etc/config/spnet.conf file must exist in the /etc/hosts or /etc/networks files. This is because spnet(8) must be executed to create the network access list (NAL) before applications can begin creating socket connections.

2.2.8.3.1 Setting up the Cray Research System As a Name Server

To use the named server, first create the /etc/hosts.usenamed file on your Cray Research system. This file need not actually contain any text; the presence of the file indicates that the domain name service is to be used. Consequently, all queries for information concerning hosts on the network will be resolved by the domain name service, rather than by looking in the /etc/hosts file.

However, you still need the /etc/hosts file to resolve names encountered during startup (for example, names in the /etc/config/interfaces file).

The /etc/named.boot file contains start-up information for the named server. When this file includes a line beginning with the keyword directory, named uses the specified directory as its current directory. Files that named must consult when starting up or while running are then read from or placed in the designated directory.

The named server always runs as a caching server. In addition, the named server can be run as a slave, caching-only, or master server. Each of these processes is described in the following sections.

The `named.boot` file must always specify, on a line beginning with the keyword `primary`, primary server authority for the reverse-address mapping domain (`in-addr.arpa`) that corresponds to the local loop-back interface (see the following section for more information on primary servers). See the *Name Server Operations Guide for BIND*, written by Kevin J. Dunlap and Michael J. Karels, for more information on name service.

2.2.8.3.2 `named` As a Slave Server

If you plan to run `named` as a slave server, in addition to the `directory` line, the `/etc/named.boot` file must also specify, on a line beginning with the keyword `forwarders`, the Internet addresses of one or more forwarding servers. Finally, it must contain a line consisting of the keyword `slave`. The following is a sample `/etc/named.boot` file for a slave server:

```
# /etc/named.boot file for slave server

directory    /usr/named
forwarders   123.45.67.89   234.56.78.90
primary      0.0.127.in-addr.arpa localhost.rev
slave
```

When the `/etc/named.boot` file is configured for a slave server, and it lists one or more forwarding servers to resolve recursive queries, all queries that cannot be answered from the local server's cache of responses are forwarded to the forwarding servers until one of the forwarding servers resolves the query. Responses are cached by the local server, resulting in faster responses to queries and less network traffic than the time and traffic associated with the remote server method (see Section 2.2.8.3.5, page 84).

With this method, direct access to root domain name servers on the Internet is not required. However, this method requires a remote server that can resolve recursive queries.

2.2.8.3.3 `named` As a Caching-only Server

If you plan to run `named` as a caching-only server, in addition to the `directory` line, the `/etc/named.boot` file must designate, on a line beginning with the keyword `cache`, a zone file that contains information about the root domain name servers on the Internet. A *zone* is a delegated subset of the domain name service tree. It contains the tree that is specified by the domain name minus subtrees delegated to other zones. It is the portion of the domain name service tree under a single administrative control. A *zone file* is a text file that contains information about a given zone.

The following is a sample `/etc/named.boot` file for a caching-only server:

```
# /etc/named.boot file for caching-only server

directory    /usr/named
cache        .                      root.cache
primary      0.0.127.in-addr.arpa   localhost.rev
```

In the preceding example, the third field on the lines that begin with the keywords `cache` and `primary` designate the files `root.cache` and `localhost.rev` (in the `/usr/named` directory) as zone files; `root.cache` contains the Internet addresses of and information about the root domain name servers on the Internet, and `localhost.rev` contains the information that refers the special Internet address `127.0.0.1` to the local Cray host.

The caching-only method does not require (but can use) a remote forwarding server that can resolve recursive queries. It does require direct access to the root domain name servers on the Internet.

2.2.8.3.4 `named` As a Master Server

If you plan to run `named` as a master server, you will need all of the information specified in the `/etc/named.boot` file for a caching-only server, and also additional lines beginning with the keywords `primary` or `secondary` for any zones over which the local `named` server has primary or secondary authority.

A *primary master server* for a zone loads the data for that zone from a zone file on disk (specified in the `/etc/named.boot` file). The data in the zone file consists of the authoritative host names, Internet addresses, and other information for the zone.

A *secondary master server* for a zone is delegated authority for the zone by the zone's primary master server, and periodically updates the data for the zone as needed. This data can also be stored in a back-up copy on disk to provide uninterrupted service if the primary master server for the zone is unavailable and the local server has initialized its data.

The following is a sample `/etc/named.boot` file for a master server:

```
# /etc/named.boot file for master server

directory    /usr/named
```

```
cache        .                          root.cache
primary      0.0.127.in-addr.arpa       local
primary      ourdomain.com              ours
primary      12.in-addr.arpa            ours.rev
secondary    theirdomain.edu            theirs.bak
secondary    78.56.234.in-addr.arpa     theirs.rev.bak
```

In the preceding example, the last four lines designate the master files (`ours`, `ours.rev`, `theirs.bak`, and `theirs.rev.bak`), which contain information about the associated zones (`ourdomain.com`, `12.in-addr.arpa`, `theirdomain.edu`, and `78.56.234.in-addr.arpa`, respectively). The master files for the zones over which this server has primary authority (`ours` and `ours.rev`) must contain the actual information about the hosts and Internet addresses in the network; that is, these are the files that must be updated if a host is added to or deleted from the network. The master files for the zones over which this server has secondary authority (`theirs.bak` and `theirs.rev.bak`) must contain back-up copies of the information about the associated zone, as received from the zone's primary server and written to the file by the local `named` process. This information must not be changed directly.

One server can serve as a master for multiple zones; it can be designated as primary for some and secondary for others. Queries are resolved by consulting the local cache (for authoritative and nonauthoritative data), any forwarding servers listed in the `/etc/named.boot` file, or root domain name servers on the Internet.

This method does not require (but can use) a remote forwarding server that can resolve recursive queries. It does require direct access to the root domain name servers on the Internet.

The decision to make a domain name server that is running on the local Cray host a master server depends on your local network's domain service configuration. You might prefer to let other servers perform most of the domain name resolution for the Cray host by running the Cray host's domain name server as a slave or caching-only server. In this way you can reserve the power of the Cray host for application processing. You might, on the other hand, prefer to give authority over certain domains to this server even though this may place slightly greater demands on the Cray host's resources.

2.2.8.3.5 Using the Domain Name Resolver Library Routines

Note: Use of the resolver client is not allowed with the Cray ML-Safe configuration of the UNICOS system. See Section 2.2.8.3, page 81, for more information about `named`(8) in UNICOS security.

The resolver library routines are the client portion of the domain name server. It resolves names whenever the /etc/hosts.usenamed file exists (see gethost(3) for exceptions). The optional resolv.conf file allows configuration of these routines.

The /etc/resolv.conf file can specify, on a line beginning with the keyword domain, the domain that contains the local host; otherwise, the resolver gets the default domain name from gethostname(2). On separate lines beginning with the keyword nameserver, the file must specify the Internet address of each remote host running domain name servers. These servers recursively process queries from the local Cray host. The following sample /etc/resolv.conf file specifies the local domain and two such remote hosts:

```
# Sample /etc/resolv.conf file

domain ourdomain.com
nameserver 127.0.0.1
nameserver 123.45.67.89
nameserver 234.56.78.90
```

The domain name resolver library routines do not cache any responses received (all queries are resolved independently of each other), which could result in slow responses and increased network traffic if a local name server daemon is not running. Therefore, it is recommended to run a local name server when the system is configured to resolve host names by using the Domain Name Service.

2.2.8.4 The sendmail Daemon

The sendmail(8) daemon performs Simple Mail Transfer Protocol (SMTP) operations.

Note: For UNICOS security, the /usr/mail and /usr/spool/mqueue directories must be installed as multilevel directories. See *General UNICOS System Administration*, publication SG–2301, for information on installing multilevel directories with UNICOS security.

With the UNICOS system, it is not necessary to use the newaliases(1) command when implementing the SMTP. The program that implements the SMTP is called sendmail(8). The sendmail program implements both the client side and the server side of SMTP mail services; the mode of operation is determined by the manner in which sendmail is invoked. The sendmail program is in the /usr/lib/sendmail file, as it is on most other systems that run under operating systems based on 4.4 BSD. As a client, sendmail is not called directly by the user, but indirectly through the UNICOS mail(1) interface.

The `sendmail` daemon usually begins execution at system startup when it is invoked from the `/etc/config/daemons` shell script. If it is not started in this manner, the super user must invoke `sendmail`, as in the following example:

```
/usr/lib/sendmail -bd -q30m
```

With the Cray ML-Safe configuration of the UNICOS system, `sendmail` must be invoked by a security administrator or a system administrator (active `secadm` or `sysadm` category). The following is an example of enabling security administrator status, invoking `sendmail`, and disabling security administrator status:

```
setucat secadm
/usr/lib/sendmail -bd -q30m
setucat 0
```

For a system administrator, use `setucat sysadm` instead of `setucat secadm`.

The `-bd` option specifies that `sendmail` must operate as an SMTP server process; the `-q` option sets the frequency with which `sendmail` must process mail in its queue. In this example, the `sendmail` daemon processes queued mail every 30 minutes. If you plan to run the `sendmail` daemon, add a line similar to the preceding command line to the `/etc/config/daemons` file. Set `-q` to the frequency you desire (see `sendmail`(8) for more information on how to specify this option).

The `/usr/lib/sendmail.cf` file, referred to as the `sendmail` configuration file, contains a set of directives to the `sendmail`(8) program. These directives instruct the program about how to interpret and deliver mail messages to and from the UNICOS system. The `sendmail` configuration file is distributed as a skeleton that you must customize for your site.

Warning: Modification of the /usr/lib/sendmail.cf file must comply with the guidelines set forth in the single-user mode descriptions in the "UNICOS security feature" section of *General UNICOS System Administration*, publication SG–2301. In addition, the sendmail daemon is running as a security administrator or system process when commands used in /usr/lib/sendmail.cf are executed. Therefore, additional care must be taken to ensure that the operations that these commands perform follow the rules and restrictions that are enforced for a security administrator, as described in the "UNICOS security feature" section of *General UNICOS System Administration*, publication SG–2301.

The /usr/lib/sendmail.cf file should not contain user-specified information unless that information has been verified to be acceptable by a security administrator. Users should be encouraged to use their own .forward files to customize their relationship with sendmail wherever possible.

None of the suggested modifications in this description violate the intent of this warning.

The lines that you must change are accompanied by comment lines that describe the changes to be made. At a minimum, you will need to make changes to the following lines:

- Near the beginning of the file, on the line reading

  ```
  DDdomain.domain
  ```

  change domain.domain to the domain name of your network.

  Note: You can obtain the domain name of your network from the domain parameter of the resolve.conf file.

- If your system host name, as configured by the hostname(1) command (see Section 2.2.9.4, page 112), does not include your domain name, locate the following line near the beginning of the file:

  ```
  #DE$D
  ```

  Uncomment the line by removing the initial #.

- Near the beginning of the file, on the line reading

  ```
  Cw
  ```

append the host name of the UNICOS system, all names from the `/etc/hosts` file or domain name server that refer to specific network interfaces on the UNICOS system, and any other aliases for the UNICOS system. Consider the following examples for Model E and GigaRing based systems:

If Model E based UNICOS system is given the official host name `cray`, has two separate HYPERchannel interfaces labeled `cray-np0` and `cray-np1`, and also has been given the alias `supercomputer`, the line must be modified to read as follows:

```
Cwcray cray-np0 cray-np1 supercomputer
```

If a GigaRing based UNICOS system is given the official host name `cray`, has two separate FDDI interfaces labeled `cray-gfddi0` and `cray-gfddi1`, and also has been given the alias `supercomputer`, the line must be modified to read as follows:

```
Cwcray cray-gfddi0 cray-gfddi1 supercomputer
```

The actual order of the names on the line is not significant.

If you want the UNICOS system to interpret mail addresses and deliver mail messages directly, you must rewrite the `sendmail` configuration file for your specific needs. However, if you are integrating the UNICOS system into an existing network on which another system already serves as a central clearinghouse for mail traffic on the network, you can modify the distributed UNICOS `sendmail` configuration file as follows:

- Near the beginning of the file, on the line reading

  ```
  DMmailhost
  ```

  change `mailhost` to the host name of the central mail system.

After you have identified a central mail system on the network, you can modify the `sendmail` configuration file to have the UNICOS system send all or some of its mail to the central mail system, as follows:

- To have all nonlocal mail automatically forwarded to the central mail system, locate the following line near the beginning of the file:

  ```
  #DA$M
  ```

  Uncomment the line by removing the initial #.

- To have all mail forwarded to the central mail system, locate the following line near the beginning of the file:

  ```
  #DX$M
  ```

  Uncomment the line by removing the initial #. This disables local delivery; no mail can be delivered locally on the Cray Research system.

- To have mail with nonlocal addresses of the form *host* ! *user* (using the UUCP style) sent to the central mail system, locate the following line near the beginning of the file:

  ```
  #DU$M
  ```

  Uncomment the line by removing the initial #.

- To have mail with addresses that specify nonlocal domains sent to the central mail system, locate the following line near the beginning of the file:

  ```
  #DN$M
  ```

  Uncomment the line by removing the initial #.

  Nonlocal domains are addresses of the form *user* @ *host.domain*; *domain* is not the same as the local domain that is specified in the configuration file.

For more information about sendmail, see the *Sendmail Installation and Operation Guide* by Eric Allman.

2.2.8.5 The snmpd Daemon

> **Note:** The use of snmpd is not allowed with Cray ML-Safe configuration of the UNICOS system.

The snmpd(8) daemon, also known as a *server/agent*, performs Simple Network Management Protocol (SNMP) operations on Cray Research systems. The agent resides in the background and listens for SNMP requests on port 161. When a request is received from a management station, snmpd performs the requested operations, as defined by RFC 1155 and 1157, and it provides management variables from the management information base (MIB), as defined by RFC 1213. See Appendix A, for a list of the MIB variables that Cray Research supports.

The following steps enable the snmpd daemon:

1. Add the SNMP and SNMP-trap ports to the /etc/services file by inserting the following lines (if they are not already there):

```
snmp 161/udp
snmp-trap 162/udp
snmp-trap 162/tcp
```

2. Assign management station community names to the `/etc/snmpd.conf` file. This is a security feature in the SNMP protocol. Any community not listed in `/etc/snmpd.conf` is not serviced (see the following section for more details).

3. Ensure that `/etc/snmpd` is started by the `/etc/config/daemons` file when the system is initialized.

Cray Research supports all operations defined by RFC 1157.

2.2.8.5.1 The `/etc/snmpd.conf` File

The `/etc/snmpd.conf` file contains a list of communities that are allowed to access the SNMP agent on the Cray Research system. The following is the sample `/etc/snmpd.conf` file that is in the source file. In this sample, the file contains keywords and parameters that specify access limits.

```
######################################################################
#
# Sample snmpd configuration file:
#
# 1. Fill-in the value for "sysContact" and "sysLocation" below, e.g.,
#
#       variable        sysContact      "joe operator <joeo@cray.com>"
#
#       variable        sysLocation     "upstairs machine room"
#
#    All the other objects in the system group are automatically
#    filled-in by the agent.
#
# 2. If your site has a management station that listens for traps,
#    fill-in the information for the trap sink, e.g.,
#
#       trap            traps           a.b.c.d
#
#    where "traps" is the community that the traps should be logged
#    under and a.b.c.d is the IP-address of the host where a trap
#    sink is listening on UDP port 162.
#
# 3. Fill in community statements to provide the correct access to
```

```
#    the workstations running the manager programs.
#
#       community       name    address         access          view
#
#    where "name" is the name that is used to make snmp queries,
#    "address" is the ip address of the host that may use the
#    community, "access" is one of readOnly, readWrite, or none,
#    and "view" is the subid of the view applicable to this community
#    name.  An "address" of 0.0.0.0 allows all ip-addresses to use the
#    community.
#
# 4. Fill in view statements that define which portion of the mib a
#    particular community can access.
#
#       view            subid          mib_subtree
#
#       where subid is a mib sub-identfier that identifies this view.
#       Only the "n" portion need be changed, n can be any number from 1
#       to 255.  mib_subtree can be any combination of mib sub identifiers.
#
########################################################################

readall;

community       public          localhost               readOnly
community       manage          localhost               readWrite       1.17.1
community       system          localhost               readOnly        1.17.2

view            1.17.1          system interfaces ip
view            1.17.2          system

logging         file=snmpd.log  size=500
logging         slevel=fatal    slevel=exceptions       slevel=notice
logging         sflags=close    sflags=create           sflags=zero

variable        sysContact      "Your name <Your@address>"
variable        sysLocation     "Your location "

trap            traps           localhost
```

2.2.8.5.2 Using the Set Operation to Make Configuration Changes

The `snmpd` daemon supports the use of the set operation on the MIB variables, as defined by RFC 1213. You can use the `snmptest`(1) command to make configuration changes. Follow the prompts after you enter `snmptest`.

> **Note:** When you use `snmp` set requests to make configuration changes, the changes remain in effect only until the next boot of the UNICOS system. These changes do not affect the configuration files or the install tool database.

You can make the following network configuration changes with `snmp` set requests:

- Add, delete, and change values of routes, as follows:
  - To add a new route, set the `ip.iproutetable.iproutentry.ipnexthop.128.162.3.4` variable to `128.162.6.7`, and set the `ip.iproutetable.iproutentry.iproutetype.128.162.3.4` variable to `3` if it is to a directly connected network or `4` if it is to an indirectly connected host or gateway. This set operation is equivalent to the `route add 128.162.3.4 128.162.6.7` command.
  - To delete a route, set the `ip.iproutetable.iproutentry.iproutetype.128.162.3.4` variable to `2` (this sets the type to `invalid`). This set operation is equivalent to the `route delete 128.162.3.4` command.
  - To change the values of an existing netmask, set the `ip.iproutetable.iproutentry.iproutenetmask.1.2.3.0` variable to `ff ff ff 00`. This set operation is equivalent to the `route change 1.2.3.0 -netmask 0xffffff00` command.
- Change network interfaces, as follows:
  - To change the logical state of a network interface to `up`, set the `interfaces.iftable.ifentry.ifadminstatus.1` variable to `1`. For Model E based systems, this set operation is equivalent to the `ifconfig np0 up` command, where `np0` is the first interface. For GigaRing based systems, this set operation is equivalent to the `ifconfig gfddi0 up` command, where `gfddi0` is the first interface.
  - To change the logical state of network interface to `down`, set the `interfaces.iftable.ifentry.ifadminstatus.1` variable to `2`. For Model E based systems, this set operation is equivalent to the

`ifconfig np0 down` command. For GigaRing based systems, this set operation is equivalent to the `ifconfig gfddi0 down` command.

– (For Model E based systems only) To add a `hyroute` entry on interface `14` (HIPPI), set the

`mgmt.mib-2.at.atTable.atEntry.atPhysAddress.14.1.128.162.94.13`

variable to `01 00 00 07 00 20 00 30`. This set operation is equivalent to the `hyroute` command directive

`add direct 128.162.94.13 01000007 0020 0030 mtu`

where `128.162.94.13` is the Internet address of the host name, `01000007` is the I-field, `0020` is the minor input number, and `0030` is the minor output number. The mtu is the mtu of the interface as specified by the `ifconfig`(8) command.

Following is an example of adding a `hyroute` entry on a HIPPI interface:

```
poplar09$ snmptest squall write
Please enter the variable name: $S
Request type is SET REQUEST
Please enter the variable name:
         mgmt.mib-2.at.atTable.atEntry.atPhysAddress.14.1.128.162.94.13
Please enter variable type [1|s|x|d|n|o|t|a]: o
Please enter new value: 01 00 00 07 00 20 00 30
Please enter the variable name:
Received GET RESPONSE from 128.162.82.6
requestid 0x4ef53739 errstat 0x0 errindex 0x0
Name: mgmt.mib-2.at.atTable.atEntry.atPhysAddress.14.1.12.8.162.94.13
OCTET STRING-  (hex): 01 00 00 07 00 20 00 30
Please enter the variable name: $Q
poplar09$
```

– (For Model E based systems only) To add a `hyroute` entry on interface `1` (HYPERchannel), set the

`ip.ipNetToMediatable.ipNetToMediaentry.ipNetToMediaphysaddress.1.128.162.3.4`

MIB variable to `0 0 66 77`. This set operation is equivalent to the `add direct 128.162.3.4 6677 ctl access mtu` command, where `ctl` and `access` are the defaults for the interface. The mtu is the mtu of the interface as specified by the `ifconfig` command.

- (For Model E based systems only) To delete a `hyroute` entry on interface `1`, set the

```
ip.ipNetToMediatable.ipNetToMediaEntry.ipNetToMediatype.1.128.162.3.4
```

variable to `2`.

- Turn IP forwarding on or off, as follows:
  - To turn on IP forwarding, set the `ip.ipForwrding.0` variable to `1`. This set operation is equivalent to the `netvar -f on` command.
  - To turn off IP forwarding, set the `ip.ipForwrding.0` variable to `2`. This set operation is equivalent to the `netvar -f off` command.
- Enable or disable the sending of SNMP authentication traps, as follows:
  - To enable the sending of SNMP authentication traps, set the `snmp.snmpEnableAuthenTraps.0` variable to `1`.
  - To disable the sending of SNMP authentication traps, set the `snmp.snmpEnableAuthenTraps.0` variable to `2`.
- Change the text describing the system contact and location, as follows:
  - To change the text describing the system contact, set the `system.sysContact.0` variable to any ASCII string less than 255 characters.

    Following is an example of changing the `sysContact` MIB variable to the ASCII string `phil`:

```
poplar09$ snmptest
usage: snmptest gateway-name [community-name] [-P port]
poplar09$: snmptest squall write
Please enter the variable name: $S
Request type is SET REQUEST
Please enter the variable name: mgmt.mib-2.system.sysContact.0
Please enter variable type [i|s|x|d|n|o|t|a]: s
Please enter new value: phil
Please enter the variable name:
Received GET RESPONSE from 128.162.82.6
requestid 0x4ef53739 errstat 0x0 errindex 0x0
Name: mgmt.mib-2.system.sysContact.0
OCTET STRING- (ascii): phil
Please enter the variable name $Q
poplar09$
```

- To change the text describing the system location, set the `system.sysLocation.0` variable to any ASCII string less than 255 characters.

Following is the list of MIB variables that you can set. For a definition of data formats, see RFCs 1155 and 1213.

MIB variable	Setting
`sysLocation`	Can be set to any ASCII octet string.
`sysContact`	Can be set to any ASCII octet string.
`sysName`	Can be set to any ASCII octet string.
`ifAdminStatus`	Can be set to either `1` (up) or `2` (down).
`snmpEnableAuthenTraps`	Can be set to either `1` (enabled) or `2` (disabled).

`ipForwarding`

Can be set to either `1` (forwarding, acting as a gateway) or `2` (not forwarding, not acting as a gateway).

`ipDefaultTTL`

If set, it must be `255`, the default IP maximum time-to-live.

`ipRouteDest`

If set, it must be the IP address of the route's destination.

`ipRouteIfIndex`

If set, it must be an integer with the value of the interface index of the route.

`ipRouteMetric1`

Can be set to `-1` (no metric), `0` (a directly connected network, not a gateway), or `1` (a route to a gateway)

`ipRouteMetric2`

If set, it must be `-1` (no metric).

`ipRouteMetric3`

If set, it must be `-1` (no metric).

`ipRouteMetric4`

If set, it must be `-1` (no metric).

`ipRouteMetric5`

If set, it must be `-1` (no metric).

`ipRouteNextHop`

Can be set to the IP address of the gateway of the route to create a new route or change an existing route.

`ipRouteType`

Can be set to `2` (invalid, to delete the route), `3` (direct, to create a route to a direct network), or `4` (remote, to create a route to a gateway).

`ipRouteMask`

Can be set to a valid subnet mask if the destination is a network, or it can be set to `255.255.255.255` if the destination is a host.

`atphysaddress`

This is the hexadecimal octet string of the physical address. To delete the entry, provide a string of length 0; for HYPERchannel, provide a string of length 4; for FDDI or Ethernet, provide a string of length 6; for HIPPI, provide a string of length 8.

`atnetaddress` or `ipNetToMedianetaddress`

If either variable is set, it must be to the IP address of this entry.

`atifindex` or `ipNetToMediaifindex`

If either variable is set, it must be to the value of the interface index for this entry.

`ipNetToMediaphysaddress`

This is the hexadecimal octet string of the physical address. For HYPERchannel, provide a string of length 4; for FDDI or Ethernet, provide a string of length 6; for HIPPI, provide a string of length 8.

`ipNetToMediaType`

Can be set to `2` (invalid, an invalidated mapping), `3` (dynamic), or `4` (static, if this is to be a permanent Address Resolution Protocol entry).

2.2.8.6 The `ntpd` Daemon

Network Time Protocol (NTP) provides the mechanisms to synchronize time and coordinate time distribution in a large, diverse internetwork. The servers that implement this mechanism are known as *timeservers*. Timeservers synchronize local clocks within a subnet by propagating time information from primary hosts, which obtain national standardized time information from radio or other very accurate sources. These servers can also redistribute reference time by means of local algorithms and time daemons. A timeserver is either a server or a peer read from the NTP configuration file (see Section 2.2.8.6.1, page 99).

The NTP protocol is implemented on Cray Research systems by the `ntpd` daemon process. When `ntpd` is started from the `tcpstart`(8) script, it begins gathering statistics from its timeservers. It sends several messages to each candidate timeserver. Then each timeserver returns a reply message which contains several items, including the timeserver's local time and the claimed accuracy of its clock. By measuring the magnitude and distribution of the packet turnaround times for each timeserver, and by comparing the reported accuracy of each timeserver clock with the others, the `ntpd` daemon determines which of the candidate timeservers is currently the most accurate from the perspective of the local host. Because clock accuracy, turnaround-time magnitude, and turnaround-time distribution are all considered by the selection algorithm, there is no guarantee that the closest timeserver (smallest average turnaround time) is selected as the best timeserver.

To increase the possibility of making a good initial timeserver selection, `ntpd` performs several measurements during the time span of several minutes before actually making the selection. When the initial selection is made, `ntpd` might call `settimeofday`(2) to synchronize the time on the local host with that of the timeserver that it selected. When this happens, local users observe a *time warp*, a term used to describe an instant in which local time appears discontinuous. This initial time warp can be quite long. To prevent this time warp from affecting UNICOS applications, it strongly recommended that the `/etc/ntp -s -f` *host1 ... hostn* command be executed prior to invoking `ntpd` (*host1 ... hostn* are servers and peers taken from the `/etc/ntp.conf` file). Usually, this command forces the local time to be synchronized with one of the timeservers. This makes the initial time warp occur during system startup and, therefore, before the user processes begin. Alternatively, you can invoke the `/etc/ntpstart.sh` script. This script issues the appropriate `ntp` command before invoking `ntpd`.

> **Note:** Time warp can affect software (for example, performance tests) that depends on smooth time and accounting. It can also affect the performance of such commands as `make`(1), `alarm`(2), and `sleep`(1).

After the local time is set, it usually remains accurate. However, `ntpd` continues to poll all configured timeservers at varying rates. The timeserver considered the most accurate is polled approximately once every 64 seconds; the timeservers initially considered less accurate are polled less often, perhaps once every 512 or 1024 seconds. After each poll, `ntpd` determines whether the local time is sufficiently accurate. If not, `ntpd` begins the process of determining whether the time difference is caused by clock drifting, and not by unexpected packet delays. Usually, it is packet delays that introduce the doubt about the time accuracy. However, when `ntpd` becomes convinced that its local clock has drifted too far from real time, it must adjust the local clock again. Usually, `ntpd` can use the `adjtime`(2) system call to gradually speed up or slow down the system clock. Occasionally, the adjtime(2) system call is not sufficient, and ntpd must call settimeofday(2). This creates another time warp. Fortunately, this is a relatively rare occurrence on Cray Research systems. Most of the time, ntpd can use the adjtime(2) system call to keep local time synchronized with network time. Unless something very unusual happens, such as simultaneously losing contact with most time servers, the system does not need to create time warps by using settimeofday(2). If this type of backward time movement is considered unacceptable at your site, ntpd must not be run on your server. In reality, however, it is not very probable that these adjustments will adversely affect UNICOS processes.

The ntpd daemon dynamically selects the best timeserver to use at any given time. If a path from the local host to its best timeserver becomes congested or lost, ntpd automatically selects another timeserver with which to synchronize. When the path later clears, ntpd can automatically revert to using the original timeserver if its performance is again superior to that of the other available timeservers.

The ntpd daemon is robust enough to ignore data from timeservers that appear suspicious. For example, ntpd disregards data from even a close timeserver if the time it reports disagrees substantially with the time reported by most other servers. Consequently, it is not likely to be fooled by a nonfunctional timeserver if a sufficient number of candidate timeservers are configured.

This implementation is based on the NTP version 1 protocol, described in detail in RFC 1059. Further information about NTP can be found in RFC 1119 and RFC 1129.

Note: The use of the ntpd daemon is not allowed with the Cray ML-Safe configuration of the UNICOS system.

2.2.8.6.1 The /etc/ntp.conf File

To enable the Network Time Protocol (NTP) facility, you must create the /etc/ntp.conf file, supplying timeserver information as shown in the following example:

```
# /etc/ntp.conf file

precision -10
server       wwvb.isi.edu
peer         umd1.umd.edu
server       130.126.174.40
```

`precision`
: Specifies the accuracy of the local clock to the nearest power of 2 seconds. If you do not include this line, `ntpd` is forced to try to determine it; this process is not very effective. For Cray Research systems, a precision of `-10` gives good results, but your system's precision requirements can differ according to its frequency. Use the following guidelines for setting the precision of your local clock:

Frequency	Precision
60 Hz	2**-6
100 Hz	2**-7
1000 Hz	2**-10

`server`
: In the first instance, `server` identifies a remote host with which the local host can synchronize. This remote host does not need to know anything about the local host, because the remote host does not synchronize with the local host under any circumstances. This `server` line consists of the keyword `server`, followed by at least one blank character, followed by the name of a remote host. The remote host's name can be specified in any format that is compatible with the local implementation of `gethostbyname`(3).

In the second instance, `server` specifies the server's address in the familiar dot notation.

`peer`
: Like the `server` line, this line identifies a remote host with which the local host can synchronize. However, the `peer` line also implies that the remote host can synchronize with the local host, if appropriate. For this peer relationship to work properly, if host `A` is a peer in host `B` 's configuration file, host `B` must be a peer in host `A` 's configuration file. Configuring a remote host as a peer without the consent of the remote host is functionally equivalent to configuring the remote host as a server.

The `peer` line consists of the keyword `peer`, followed by at least one blank character, followed by a host name.

> **Note:** The `ntp`(8) man page, and this section, present specific requirements for correctly selecting NTP peers and servers. Refer to this documentation before you select your peers.

`passive` (Not shown in the example). This identifies a type of relationship with a remote host that is supported, but not recommended. The configuration syntax is like that of `server` and `peer`. The passive relationship causes packets to be sent to the specified remote host when it polls the local host. This prevents the local host from initiating synchronization with the remote host, but it forces the local host to synchronize with the remote host through remote demand. Because this relationship gives too much control to the remote host, and it violates the traditional client/server model, Cray Research does not recommend configuring any passive hosts in the configuration file.

2.2.8.6.2 NTP Server Categories

NTP servers are divided into categories called *strata*, based on their distance from NTP servers that have reference clocks physically attached. Servers deriving their time from attached clocks are defined as being in stratum 1. Servers that synchronize with stratum-1 servers are in stratum 2, servers that synchronize with stratum-2 servers are in stratum 3, and so on. This classification scheme creates a hierarchy of time servers, with those in the lower numbered strata being more accurate and reliable.

If you are configuring only the Cray Research system to run NTP, the configuration task is relatively simple. Configure the `/etc/ntp.conf` file with three or four Internet stratum 1 and 2 servers; this is a good trade-off between the benefits of redundancy and the costs of protocol processing.

Configuration becomes more complex when you are trying to design the overall NTP architecture of a local subnet. Consider the example in which you want to begin running NTP not only on your Cray Research system, but also on several other local hosts (if their NTP daemon executable files are available to you).

You must determine which servers will be in stratum 2 and which servers will be in stratum 3. A good guideline is to select three of your systems with the best clocks and your fileservers to be local servers. Choose six stratum-1 Internet hosts and pair them off (a list of NTP servers is available through anonymous FTP from `louie.udel.edu` in the `pub/ntp/clock.txt`) file. For each pair of stratum-1 hosts, choose an external stratum-2 host that synchronizes with primary servers other than that pair. Then configure each of your local servers in the following manner:

```
server    one_of_the_stratum_1_hosts
server    the_other_stratum_1_host
server    corresponding_external_stratum_2_host
peer      one_of_the_other_local_servers
peer      the_third_local_server
```

This is an extremely robust configuration. It is resistant to nonfunctional timeservers and generates less traffic than would occur if multiple machines were all communicating with the same set of external peers. The second stratum-1 host in each pair can be further away, because there is usually less traffic.

The remaining machines can now synchronize with your three local stratum-2 servers. They can be configured with the following entries:

```
server    local_stratum_2
server    another_local_stratum_2
server    the_third_local_stratum_2
```

2.2.8.7 The `inetd` Daemon

The `inetd`(8) daemon provides a mechanism for starting daemons that are listed in the `/etc/inetd.conf` file. The `inetd` daemon is a *super server* because it listens for incoming requests for the services. Whenever a request is received, `inetd` starts the individual server process. Following is a list of the daemons that `inetd` starts and the service each performs.

> **Note:** The daemons listed with asterisks perform services that must not be configured with the Cray ML-Safe configuration of the UNICOS system.

Daemon	Service
`fingerd`(8)	Remote user information display server
`ftpd`(8)	Internet file transfer protocol server
`ntalkd`(8)*	Visual communication server

`rexecd`(8)	`rexec`(3) library routine server
`rlogind`(8)	Remote login server
`rshd`(8)	Remote shell server
`telnetd`(8)	Internet virtual terminal server
`tftpd`(8)*	Internet trivial file transfer protocol server
`ypupdated`(8)*	Network information service (NIS) update server
`rstatd`(8)*	Remote status daemon
`rusersd`(8)*	Remote user information daemon
`sprayd`(8)*	Remote spray daemon (used for testing)
`rwalld`(8)*	Remote write all daemon

If you are using the UNICOS ICMS for your configuration, you can use the `Configure System -> Network configuration -> TCP/IP configuration -> Internet daemon` menu to configure the list of services for which `inetd` listens. The following shows the sample `/etc/inetd.conf` file that is included in the source file. Table 2, page 104, describes each column as it relates to creating or modifying this file.

```
#
# Sample /etc/inetd.conf file
# Internet server configuration database
#
ftp     stream  tcp     nowait  root    /etc/ftpd     ftpd
telnet  stream  tcp     nowait  root    /etc/telnetd  telnetd
5100    stream  tcp     nowait  root    /etc/telnetd  telnetd -D report
shell   stream  tcp     nowait  root    /etc/rshd     rshd
login   stream  tcp     nowait  root    /etc/rlogind  rlogind
exec    stream  tcp     nowait  root    /etc/rexecd   rexecd
# Run as user "uucp" if you don’t want uucpd’s wtmp entries.
#uucp   stream  tcp     nowait  root    /etc/uucpd    uucpd
finger  stream  tcp     nowait  nobody  /etc/fingerd  fingerd
#tftp   dgram   udp     wait    tftp    /etc/tftpd    tftpd
#comsat dgram   udp     wait    root    /etc/comsat   comsat
#ntalk  dgram   udp     wait    root    /etc/ntalkd   ntalkd
echo    stream  tcp     nowait  root    internal
discard stream  tcp     nowait  root    internal
chargen stream  tcp     nowait  root    internal
daytime stream  tcp     nowait  root    internal
time    stream  tcp     nowait  root    internal
```

```
echo    dgram   udp     wait    root    internal
discard dgram   udp     wait    root    internal
chargen dgram   udp     wait    root    internal
daytime dgram   udp     wait    root    internal
time    dgram   udp     wait    root    internal
#
#
# RPC services syntax:
# <rpc_prog>/<vers> <socket_type> rpc/<proto> <flags> <user> <pathname> <args>
ypupdated/1   stream  rpc/tcp wait root /etc/ypupdated ypupdated
rstatd/2-4    dgram   rpc/udp wait root /etc/rstatd    rstatd
rusersd/1-2   dgram   rpc/udp wait root /etc/rusersd   rusersd
sprayd/1      dgram   rpc/udp wait root /etc/sprayd    sprayd
rwalld/1      dgram   rpc/udp wait root /etc/walld     rwalld
```

Table 2. `/etc/inetd.conf` file columns

Column number	Column name	Description
1	Service name	Specifies the service. If a service is not needed, you can disable it by commenting it out with a # preceding the line. In the preceding sample file, `uucp`, `tftp`, `comsat`, and `ntalk` services have been disabled. The `inetd` program searches the `/etc/services` file for the specified service and obtains the port number, which can also be directly specified in this column, in place of the service name. The `inetd` daemon opens the port number and begins listening for incoming requests on it. For RPC-based servers, the server name is followed by a slash (/), which is followed by the version number of the protocol (for example, `sprayd` /1 indicates version 1 of `sprayd`, and `rstatd` /2-4 indicates versions 2 through 4 of `rstatd`).
2	Socket type	Specifies the use of either a stream (TCP) or a datagram (UDP) socket.
3	Protocol type	Specifies which protocol is used: TCP (socket type is `stream`), or UDP (socket type is `dgram`). For RPC-based servers, the protocol type is preceded by `rpc/` (for example, `rpc/tcp` or `rpc/udp`).

Column number	Column name	Description
4	Single-threaded/multithreaded	Indicates whether a new server's status is single-threaded (`wait`) or multithreaded (`nowait`) (see `inetd.conf`(5) for more information).
5	User	Describes the access permissions for the daemons. The `ftp`, `telnet`, `shell`, and `login` servers require root permission; the `finger` and `tftp` servers should be run as users with limited capability. In the preceding sample file, the `finger` server runs with the capability of user `nobody`; the `tftp` server (if enabled) runs with the capability of user `tftp`. You must create these users and assign limited permissions to them.
6	Server program	Indicates the location of the program. The `inetd` server requires an entry here. For internal services, put `internal` in this column. For example, in the preceding sample file, the `telnet` daemon is located in `/etc`; `echo` is an internal service.
7	Server program and arguments	Indicates the program's name and describes the arguments to be used on the `exec`(2) system call that `inetd` executes. In the preceding sample file, a `telnet` daemon is available on port 5100, which operates in diagnostics reporting mode. The `-D` argument is specified in the last column. See `telnetd`(8) for more information on this argument.

Note: For security reasons, Cray Research recommends that you disable `tftpd`(8). If the site requires `tftdpd`, see Section 2.2.8.7.7, page 109, for configuration information. `tftpd` must not be run with the Cray ML-Safe configuration of the UNICOS system.

2.2.8.7.1 The `fingerd` Server

The server program for the remote `finger`(1B) routine is `fingerd`(8).

Note: The `fingerd` server must not be run with the Cray ML-Safe configuration of the UNICOS system.

2.2.8.7.2 The `ftpd` Server

The server program for the Internet file transfer protocol is `ftpd`(8). The `/etc/ftpd` command accepts the following options:

Option	Description
`-d`	Logs debugging information to the `syslogd` file.
`-l`	Logs each `ftp` session to the `syslogd` file.
`-t` *timeout*	Terminates an inactive session after *timeout* seconds
`-v`	Logs debugging information to the `syslogd` file.

See `ftpd`(8) for a complete list of options.

If users create their own `$HOME/.netrc` files in the working directories of the client hosts, they do not have to provide the `ftp` server with their user names or passwords. For information on the `$HOME/.netrc` files, see the *TCP/IP Network User's Guide*, publication SG–2009. A version of `ftpd` that supports Kerberos authentication is available (see the *Kerberos Administrator's Guide*, publication SG–2306).

If the user name is `anonymous` or `ftp`, and an `ftp` account is present in the password file, the user is allowed to log in by specifying any password. The `chroot`(2) system call is executed to change to the login directory of the `ftp` account. Because anyone can log in under `anonymous`, it is advisable to restrict the access privileges to this account: files and directories should not be owned by the `ftp` account, and read-only permission should be set. Because of the `chroot` system call, the `ftp` account must have a `bin` directory with the `ls`(1) and `pwd`(1) commands in it so that the `ftp dir` command works.

The `/etc/ftpusers` file contains the names of users who are denied access to `ftp` from a remote host. Each time an `ftp` user attempts to log in, the `ftpd`(8) server searches this file for the user's login name. If the name is found, the user is denied access. Valid user names (that is, names of users who should have access) must not appear in the `/etc/ftpusers` file; if they do, access is denied them.

An example of an `/etc/ftpusers` file is as follows:

```
# Sample etc/ftpusers file

# denied ftp users
todd
doug
```

```
cheryl
bonnie
```

2.2.8.7.3 The `ntalkd` Server

The `ntalkd`(8) program is the remote server used by the UNIX `talk`(1B) command. This program is a visual communication program that copies lines from your terminal to the terminal of another user.

> **Note:** The `ntalkd` server must not be run with the Cray ML-Safe configuration of the UNICOS system.

2.2.8.7.4 The `rexecd` Server

The server program for the remote execution routine is `rexecd`(8), which provides an existing server for custom-designed network programs. (See `rexec`(3) for more information.) For information about how users on hosts that run under operating systems based on UNIX can use remote execution for their own applications, see `rexecd`(8).

Remote users who want to use the `rexecd` server on the Cray Research system (the local host) must authenticate themselves with user names and passwords for their accounts. Users have three options for specifying names and passwords:

- Code the name or password into the local program.
- Direct `rexec`(3) to prompt the user for the name or password in the client program.
- Store the name or password in the user's `$HOME/.netrc` file on the client.

2.2.8.7.5 The `rlogind` and `rshd` Servers

The `rlogin`(1B) program allows remote login to other hosts that run under operating systems based on UNIX (see the *TCP/IP Network User's Guide*, publication SG–2009. The `rsh`(1) program allows the execution of one command on other hosts that run under operating systems based on UNIX, and it handles requests for the `rcp`(1) (remote copy) commands. Versions of `rlogind`(8) and `rshd`(8) that support Kerberos authentication are available (see the *Kerberos Administrator's Guide*, publication SG–2306, for details).

These programs allow users at other hosts to log in and execute commands on a Cray Research system.

The rlogin, rcp, and rsh programs provide the following:

- Automatic remote login. Users are not required to enter their user names and passwords on the serving hosts because the system verifies login information based on the /etc/hosts.equiv, the $HOME/.rhosts, and the /etc/password files.
- Terminal characteristics automatically passed to the serving host. Users are not required to specify their terminal type to the serving host.

To allow automatic user login, you can create an /etc/hosts.equiv file on the server host (see Section 2.2.5.3, page 37), or users can create their own $HOME/.rhosts files (see Section 2.2.11.2, page 126). One of these files must be properly configured to use the rsh and rcp commands. However, the rlogin command does not require these files. If they are not present, rlogind validates the user who is making the request by doing the following:

1. Prompts users for their user names on the server host.
2. Verifies that the user names are in the server host's password file and are password-protected; they must not have a null password.
3. Prompts users for their passwords, which they must supply before remote login operations can be performed.

2.2.8.7.6 The telnetd Server

The telnetd(8) program is a server to the DARPA standard telnet virtual terminal protocol. It operates by allocating a pseudo-terminal device for a client who is attempting to connect. After this allocation is complete, a login process is initiated on the slave side of the pseudo-terminal with stdin, stdout, and stderr assigned to the pseudo-terminal. telnetd manipulates the master side of the pseudo-terminal and uses the telnet protocol to pass data between the client and the login process.

The telnetd daemon is started by the inetd(8) daemon whenever a request comes in on the specified port. telnetd supports the following options, which can be specified in column 7 of the /etc/inetd.conf file as the program arguments (see telnetd(8) for a complete list of options):

-r *low_pty high_pty*

Specifies the incrementing range for finding a free pseudo-terminal. When allocating pseudo-terminals, telnetd begins at *low_pty* and continues incrementing by 1 until either a free pseudo-terminal is found, or *high_pty* has been tried. The defaults for *low_pty* and *high_pty* are 0 and 100 (the value of the `sysconf` variable `SC_CRAY_NPTY`), respectively.

`-h` Suppresses system message display. When a user specifies `telnet` to access a Cray Research system, a system message is displayed prior to the login prompt if this option is not specified. This system message indicates the remote host's name, operating system, and so on.

2.2.8.7.7 The `tftpd` Server

The server program for the Internet trivial file transfer protocol is `tftpd`, which does not have a login facility. Because it does not validate users, this server can be used to transfer only publicly readable files; however, the `tftpd` server supports Kerberos authentication. Thus, authentication of the client can be performed through the Kerberos subsystem; users can access all files that would be available to them if they were logged in locally.

For security reasons, you should disable the `tftp` service. However, if this service is needed, the following steps can be taken:

1. Create a user `tftp` file with limited privileges.
2. Modify the `/etc/inetd.conf` file to set the `tftp` access permission parameter to the user created in step 1 (column 5 of the `tftp` line in the `/etc/inetd.conf` file).
3. Edit the `/etc.tftpd.conf` file to include the directories you select if you want the inbound `tftp` to access only certain directories (such as `/tmp`, `/usr/tmp`, and so on). The `/etc/tftpd.conf` file contains a list of the directories that are available through `tftp` access. A directory not listed in this file is not accessible through `tftpd`.

You must provide the full path name of each directory specified in the `/etc/tftpd.conf` file (for example, `/tmp`, `/usr/tmp`, and so on) and its access permissions (`R` or `r` for read only, `W` or `w` for write only, and `RW`, `WR`, or `rw` for read/write). If the `tftpd` access permissions are different from the directory's usual access permissions, the directory's usual permissions override the `tftpd` access permissions. For example, if a directory cannot be read by others, putting that directory in the `/etc/tftpd.conf` file with read permission does not permit read access.

The following example shows a sample /etc/tftpd.conf file. In this example, /garbage is readable and writable through tftp, and /tmp is readable through tftp, if these directories set public read/write and read permissions, respectively.

```
#This is the tftpd configuration file.  It contains the list of
#directories and the type of access for these directories for tftpd.

#The format is as follows:
#       Mode    Directory
#       where Mode is either R (read only access via tftpd), W
#       (write only access via tftpd), or RW or WR (read/write
#       access via tftpd.)  Each directory has to be specified on
#       a separate line.
#
#
#NOTE tftpd is a big security risk and should not be used unless
#      necessary.
#
     RW  /garbage
     R   /tmp
```

Note: The tftpd daemon must not be configured with the Cray ML-Safe configuration of the UNICOS system.

2.2.9 Performing Startup Procedures

When the system starts up, the networking software is started by the /etc/tcpstart script, which is typically called by the network start-up script, /etc/netstart (which is, in turn, typically called by the system start-up script, /etc/rc).

Note: The /etc/tcpstart script that is supplied with the UNICOS system should not be modified directly.

The default /etc/tcpstart script supplied with UNICOS is designed to be sufficiently general in its capabilities to support the startup of networking on a majority of UNICOS systems (if the underlying configuration files explained in this section are configured correctly).

You can start the UNICOS networking software by using a method other than the supplied /etc/tcpstart file. Sometimes administrative procedures for starting networks are written already, or (infrequently) the local configuration has special needs that are too complex for the supplied /etc/tcpstart file.

(If the latter is true, inform Cray Research of your needs so that they can be considered for future revisions of `/etc/tcpstart`.) Nevertheless, becoming familiar with the actions taken by the supplied `/etc/tcpstart` file is valuable, because any alternative script or method you use to start the UNICOS networking software must accomplish the goals described in this section.

The default for UNICOS is for the `/etc/tcpstart` script to perform the following functions:

1. Calls a local script (`/etc/tcpstart.pre`), if present
2. Initializes kernel networking variables
3. Updates the binary copy of the `/etc/hosts` database
4. Configures the host name of the system
5. With UNICOS security, loads the NAL, WAL, and IPSO maps
6. Initializes the networking interfaces
7. Calls a local script (`tcpstart.mid`), if present
8. Sets up routing
9. Starts the networking daemons related to TCP/IP
10. Calls a local script (`/etc/tcpstart.pst`), if present

Each of these steps is discussed in the following sections.

2.2.9.1 Calling the First Local Script

The `/etc/tcpstart` script begins by calling the local script `/etc/tcpstart.pre` if it exists and is executable. You should place the following in this script:

- TCP/IP start-up processes that are specific to your local system
- TCP/IP start-up processes that must be performed before the networking software is started
- TCP/IP start-up processes that cannot be accomplished by any of the other mechanisms provided

2.2.9.2 Initializing Kernel Networking Variables

To initialize kernel networking variables that are configurable while the system is running, the `/etc/tcpstart` script calls the `/etc/netvar` utility with the contents of the `/etc/config/netvar.conf` file as arguments to `netvar`. Lines in the `/etc/config/netvar.conf` file that begin with a # are considered comments and are ignored. For example, the following `/etc/config/netvar.conf` file turns on IP forwarding in the kernel (`-f on`), turns off sending of Internet control message protocol (ICMP) redirect packets (`-r off`), and sets the default TCP/IP send space to 32,768 bytes:

```
# /etc/config/netvar.conf file

# set networking kernel variable at boot time

-f on
-r off
-t 32768
```

See `netvar`(8) for a full list of the kernel variables it can set and the associated flags.

2.2.9.3 Updating the Binary Hosts Database

To ensure that the binary host name and address database `/etc/hosts.bin` is current with the information in the text file version `/etc/hosts`, the `/etc/tcpstart` script calls the `mkbinhost`(8) command. This command updates `/etc/hosts.bin` whenever `/etc/hosts` has changed, to avoid problems that could arise from incorrect name translations.

2.2.9.4 Configuring the Host Name

The `/etc/tcpstart` script next configures the running system with the system host name. Because a system can determine its host name in various ways, the `/etc/tcpstart` script follows this procedure:

1. If the `/etc/config/hostname.txt` file exists, the `/etc/tcpstart` script sets the system host name to the contents of the file.

2. Otherwise, if the `/etc/net/makehostname` script exists and is executable, the `/etc/tcpstart` script executes the script and sets the system host name to the output of its execution.

3. Otherwise, the `/etc/tcpstart` script sets the system host name to the system name compiled into the UNICOS kernel, as reported by executing the following:

   ```
   uname -n
   ```

   (See `uname`(1) for details.)

The rules to set the host name can be summarized, as follows:

- If you want the system host name to remain the same as the UNICOS kernel system name, do not do anything.
- If you want the system host name to be different, and the name you want is a simple character string, place it in the `/etc/config/hostname.txt` file. For example, if you want your system host name to be `mycray`, place the following in the `/etc/config/hostname.txt` file:

  ```
  mycray
  ```

- Alternatively, you can generate the system host name at boot time by creating a script to do so, placing it in the `/etc/config/makehostname` file, and making the script executable. For example, if you want to append the domain name `our.domain` to the kernel system name as reported by `uname`(1), place the following in the `/etc/config/makehostname` file:

  ```
  # tiny script to create our host +
  # domain name from our uname

  echo ‘uname -n‘.our.domain
  ```

  Then make the script executable by typing the following command:

  ```
  chmod +x /etc/config/makehostname
  ```

2.2.9.5 Loading the Maps

With UNICOS security, you must load the NAL, WAL, and IPSO maps from the `/etc/config/spnet.conf` file. See `spnet`(8) for a description of the `spnet.conf` file.

2.2.9.6 Initializing the Network Interfaces

After the host name is configured, the TCP/IP startup procedure should initialize the networking interfaces that permit TCP/IP communication over the attached networks.

2.2.9.6.1 Using the UNICOS `tcpstart` Script to Initialize Interfaces

The `/etc/tcpstart` script calls the utility script `/etc/initif` to initialize the networking interfaces. `/etc/initif` consults the `/etc/config/interfaces` file for information about each interface to be initialized.

If you are using the UNICOS ICMS for configuration of your networking interfaces, the UNICOS ICMS maintains the `/etc/config/interfaces` file with the information you supply by using the `Configure System -> Network configuration -> General network configuration -> Network interface configuration` menu.

If you are not using the UNICOS ICMS, you must place the information about your network interfaces directly in `/etc/config/interfaces`. Each line in `/etc/config/interfaces` describes the startup of one interface. The format of each line is as follows:

interface_name *hycf_file* `or` *arp_file* *address_family* *host* *destination*
`[`*ifconfig_arguments*`]`

hycf_file (Model E based systems only)
: Name of a file containing the hardware address information associated with this interface. If *hycf_file* begins with a leading `/` (slash), it is assumed to be a full path name; otherwise, it is assumed to be the name of a file relative to the configuration directory `/etc/config`.

arp_file (GigaRing based systems only)
: Name of a file containing the hardware address information associated with ghippi or gr interface only. If *arp_file* begins with a leading `/` (slash), it is assumed to be a full path name; otherwise, it is assumed to be the name of a file relative to the configuration directory `/etc/config`.

interface_name
: Kernel identifier of the interface to be configured (for example, `lo0`, `np1`, and so on).

address_family
: The address family of the address specified as the *host* argument. For Internet addresses, this is `inet`.

host
: Internet address (or host name corresponding to the address, as found in the `/etc/hosts` database) to be associated with this interface.

destination — Internet address (or host name corresponding to the address, as found in the `/etc/hosts` database) of the destination for a point-to-point link. If this interface is not a point-to-point link, the column should contain `-` (one hyphen).

ifconfig_arguments — List of optional arguments for this interface that are passed to the interface configuration program `ifconfig`. This list consists of keywords followed by optional arguments (for example, `netmask 0xffffff00`, `-trailers`). See `ifconfig`(8) for a full list of permitted arguments.

> **Note:** If you are running with UNICOS security, also see Section 2.6, page 218, for security-related parameters.

For maximum performance between two Cray Research systems, an mtu of 65536 is recommended for HIPPI interfaces, as well as for Host-to-Host GigaRing interfaces.

For Model E based systems, you must ensure that the interface mtu is at least as large as the mtu specified in the `hycf` file. The mtu in the `hycf` file is the size of the largest IP datagram that can be sent to a given host. The interface mtu is the size of the largest IP datagram that can be received on this interface.

The following is a sample `/etc/config/interfaces` file for a Model E system that specifies three interfaces (and also the local loopback interface `lo0`):

```
#
# Configuration file for interfaces known to /etc/initif.
#
# File format is:
#
# name  hycf_file        family address     pt-to-pt-dest       args:
#                                                               netmask
#                                                               iftype
#                                                               broadcast
#                                                               mtu
#                                                               rbuf
#                                                               wbuf
#                                                               bg
#       np0 setup temporarily for 4801 through vme
#
```

```
lo0     -               inet    localhost       -
np0     /etc/hycf.ows   inet    hot-030         -         netmask 0xffffff00
                                                          iftype vme
np2     /etc/hycf.np2   inet    hot-fddi        -         netmask 0xffffff00
                                                          iftype n130
hi0     /etc/hycf.hippi inet    hot-hippi       -         netmask 0xffffff00
                                                          mtu 65536
```

The following is a sample `/etc/config/interfaces` file for a CRAY J90 system that specifies three interfaces (and also the local loop-back interface `lo0`):

```
#
# Configuration file for interfaces known to /etc/initif (to be brought
# up at system startup by /etc/tcpstart).
#
# File format is:
#
# name  hycf_file       family  address        pt-to-pt-dest    args:
#                                                               netmask
#                                                               iftype
#                                                               broadcast
#                                                               mtu
#                                                               rbuf
#                                                               wbuf
#                                                               bg
#
lo0     -               inet    localhost       -
en0     -               inet    sn5194-ccn      -           netmask 0xffffff00
fddi0   -               inet    sn5194-fddi     -           netmask 0xffffff00
hi0     /etc/hycf.hippi inet    sn5194-hippi1  frost-hippi1  netmask 0xffffff00
                                                            mtu 65536
```

The following is a sample `/etc/config/interfaces` file for a GigaRing based system that specifies one active interface (and the active local loopback interface `lo0`):

```
#
# Configuration file for GigaRing network interfaces to be brought
# up by interfaces /etc/tcpstart through /etc/initif.
#
# Supported network interfaces are:
#
# name    arp_file         family address      pt-to-pt-dest       ifconfig_args
# ------------------------------------------------------------------------------
```

```
# gether0 -                 inet   snXXXX-ether -             netmask 0xffffff00
# gfddi0  -                 inet   snXXXX-fddi  -             netmask 0xffffff00
# ghippi0 /etc/ghippi0.arp inet   snXXXX-hippi -rbuf32 wbuf32 netmask 0xffffff00 hwloop
# gatm0   -                 inet   snXXXX-atm   -             netmask 0xffffff00
# gr0     /etc/gr0.arp      inet   snXXXX-gr    -             netmask 0xffffff00
#
# name    arp_file          family address      pt-to-pt-dest      ifconfig_args
#
lo0     -                   inet   localhost    -
gether0 -                   inet   snXXXX-ether -             netmask 0xffffff00
```

2.2.9.6.2 Using Your Own Procedures to Initialize Interfaces

If you are not using the `/etc/tcpstart` script that is supplied with the UNICOS system, your startup procedure must initialize the networking interfaces for your attached networks.

You can initialize your system's interfaces by using the same `initif`(8) script that is used by the `/etc/tcpstart` script that is supplied by the UNICOS system. If you choose this method, consult the preceding section or `initif`(8) for operating details.

If you prefer not to use the `initif` script, you must arrange for your startup procedure to execute the following commands for each interface to be initialized at startup:

- `fddiload`(8) (IOS–E based systems that contain one or more FDDI interfaces only).

  Cray Research systems that have one or more FDDI interfaces must first have each of the FDDI channel adapters (FCAs) downloaded with FDDI microcode. The `fddiload` command performs this function. The microcode binary file resides in the `/etc/micro/fca1.ucode` file.

- `hyroute`(8) (Model E and model V based systems only).

  After the IOS channel is initialized for the networking interface (if appropriate), the interface must be initialized with information about the hardware addresses of the systems on its attached network. This is accomplished with the `hyroute`(8) command and the appropriate `hycf` file for the interface.

  For example, if the information about the hardware addresses of the systems attached to the network of interface `np0` is stored in the `/etc/hycf.np0` file, you must arrange for your startup procedure to perform the following command before proceeding with configuration of the np0 interface:

```
hyroute np0 -s /etc/hycf.np0
```

For information about creating the proper hycf file for an interface, see Section 2.2.6.4, page 46.

- ifconfig(8)

  When you have initialized the hardware addresses for a network interface, you must initialize the interface to an active state by using the ifconfig(8) command. The ifconfig command initializes various parameters associated with the interface, including the specific Internet address that identifies the interface to the TCP/IP software.

  The following examples show a typical ifconfig command executed during system startup:

  For Model E based systems:

```
ifconfig np0 mycray-net1 netmask 0xffffff00 iftype np
```

  For GigaRing based systems:

```
ifconfig gfddi0 mycray-net1 netmask 0xffffff00 iftype np
```

  In these examples, mycray-net1 is the host name for the Internet address that is associated with the np0/gfddi0 interface. The command also specifies that addresses for the hosts on this network have a subnet mask of 0xffffff00 (for more information about subnets and subnet masks, see Section 2.1.2.2, page 10).

  The following examples show a typical ifconfig command for a HIPPI interface:

  For Model E based systems:

```
ifconfig hi0 sn2402-hippi mtu 65536 netmask 255.255.255.0
```

  For GigaRing based systems:

```
ifconfig ghippi0 sn2402-hippi mtu 65536 netmask 255.255.255.0
```

  If you specify the ptp argument and the interface is brought up on the dedicated path, all HIPPI packets are sent in hold-connection mode. This means that a HIPPI connection is made the first time a packet is sent. The connection remains in place until the interface is configured down.

Following is an example of the `ifconfig` command for a HIPPI point-to-point connection:

```
ifconfig hi0 sn2402-hippi sn5194-hippi ptp mtu 65536 netmask 255.255.255.0
```

The typical configuration for a Host-to-Host GigaRing interface is as follows:

```
ifconfig gr0 sn9132-gr netmask 0xffffff00
```

2.2.9.7 Calling the Midpoint Local Script

The `/etc/tcpstart` script next calls the local script `/etc/tcpstart.mid` if it exists and is executable. You should place the following in this script:

- Processes that are specific to your local system
- Processes that must be performed after the network interfaces have been initialized but before additional static routes have been installed
- Processes that cannot be accomplished by any of the other mechanisms provided

2.2.9.8 Setting up Routing

After the networking interfaces are initialized, the TCP/IP startup procedure should initialize the kernel tables for routing of network traffic. This initialization must be performed before the startup procedure starts any other networking software (such as system daemons), which may need routing information to communicate with remote hosts.

2.2.9.8.1 Using the UNICOS `tcpstart` Script to Set up Routing

The `/etc/tcpstart` script initializes the kernel tables for routing of network traffic from information placed in the `/etc/gated.conf` file. You can create the `gated.conf` file by using the `Configure System -> Network configuration -> TCP/IP configuration -> Routing` menu.

Usually, when the `gated`(8) routing daemon is started (see Section 2.2.8.1, page 65), it installs dynamic routing information from the `/etc/gated.conf` file to initialize the routing table in the kernel. However, if the `/etc/sdaemon` program indicates that the `gated` daemon is not starting as part of the group of TCP/IP daemons that start during system startup, the `/etc/tcpstart` script executes the `/etc/staticrts` script to initialize the kernel routing table with the static routes listed in the `/etc/gated.conf` file.

> **Note:** Even if you are not using dynamic routing (that is, the `gated`(8) program), the `/etc/staticrts` script assumes that the information that describes your static routes is located in the `/etc/gated.conf` file.

Using the `gated` routing daemon is the generally preferred method of installing routing information because of the dynamic routing capabilities of `gated`. For a full discussion of its capabilities and configuration, see Section 2.2.8.1, page 65. However, sites with simple networks that do not need the dynamic routing capabilities of `gated` can avoid the overhead of the daemon by disabling the `gated` daemon and relying on the `/etc/staticrts` script.

UNICOS extensions to the format of the `/etc/gated.conf` file allow configuration of all Cray Research proprietary routing features, such as configuring an mtu size for each route and the ability to impose route restrictions on users in a specific list of groups. Thus, it should always be possible to configure your system routing tables adequately by using the `/etc/gated.conf` file and either the `gated` daemon or the `/etc/staticrts` script.

If, however, it becomes necessary to configure your system startup procedures to use the `route` command directly, you can use the following methods to arrange for the `/etc/tcpstart` script to execute the appropriate `route` commands at system startup (in decreasing order of preference):

- Place a line in the `/etc/config/daemons` file to execute a local start-up script that contains the necessary `route` commands. See Section 2.2.9.9, page 121, for a description of this file. The line must be part of the TCP group of daemons, and it must be placed in the file before any other lines that belong to the TCP group of daemons. The line can have any string you want in the `tag` column; it must contain the string `YES` in the `start` column; and it must have a hyphen in the `kill` column, followed by the name of the script.

  For example, if the script to be executed is `/etc/myroutes`, you must add the following line to the `/etc/config/daemons` file:

  ```
  TCP    routes    YES    -    /etc/myroutes
  ```

- Replace the `/etc/staticrts` script that is supplied with the UNICOS system with a local start-up script that contains the necessary `route` commands.

- Edit the `/etc/tcpstart` file to add the necessary `route` commands before the call to `etc/sdaemon`, which starts the TCP group of daemons.

Caution: The last two methods of setting up your own static routing tables are not recommended because the installation of future revisions of the UNICOS system can overwrite the `/etc/staticrts` and/or the `/etc/tcpstart` scripts with updated versions. If you have chosen either of these methods, you must take the necessary steps to preserve the routing information that is contained therein as a local configuration modification.

2.2.9.8.2 Using Your Own Procedures to Set up Routing

If you are not using the `/etc/tcpstart` script supplied with the UNICOS system, your startup procedure must arrange to initialize the kernel routing tables with the appropriate routing configuration for your network topology.

You may elect to use the full dynamic routing capabilities of `gated`(8), in which case you should place the routing configuration for the `gated` daemon in the `/etc/gated.conf` file (see Section 2.2.8.1, page 65), and start `gated` as part of the TCP/IP daemon process (see Section 2.2.9.9, page 121, for information about starting daemons).

If you do not need the dynamic routing capabilities of `gated`(8), you can define static routing information in the `/etc/gated.conf` file and use the `/etc/staticrts` script to initialize the kernel routing table with this information. Alternatively, you can place `route`(8) commands in your start-up script to add routes directly to the kernel routing table.

2.2.9.9 Setting up Daemons

The `/etc/config/daemons` file contains a list of processes, known as *daemons*, necessary for system operation. To build the file, use the `Configure systems` -> `System daemons configuration` -> `System daemons table` menu. In the sample `/etc/config/daemons` file, the columns are as follows:

Column	Description
`group`	Indicates the product to which the process belongs
`tag`	Indicates the name by which you want the process to be known
`start`	Indicates whether the process is to be started at system startup

`kill`	Contains the name of the file that contains the process ID of the currently executing daemon, or a hyphen (`-`) that indicates "do not kill," or an asterisk (`*`) that indicates "perform `ps	grep` *pathname* to find the process ID"
`pathname`	Indicates the command to be executed to start the daemon
`arguments`	Indicates the arguments to be used with the command in the `pathname` column

```
# /etc/config/daemons
#
# Configuration file for TCP daemons (and other commands) started by
# /etc/tcpstart.
#
# File format is:
#
# group tag        start      kill          pathname    arguments
#
TCP     gated       YES   /etc/gated.pid   /etc/gated   /usr/tmp/gated.log
TCP     named       YES   /etc/named.pid   /etc/named
TCP     inetd       YES   -                /etc/inetd   /etc/inetd.conf
TCP     talkd       NO    *                /etc/talkd
TCP     sendmail    YES   *                /usr/lib/sendmail  -bd -q30
```

`/etc/tcpstart` calls the utility script `/etc/sdaemon` to start the daemons. The `sdaemon` script consults the `/etc/config/daemons` file and starts the daemons that are listed there.

If you are not using the default `tcpstart` script, execute the daemons in your `tcpstart` script.

If you are using the default `tcpstart` script, check the `/etc/config/daemons` file to ensure that all appropriate daemons are listed. Comment out any daemons that should not be run at your site; add any daemons that your site needs.

The `/etc/inetd.conf` file contains a list of the daemons that `inetd`(8) can start. Check this file to ensure that all appropriate daemons are listed. Comment out any daemons that should not be run at your site.

The daemon processes that can be set up are listed in Section 2.2.8, page 64.

2.2.9.10 Calling the Final Local Script

The last process that /etc/tcpstart performs is to call the local script /etc/tcpstart.pst, if it exists and is executable. You should place in this script the following network-related processes:

- Processes that are specific to your local system
- Processes that must be performed after the networking software is started
- Processes that cannot be accomplished by any of the other mechanisms that are provided

2.2.10 Using the telnet Linemode Feature

The telnet linemode feature improves efficiency by moving line-oriented character processing from the Cray Research system to the front-end system. Usually, this process is transparent to the user. However, because of the distribution of character processing between the two systems, the user might see some minor problems in the following areas:

- Tab settings
- Special character processing
- Command completion and editing shells (ksh and tcsh)
- Simulated terminal input

2.2.10.1 Tab Settings

Users might notice some erratic screen activity when tabs are sent to their terminals. This activity is related to a difference in tab processing between the front-end system and the Cray Research system. Some screen-oriented applications, such as vi, appear to overwrite some characters randomly on the screen as the cursor moves through the text. Also, some commands might produce columns separated by tabs and one line (usually the first line of output) that is not aligned with the other lines. The vi editor can be affected in this way if line numbers are displayed.

You can address these problems by using the stty(1) command to check the default tab processing characteristics for the front-end system and Cray Research system tty drivers. The processing type should be set to either hard or soft tab settings; use hard tabs for best results.

The following example shows output from a common UNIX front-end system and a Cray Research system with the proper settings:

```
cunix> stty
new tty, speed 9600 baud; tabs crt pass8       <- "tabs" = hard tabs
pendin decctlq
start <undef>, stop <undef>, dsusp <undef>, lnext <undef>

Cray> stty
speed 9600 baud; -parity hupcl
eol <undef>;
-inpck icrnl onlcr      <- tab info appears here if not hard tabs
echo echoe echok
```

You can set hard tabs by using `stty tabs` command. If you cannot set both ends to use hard tabs, setting soft tabs (also known as *tab expansion*) on both ends is preferred. When using soft tabs, columnar output is sometimes imperfect. However, the worst formatting occurs when hard tabs are set on the Cray Research system and soft tabs are set on the front-end system; this situation should be avoided.

2.2.10.2 Special Character Processing

One aspect of supporting the `telnet linemode` feature involves special characters that are recognized by terminal drivers. When the front-end `telnet` program reads in a special character (such as an interrupt character), the front-end system must forward this character to the remote host for immediate processing. Unfortunately, many `telnet` implementations support an older `telnet linemode` feature, rather than the `telnet linemode` standard (RFC 1116). Although the older `telnet linemode` feature usually works well enough not to be noticeable to users, including the job control feature can cause the suspend character `CONTROL-Z` not to be forwarded to the Cray Research system.

You can solve this problem either by switching to character mode, or (the preferred solution) obtaining the latest copy of the `telnet` client.

You can set up character mode by giving a command to the `telnet` program to switch to character mode. Many `telnet` implementations accept the `mode character` command at their command prompt. (Check your front-end system's documentation for details.) Another method is to place the `stty -extproc` command in your login script (`.profile` for `/bin/sh` users and

.login for /bin/csh users) on the Cray Research system. However, using character mode is not the preferred solution because it defeats the efficiency gained by making the telnet linemode feature available.

2.2.10.3 Command Completion/editing Shells (ksh/tcsh)

Using the ksh or tcsh shell removes the effect of the telnet linemode feature. Typically, these shells turn off echo and line editing and perform their own echoing and editing of the command line. Users who execute by using these shells cannot realize full advantage of the performance benefits of the linemode telnet feature.

2.2.10.4 Simulated Terminal Input

BSD UNIX has an ioctl procedure to simulate terminal input. This procedure is used by the Berkeley mail feature when you use ~h to edit the mail header. It uses TIOCSTI to echo what you have typed so that you can edit it. Currently, the telnet linemode feature has no way of handling this facility.

2.2.11 Assisting Users in Setting up Environments

This section describes the following facilities for users:

- $HOME/.netrc file
- $HOME/.rhosts
- bftp facility

2.2.11.1 The $HOME/.netrc File

The $HOME/.netrc file is created by users and consists of the ftp(1B) and rexec(3) user authentication table. This file, located in a user's home directory, lists the host name, user name, and password for the user account on the remote host. When a user on the local host requests an ftp or rexec connection, the user's $HOME/.netrc file is searched and the user's login ID and password are automatically sent to the remote host. Consequently, the user is automatically logged in and is not prompted to provide either the login ID or the password.

Only official host names (not aliases) can be used in this file. If $HOME/.netrc does not exist, or exists but contains no entry for the host being accessed, the user is prompted for a login name and password.

Because this file contains password information, `ftp` and `rexec` require that it be accessible only to the owner; if it is not, an error message appears and `ftp` aborts. The *TCP/IP Network User's Guide*, publication SG–2009, contains additional information on `$HOME/.netrc` files.

The format of this file is as follows:

`machine` *hostname* `login` *userid* `password` *password*

hostname — Remote host's name as given in the `/etc/hosts` file. Aliases are not allowed.

userid — The user's login ID on the remote system.

password — The user's password on the remote system.

2.2.11.2 The `$HOME/.rhosts` File

The `$HOME/.rhosts` file, located in a user's home directory, is a private version of `/etc/hosts.equiv` and is used by the same servers as `/etc/hosts.equiv`. This file allows local accounts on the TCP/IP host to be used by specific remote users from specific remote hosts. This is especially helpful if users' login names on their remote hosts differ from their login names on the local host, or if you choose not to include all hosts in the `/etc/hosts.equiv` file. You do not maintain this file; however, you can supply a new user with a default `.rhosts` file.

If you place a remote user's login name in the second field of `/etc/hosts.equiv`, the user's `$HOME/.rhosts` file is not checked when the `-l` option of the `rlogin` command is specified; instead, the remote user is given automatic access to the account of the flagged user. See Section 2.2.5.3, page 37, for the details of setting up the `/etc/hosts.equiv` file.

The format of the `.rhosts` file is as follows:

official_host_name login_name `#optional comment`

The following provides an example of a `.rhosts` file for a user named Bonnie. Notice that Bonnie's login name on host `twg` is different from her login name on the other hosts.

```
# .rhosts file for Bonnie
#
cray1   bonnie
cray2   bonnie
twg     bon
```

If the file is writable by anyone other than the owner, the autologin information is ignored. For more information about the rules for setting up a `.rhosts` file, see the *TCP/IP Network User's Guide*, publication SG–2009.

Note: Additional restrictions are imposed when you are running with UNICOS security. See Section 2.6, page 218, or the *TCP/IP Network User's Guide*, publication SG–2009, for more information.

Caution: If the super user on the Cray Research system includes the remote host's name and the login name `root` in a `.rhosts` file that is created in the root directory of the local host, the root user from the remote host gains automatic authentication to the root account of the Cray Research system.

2.2.11.3 The `bftp` Facility

The `bftp` facility is an interactive user interface for batch network file transfers. The `bftp` program collects and queues information that is required for each file transfer, and a file transfer service (FTS) manages the file transfer for each request as the host becomes available on the network. After the user provides the appropriate information, the request is queued and the user is free to continue working without waiting for the completion of the file transfer.

The `bftp`(1B) command is most commonly invoked by a user already logged on to the Cray Research system, as follows:

```
prompt> bftp sncray
```

It is also possible to access `bftp` from a remote site by using the `-B` option of the `telnetd`(8) command. This is accomplished by running the `telnet` server `telnetd`(8), on an alternate port (one other than the normal `telnet` port `23`). Using `telnet` for remote access to that port number allows the user to log in and access the `bftp` command, rather than a shell.

For example, to support remote `bftp` access on port `50`, the `telnetd` entry in the `inetd.conf` file would be as follows:

```
50  stream  tcp  nowait  root  /etc/telnetd  telnetd -B 50
```

The `telnet` command to access `bftp` would be as follows:

```
prompt> telnet sncray 50
```

2.3 Network Tuning

Tuning is the process of adjusting the configuration of a system to optimize its efficiency. Tuning the UNICOS network software on your Cray Research system lets you achieve the maximum performance possible from your computer network and the Cray Research system.

The network software configuration that is included with the UNICOS system works effectively. It is designed to adapt, as much as possible, to the system's capabilities and to use those capabilities efficiently. However, the system configuration imposes limits. You must set the configuration properly to allow the software to make the best possible use of the hardware and to operate the network at its peak efficiency.

This section explains how to tune UNICOS network software parameters to achieve maximum performance. Although the default parameters included in the software might work well and require no tuning, by using this guide you can determine the changes, if any, you should make to optimize your system's network performance. To help you achieve performance gains, this section explains how the adjustable components of the system work and how you can affect their operation by making changes in the configuration information. These adjustable components include the following categories:

- Data transmission unit size
- Buffering and memory requirements
- Network routing

Each of the preceding has an enormous effect on network performance.

2.3.1 Data Transmission Units

Network software transfers data from one peer to another in data transmission units called *datagrams*. Each datagram consists of user data and a header that contains information used by the network software. IP carries datagrams between hosts on the network. TCP datagrams (known as *segments*) and UDP datagrams are carried in IP datagrams.

The network carries datagrams in *packets*, which consist of a header used by the hardware and the data to be carried in the packet. This data usually consists of higher-level datagrams, such as IP datagrams.

The maximum size of packet data that the network hardware can transmit at one time is known as the *maximum transmission unit*, or simply *mtu*. For TCP/IP, the packet size includes the segment size plus the 40 bytes of TCP and IP headers. For example, because the Ethernet can transmit 1500 bytes at a time, the Ethernet's mtu is 1500. The maximum TCP/IP segment an Ethernet can carry is 1460 bytes (1500 bytes minus 40 bytes for the TCP/IP headers).

You can control the actual size of the datagram, which lets you optimize network performance. Because the headers are of a fixed size for a given connection, there is a fixed amount of processing for each datagram, regardless of the amount of user data it contains. Network performance is generally improved by sending the largest possible datagram over a given network connection.

2.3.1.1 Interface Mtu—Model E and Model V Based Systems Only

Use the `hycf.` *name* configuration files and the `hyroute`(8) command to set the mtus of various directly connected hosts. An `hycf.` *name* file can be created for each network interface that is available to the Cray Research system. The `hycf` file controls the interface write mtu; the `ifconfig` command controls the interface read mtu. The `hycf` file is later used as input to the `hyroute` command, which is invoked by the `/etc/tcpstart` file at boot time. Each entry or host contains an mtu value. You can set the mtu value based on the mtu of the other hosts in the network. You can obtain this value by issuing a `netstat -i` command (or its equivalent) on the specific front-end system.

2.3.1.2 Using the Interface Mtu—GigaRing Based Systems Only

Use the `/etc/config/interfaces` *mtu* parameter to modify an interface's mtu and the `ifconfig`(8) command to set the mtus of various directly connected hosts. Use the route command to set the write mtu for a directly connected host, as follows:

```
route add -interface host -link hardware.address  admmtu mtu
```

The `ifconfig` command controls the interface mtu, and is invoked by the `/etc/tcpstart` file at boot time.

2.3.1.3 Datagram Size Limitations

The two characteristics of a network that limit datagram size are the mtu of the network medium and the size of the largest datagram that a host on the network can process. It is possible for a host to be connected to a network on which the mtu is too large for the host to process. Also, the IP protocol limits the size of an IP datagram. The largest allowable IP datagram is 65,535 bytes.

Because efficient use of the network relies on using the largest possible datagram size, both TCP and IP code contain algorithms to determine the datagram size to use for a given transfer.

2.3.1.4 IP Datagram Size Selection

IP protocol uses a very simple method to determine the size of IP datagrams to be transmitted; it attempts to send the largest datagram that the outgoing network interface can carry. If the datagram size is smaller than the interface mtu, the datagram can be transmitted in one piece. If the datagram size is larger than the mtu, IP protocol breaks the datagram into pieces known as *fragments* that are smaller than the mtu. When the destination host receives the fragments, they are reassembled into one IP datagram, and processing continues as though the original datagram were not fragmented. The protocol specifies that some datagrams must not be fragmented. When IP receives such a datagram, and the interface mtu is too small, IP discards the datagram and returns an error to the sender.

The mtu for each network interface should be set as large as possible when the interface is configured. Refer to Section 2.3.2.2, page 146.

2.3.1.5 Path Mtu Discovery

The UNICOS implementation of path mtu discovery conforms to RFC 1191. Path mtu discovery allows the network protocols to perform automatic mtu sizing. Path mtu discovery is activated by default; however, it can be disabled with the `netvar` command.

Path mtu discovery extends the IP mtu selection by using the IP `don't fragment` flag. Because of the nature of the mtu discovery mechanism, mtu discovery works only with TCP/IP; however, mtu information that is discovered by TCP/IP can be used by UDP and IP protocols. When sending data, TCP/IP uses the path mtu that is stored in the routing table for a particular destination as the segment size. The default size for the path mtu is the interface mtu that will be sent to the next hop gateway. The `don't fragment` bit is set in the IP header, and if an intervening gateway returns an error message, which indicates that the datagram must be fragmented, IP lowers the mtu for that destination until an mtu that is small enough for the gateway is found. Gateways that support path mtu discovery return the correct size for the mtu; for gateways without path mtu discovery, IP uses a table of common network mtu sizes.

By using path mtu discovery, a desirable mtu can be found for TCP/IP connections so that IP fragmentation can be avoided, regardless of the mtu of the network interface. Although path mtu discovery ensures that TCP/IP does not send segments that need to be fragmented, it does not ensure that the segment size is optimal for the connection. See Section 2.3.2.2, page 146, for an analysis of other considerations for the mtu configuration.

2.3.1.6 TCP Segment Size Selection

TCP datagrams are known as *segments*. TCP protocol attempts to select a segment size that is based on information about the interface, the route, and the host that is receiving the data.

If no useful information is available to determine an optimal segment size, TCP/IP uses a segment size that is guaranteed to be acceptable to the receiving host. The value of `TCP_MSS` is commonly used. This value is derived from the IP protocol that is specified in RFC 791, which specifies that every host that supports IP must be able to process an IP datagram of at least 576 bytes. This minimum size includes both the IP and the TCP headers; therefore, the actual minimum number of bytes of data is 536 (`TCP_MSS` = 576 - 20 - 20 = 536). Some systems decrease this number to a smaller value, such as 512, which leaves enough room for unconventional TCP and IP headers that might each be larger than 20 bytes.

The general algorithm used by the TCP kernel software to select its desired segment size is as follows:

1. Determine the route to be used. If no route can be determined, use `TCP_MSS`.

   The basis for selecting a segment size is the route. The route specifies which interface is used and which host on the network receives the packet. If no route can be determined, no useful information is available; consequently, a segment size of `TCP_MSS` is the only value that is guaranteed to be acceptable to the receiving host.

2. Determine the mtu of the route if a route can be determined.

   On a Cray Research system, the mtu is obtained by querying the driver for the mtu of the network that receives the transmitted packets. If path mtu discovery is enabled, TCP/IP offers the write interface mtu as the segment size. Then path mtu discovery is used to find the best mtu for the path if a smaller mtu is necessary due to fragmentation requirements at intervening gateways.

3. Compare the mtu specified for this route with the mtu of the directly connected network; when different, use the smaller value.

   (If an mtu is specified for the route, it is specified by the `route`(8) command.)

4. Determine if an mtu is specified for the route; if not, but the receiving host is on a directly connected network, use its mtu.

5. Otherwise, compare the mtu of the directly connected host acting as a gateway and `TCP_MSS`, and use the smaller of the two. The mtu of the directly connected host should not be smaller than `TCP_MSS`, but if it is, use the host's mtu.

   If the datagram must pass through a gateway, it is possible that the datagram will be sent to networks and hosts of unknown capabilities. Therefore, `TCP_MSS` is the only value you can use to guarantee that the segment size will be correct. Section 2.3.1.6.1, page 132 provides more information to determine whether a host is directly connected.

2.3.1.6.1 Subnetting and Direct Connections

Your Cray Research system might not be directly connected to the host, but it might still use the write interface mtu size for its segment size rather than `TCP_MSS`. Many networks are set up so that all of the local networks are subnets of one internetwork. A subnet uses part of the host portion of an Internet address as an extension of the network address.

Cray TCP/IP code is compiled so that two computers on different subnets of the same network are considered directly connected for the purpose of TCP segment size selection (more information on subnets can be found in RFC 950 and in Section 2.1.2.2, page 10). This means that if the two hosts have the same network number (allowing for subnetting), the TCP segment size selection algorithm uses the write interface mtu rather than the default size of `TCP_MSS`. If the two hosts have different network numbers, the connection uses the segment size `TCP_MSS`. You can continue to override the use of the `TCP_MSS` value by using the `route`(8) command to create a route with a specified mtu or by using dynamic mtu discovery.

Subnets that are to be treated as directly connected for the purpose of segment size selection are known as *local* subnets. However, under certain circumstances such as when various subnets are connected using network media of varying mtu sizes, you might want the segment size to default to `TCP_MSS`; that is, you might not want the subnets to be considered local. If a subnet is not local, the mtu of the directly connected interface is not considered to be the same as the subnet, and the segment size on the route defaults to `TCP_MSS`.

Use the `netvar`(8) command to change the `SUBNETSARELOCAL` kernel variable. You can change this variable temporarily at any time by using the `netvar` command, or you can permanently change this variable by changing your `netvar.conf` configuration file. See Section 2.2.9.2, page 112, for more information.

2.3.1.6.2 Segment Size Acceptance and the TCP MSS Option

When a TCP/IP connection is starting up, TCP/IP hosts (including Cray Research systems) send out the TCP maximum segment size (`MSS`) option (different from `TCP_MSS`), using the value derived from the TCP segment size selection algorithm. The `MSS` option indicates the largest segment that the host is willing to receive. It may reflect the limits of the interfaces and networks that the host is connected to, or it may reflect only the buffer space available in the host. `MSS` does not have to be the same for both directions of a TCP/IP connection.

The TCP/IP segment size exchange can negate the effects of path mtu discovery. If the peer TCP/IP determines that it should offer a segment size that is less than its own interface mtu, that is the segment size that the Cray Research system uses for the connection. To ignore the peer's suggested segment size violates the TCP/IP protocol.

Many systems do not implement path mtu discovery and suggest a small segment size (usually `TCP_MSS` = 512 or 536 bytes) when connecting with nonlocal networks. In this case, path mtu discovery has no effect. You can determine whether this is occurring by using `netstat` with the `-vv` option. The `Maxseg` column indicates the segment size of each TCP/IP connection; the `Peerseg` column indicates the size of the segment that the peer TCP/IP offers when the connection is established.

2.3.2 Buffering and Memory Requirements

Various parts of the network software operate by using memory to buffer data. The network software should have enough memory so that individual components can operate efficiently; however, it should have no more memory than necessary, because extra memory that the network does not use is also unavailable for other purposes. The UNICOS system is compiled with limits on the amount of memory that the networking software can use and limits on the size of buffers that can be used when transmitting and receiving user data.

If you are using the UNICOS ICMS, you can use the `Configure System -> Kernel configuration -> Network parameters` menu to change these values when you configure your system.

The TCP protocol ensures reliable transmission by storing user data before transmitting it, so that the data can be retransmitted, if necessary. TCP does not free stored data until the receiving host acknowledges receipt of the data. A TCP connection can be viewed as a pipe with a specific capacity. The capacity of the pipe varies, depending on the average time it takes for a host to acknowledge the receipt of data. If the pipe is not kept full, data is not being transferred at the highest possible transfer rate. If TCP software cannot buffer enough user data to keep the pipe filled, the network is not operating at peak efficiency.

Alternatively, if all active TCP connections are buffering a large amount of data, there might not be enough memory allocated to network usage. If this happens, some connections are forced to wait for memory to become available before transmitting data. If there is not enough memory for all the users of the network (using TCP, UDP, IP, and NFS applications), the network software cannot operate at peak efficiency. Therefore, buffering and total memory requirements must be set so that network software can operate at maximum efficiency.

Two types of memory parameters can be configured in the TCP/IP network software. (These configurations also affect the NFS kernel software because it shares the TCP/IP memory.) These parameters specify the total amount of memory available for use by the TCP/IP and NFS software, and the maximum amount of data that can be buffered at individual sockets.

2.3.2.1 Buffered Memory (Mbufs)

The TCP/IP and NFS network software uses memory from a special memory pool. The size of this pool is built into the kernel, and memory is allocated when the system is initialized (at boot time). The memory in this pool is grouped into pieces called *mbufs*. All data that is buffered by the network software and all dynamic data structures are stored in mbufs. The size of the mbuf pool is the limit placed on the total amount of system memory that can be used by TCP/IP and NFS.

2.3.2.1.1 the Mbuf Pool

When the Cray Research system boots, one part of the network initialization is to allocate memory for the mbuf pool. The quantity of memory that is allocated depends on a constant that is compiled into the kernel from the configuration file `/usr/src/uts/cf/config.h`. This constant, `TCP_NMBSPACE`, is the number of 1-Kbyte mbufs to be allocated for use by the TCP/IP and NFS network software.

If you are using the UNICOS ICMS, you can change this value by using the `Configure System -> Kernel configuration -> Network parameters` menu. This is the absolute maximum amount of memory that is available to the network software for data buffering and storage of dynamic data structures. If this number is set too low, network performance suffers. However, after this memory is allocated from the system, it is not available to user processes. Therefore, if you allocate excess memory to the network software, user processes (particularly large processes) are deprived of some memory. The following sections describe the criteria to use to allocate memory.

The network software uses mbufs for two purposes. The first is that user data is copied into mbufs pending transmission, and data that is read from the network is read into mbufs for storage until it is read by a user process. This use is related to socket buffering, which is discussed in Section 2.3.2.1.4, page 141. The second use is to keep track of dynamic data structures. Sockets, routing table entries, NFS user ID maps, and other structures are kept in mbufs.

2.3.2.1.2 Effects of Insufficient Mbuf Allocations

Insufficient mbuf allocations can affect network performance. If mbufs are not available when user programs are writing data to the network, the programs must wait until mbufs are available (unless they are using nonblocking I/O, in which case a write error occurs). If kernel-level software that is processing input data from the network requires mbufs and none are available, data is lost and requires retransmission. If user processes are trying to write data to the network and must wait for mbufs to be available, this wait can become the limiting factor in the performance of the network connection. If this is happening to several users, they will perceive the network (and possibly the Cray Research system itself) as being slow, or even down, when it actually is not.

When the network kernel software that processes incoming data from the network needs memory, it cannot wait for mbufs to become available. If the hardware drivers do not have memory available for network packets, those packets are lost. If the protocol-processing code needs more buffer space and cannot get it, the only alternative is to drop the data that is being processed. This loss of data has a negative impact on performance because data that is lost must be retransmitted. Also, there is a delay before the sender decides that the data is lost and requires retransmission.

Before refusing an mbuf request due to lack of available mbufs, the mbuf code in the kernel flushes the mbuf pool. During the flushing process, the mbuf code retrieves all possible mbufs from the areas that are set aside to hold specific sizes of mbufs (known as *private queues*), and it tries again to satisfy the request. Then, if not enough mbufs are available, the protocols are asked to drain any mbufs that are not absolutely necessary. For example, the IP protocol frees mbufs that contain fragmented IP datagrams that are not yet fully reassembled. This data needs to be retransmitted. This collection and compaction process (flushing and draining) takes time and can result in loss of some data. If there is still not enough memory to satisfy the request, the request is denied.

A shortage of mbuf space can have a very serious impact on the performance of the network software; the amount of space should be monitored to ensure that enough memory is available. If the system is flushing or draining the mbuf pool, performance is diminished. If requests are being denied, too little memory is allocated to mbufs. If flushes and drains are occurring, but no requests are being denied, there is enough memory for the network to operate, but not enough for the network to operate at maximum performance. Fortunately, you can easily determine the optimal number of mbufs to allocate; this procedure is described in the following section.

2.3.2.1.3 Mbuf Allocation and Monitoring

Using `netstat -m` is an easy method to determine the number of mbufs your system requires. You can also use the `netstat` command to determine all of the facts about how mbufs are being used on the Cray Research system. This command tells you how many mbufs are in use, and how many are being used for each method of mbuf allocation. It also gives valuable statistics on request denials and mbuf pool flushing. Following is an example of output from a `netstat -m` command:

```
% netstat -m
941/1800 mbufs in use (1152 max), allocated as 625 mbuf clusters:
      155 mbufs allocated to data (308 maximum)
      0 mbufs allocated to packet headers (80 maximum)
      101 mbufs allocated to socket structures (117 maximum)
      101 mbufs allocated to protocol control blocks (117 maximum)
      22 mbufs allocated to routing table entries (22 maximum)
      0 mbufs allocated to fragment reassembly queue headers (1 maximum)
      1 mbufs allocated to socket names and addresses (25 maximum)
      0 mbufs allocated to socket options (1 maximum)
      4 mbufs allocated to interface addresses (4 maximum)
      0 mbufs allocated to NFS notify-when-free data areas (1 maximum)
      180 mbufs allocated to NFS static data (180 maximum)
      368 mbufs allocated to NFS dynamic data (368 maximum)
      9 mbufs allocated to system buffer headers (29 maximum)
0 mbuf queue flushes
0 protocol mbuf queue drains
0 requests for memory denied
%
```

The first line of output from `netstat -m` has four pieces of information. The first two are the number of mbufs in use at that moment and the total number of mbufs available, expressed as `941/1800 mbufs in use` in the preceding example. The next bit of information, `1152 max`, indicates the largest number of mbufs that were ever in use at any one time. This is the maximum number of mbufs in use at some point in time since the system was last booted. Finally, this line tells you how many clusters are in use at the current time. A *cluster* is a group of mbufs being used as one large mbuf.

The indented lines from the `netstat -m` display tell how many mbufs are in use for each of a variety of purposes. You can also see the maximum allocations that have occurred for each of these purposes.

In the last three lines of the display, you can see how many times the mbuf pool was flushed, and how many times the protocols were asked to drain mbufs that were not absolutely necessary. You can also see how many times an mbuf request was denied due to lack of available mbufs. The number of flushes is always greater than or equal to the number of drains, and the number of drains is always greater than or equal to the number of denials. The relationship between flushes, drains, and denials can be stated as follows:

flushes >= drains >= denials

The value of flushes minus drains tells you how many times flushing was successful at getting mbufs to satisfy a request. The value of drains minus denials tells you how many times draining was successful at getting mbufs to satisfy a request.

Five of the statistics that `netstat -m` provides are very valuable for determining the number of mbufs your system requires. These are the number of mbufs available (the second number in `941/1800`) and the maximum mbuf usage (`1152 max`) from the first output line, and the number of flushes, drains, and denials. The usefulness of these statistics is directly proportional to the length of time since the system was last rebooted. The longer the time, the more useful the statistics.

These five numbers indicate the location of your system in the performance chart shown in Figure 8.

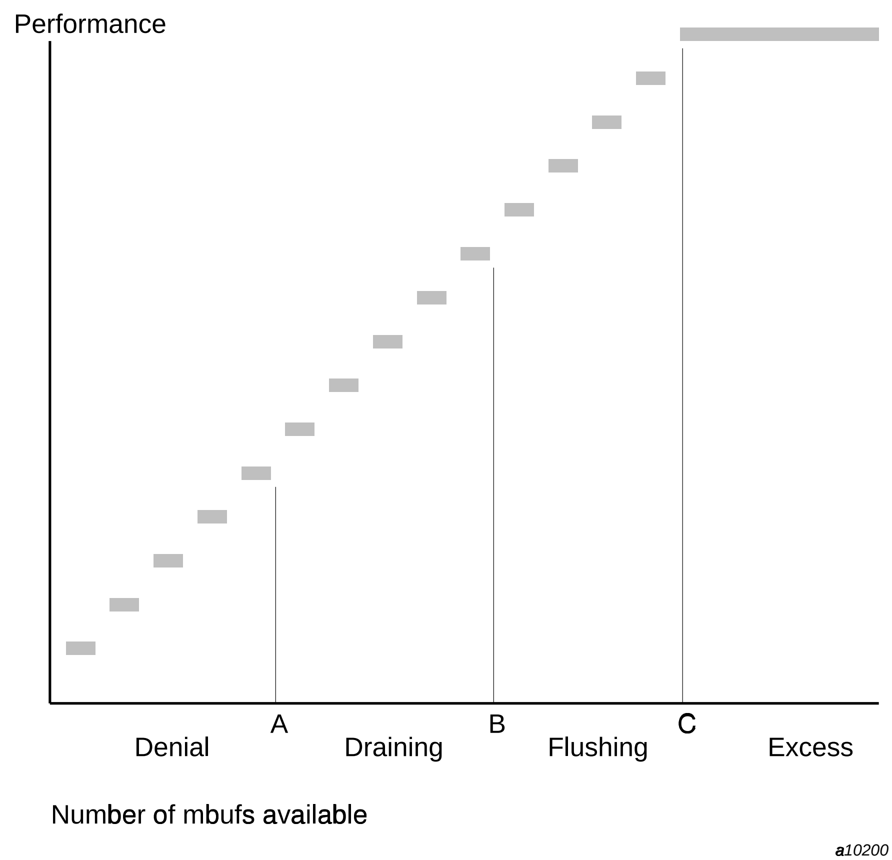


Figure 8. Performance chart

You will notice from the graph that adding mbufs improves network performance up to point C, where adding mbufs has no further effect. At this level, there are no flushes, drains, or denials, and maximum mbuf usage is equal to the number of mbufs available. The system has exactly as many mbufs as it needs. Point A on the chart is the point at which the system crosses the boundary from denying requests to simply flushing and draining to satisfy requests. Point B is the point at which draining ceases and only flushes are occurring.

You can determine the location of your system in this chart by looking at the five statistics. If any requests were denied, your system is on the bottom quarter of the chart. If draining occurred, but no requests were denied, your system is on the second quarter of the chart. If flushes occurred, but no draining occurred, your system is on the third quarter of the chart. If maximum mbuf usage was less than the number of mbufs available, your system is on the top quarter of the chart.

Gains from adding mbufs are more significant as you go down the scale. In the bottom half of the graph, data is being lost, and requires retransmission. (Whenever a drain occurs, data is lost.) A drain that is followed by a denial means that both data already received and incoming data are lost, which is a very significant performance loss. Flushing is much less significant, because the mbuf code simply clears its queues of presized mbufs; then no data and only a small amount of time are lost.

Using this graph and `netstat -m`, you can determine how mbuf allocation is affecting network performance, and you can identify the optimal mbuf allocation for your system.

The optimal level for your system depends on how your system is used. The only way to determine this is by trial and error; however, you can speed up this process by configuring more mbufs than you think you will need. Use `netstat -m`, and watch the machine's statistics. Over time you will develop an understanding of the mbuf usage. To calculate, take the highest mbuf usage and round it up to the nearest 100 mbufs (an extra buffer of safety). Then reconfigure your kernel to use this number of mbufs. You can do this by changing the value of the `TCP_NMBSPACE` parameter in the `/usr/src/uts/cf/config.h` file, or, if you are using the UNICOS ICMS, by setting the appropriate value on the `Configure System -> Kernel configuration -> Network parameters` menu. See Section 2.3.2.1.3, page 136, and Section 2.2.2.2, page 28, for more information on selecting initial mbuf pool size and changing this parameter.

If you have a system with small memory, you might want to consider making a trade-off between network performance and memory consumption. Performance decreases greatly when drains and denials are occurring, but a worthwhile trade-off can put your system into the flushing range of mbuf allocation.

If HIPPI or GigaRing is used as a network interface, you must allocate more than the usual 1800 mbufs for best data rates. A range of 3500 to 10,000 mbufs might be required, depending on how heavily the HIPPI or GigaRing interface is used.

For all interfaces, the number of mbufs used also depends on the values of rbuf and wbuf.

2.3.2.1.4 Sockets and Socket Buffers

Sockets are end points of communication between two hosts; that is, they are the points from which data is sent and at which data reaches its destination. *Socket buffers* (also known as *sockbufs*) are clusters or chains of mbufs that hold the data being transmitted and the data to be received; they are always defined in pairs. All of the buffering at a socket is done in these two associated data structures. There is a sockbuf for data being transmitted (the *send sockbuf*), and another for data being received at the socket (the *receive sockbuf*). When data is to be buffered in a sockbuf, an mbuf containing the data is added to a list of mbufs maintained in the sockbuf.

Each sockbuf has an associated buffer limit. Defaults for these limits are built into the kernel, but these limits can be changed. The `/usr/src/uts/include/sys/tcp_config.h` file specifies the default limits for TCP and UDP sockets. The `SOCKETSEND` and `SOCKETRECV` parameters specify the default sockbuf size limits for TCP. The `UDPSENDSPACE` and `UDPRECVSPACE` parameters specify the default sockbuf size limits for UDP. The `SOCKBUF_MAX` parameter specifies the maximum size limit that socket applications can specify through the `SO_SNDBUF` and `SO_RCVBUF` socket options. The `MAX_SOCKETS` parameter specifies the maximum number of open sockets.

At run time, you can set these values by adding `/etc/netvar` with the appropriate options and values to your `tcpstart` script. Selection of values for these parameters and information about how to change them are discussed in succeeding paragraphs.

The size limits on sockbufs can affect performance in more than one way. Not only do the limits restrict the amount of data that can be buffered on a socket, but the protocols also use this information.

Unlike UDP, which simply sends datagrams without considering the buffering capacity at the other end, the TCP protocol has built-in features to optimize its efficiency. Also, the Cray TCP protocol software has other optimizing features, not specified by the protocol, that further improve performance.

The TCP protocol informs the sending host about the amount of buffering that is available at the socket. One way the TCP protocol attempts to improve performance involves keeping track of the amount of data buffering space that is available at the receiving host. TCP does not send data to a host that the TCP protocol determines does not have available buffer space. This limitation improves efficiency by avoiding a waste of network bandwidth on data that must be discarded by the receiver (due to lack of space) and then resent.

The TCP protocol is a reliable protocol, and it ensures that data is transmitted and received. TCP accomplishes this by saving a copy of all data transmitted until it receives an acknowledgment from the other end of the connection that data is received. There is a limit on the amount of data that TCP/IP buffers while awaiting acknowledgment. This limit is the size of the send socket buffer.

Another way that the TCP protocol software attempts to efficiently use network bandwidth is to send only full segments of data (instead of fragments) when reasonable. A segment is the largest amount of data that can reasonably be sent and received in one datagram. This helps to reduce the number of packets sent on the network.

Because of the optimizations built into the TCP software, the strategy for achieving optimal performance is to set configuration parameters so that they equal or exceed the upper bounds of maximum performance. The TCP software efficiently uses the available resources, but it does not tie up network resources unnecessarily.

One factor to consider when determining the best size for the socket buffers is that the limits that are set are not the amount of memory that is allocated to the buffers, but the maximum amount of memory that can be used to store data on the socket buffers. When a socket is created, its socket buffer size is initialized, but no memory is allocated for that socket buffer. The buffer size simply limits the number of mbufs that can be chained into the socket buffer's mbuf list; therefore, a large socket buffer does not necessarily indicate that a large amount of memory is used for that buffer.

Choosing socket buffer size limits is not as straightforward as configuring your system for enough mbufs. This is because the sockbuf sizes are dependent on the buffering limits at the other end of the transmission. A reasonable choice is to set the default buffer sizes for TCP at 64 Kbytes, but this is not optimal. Although most processes that use TCP read the incoming data quickly, some may not. Also, if a TCP sender has a very large send buffer, but the receiver has a small receive buffer, TCP fills the send buffer but gains little (if any) performance increase, thus wasting memory. Because of these possibilities, arbitrarily large TCP buffers might waste memory resources unnecessarily. (This is also true for UDP sockets.)

There are other reasons for not always setting the default buffer sizes for TCP at 64 Kbytes. Because the buffer sizes are communicated between TCP peers, the peer knows the receive buffer size. Some TCP implementations do not calculate buffer sizes properly and do not work properly if the Cray buffer size is too large.

Choosing optimal buffer sizes is further complicated by the fact that the optimal buffer size is relative to the size of the received segments, the speed of the network, and the buffering available at the other end of the connection. For a connection between two Cray Research systems over a high-speed channel, the buffer sizes should always be 64 Kbytes or larger (for example 128 or 256 Kbytes), because large segments can be used, and the network is very fast. However, for a connection between a workstation and a Cray Research system, which goes through a front-end system, a smaller buffer size is acceptable.

Choosing optimal send and receive sockbuf size limits can be greatly simplified by considering the concept of double buffering. *Double buffering* is often used in I/O systems in which a process or hardware device is filling a buffer that another process or hardware device is reading. If there is only one buffer, one process must wait for the other to finish reading (or writing) before it can proceed. If there are two buffers, and the processes switch between them, one process can fill one buffer while the other process is reading the other buffer. Both processes can run at maximum speed at all times.

Consider the network shown in Figure 9. Suppose that the send and receive sockbuf limits at the workstation are 8 Kbytes. One direct effect of this is that the workstation never has more than 8 Kbytes of data in flight on the connection, where *in flight* means that the data is sent but not yet acknowledged. This is because the workstation can buffer only 8 Kbytes of transmitted but unacknowledged data. Also, suppose that the receiving process running on the Cray Research system is reading the data as fast as it comes in. This can be faster than the data is being sent, when considering the relative speed of the Cray Research system as compared to most workstations that communicate over an Ethernet.

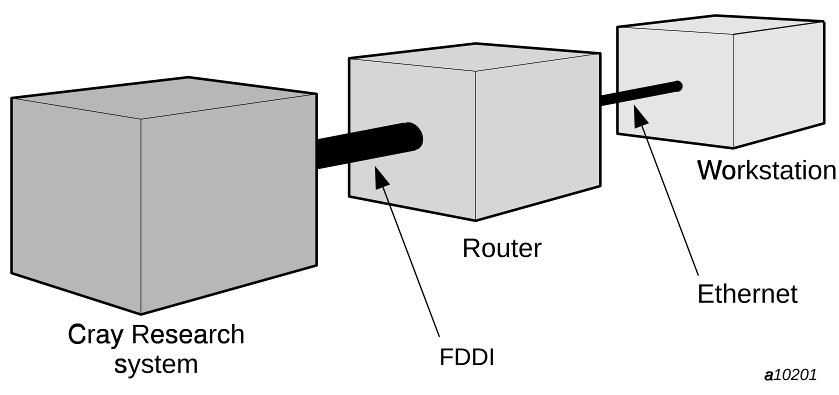


Figure 9. Double buffering network

When user data is read from the socket buffer, the data must be copied from the kernel receive buffer to the user's buffer. This takes time. If the kernel receive buffer is twice as large (double buffering) as the peer's send buffer, the peer can be filling one half of the receive buffer while the user is emptying the other half. In this situation, a receive buffer of 16 Kbytes is sufficient to achieve maximum performance over the connection.

Similarly, a 16-Kbyte limit on the send sockbuf on the Cray Research system is also sufficient to run the connection at maximum performance. Because the workstation can never buffer more than 8 Kbytes of data, TCP on the Cray Research system never tries to send more than 8 Kbytes of data without an acknowledgment from the workstation. The extra-large send buffer ensures that data is available to send when the protocol is ready to send data; because there is no waiting for data to be copied from user memory to kernel memory, a 16-Kbyte send sockbuf limit is enough.

Consider another example that uses the same network. This example relates to TCP segment size. The Cray Research system sends a TCP `MSS` option for the mtu on the FDDI connection, which defaults to 4352 bytes. With 40 bytes subtracted for the TCP and IP headers, the request size is 4312 bytes. The workstation sends out a TCP `MSS` option of 1460 bytes, based on the Ethernet mtu of 1500 bytes, minus 40 bytes for TCP and IP headers. Some workstations suggest a convenient size of 1 Kbyte (or 1024 bytes) for segments on Ethernet connections (the convenience factor involves memory allocations). Suppose the workstation requests the convenient size of 1024, and the Cray Research system honors this request and sends segments of the requested size. When the workstation receives the Cray Research system's `MSS` of 4104 bytes, it determines that the mtu on its outbound interface is lower, and it uses its own segment size.

It is necessary that the buffer limits be at least twice the segment size (double buffering) being used for this connection. This allows some operations involved in the transfer of data to overlap or run in parallel. If the buffer limits were the same as the segment size, the connection would become a synchronous mode of operation. In synchronous mode, the sender sends a full buffer (buffer limit = segment size) of data, waits for acknowledgment before refilling the send buffer with new data to send, and then sends it when the receiver informs the sender that the receive buffer is clear and there is space for more data.

If the sockbuf size limits are twice the segment size, the sender can buffer and send a second segment while the receiver is processing the first segment. When the sender is ready to send another segment, the sender might have received notice that the receiver has room to buffer the segment; if so, the sender can send it immediately. Then, the sender is never waiting for buffer space to become available at the receiver. This asynchronous mode of data transfer is more efficient than the synchronous mode of data transfer; therefore, with a segment size of 1024 bytes, the buffer limits must be at least 2048 bytes.

If the segment size is the same size as the capacity of the Ethernet (1500 bytes), which is probable for workstations that do not round down the segment size to a convenient size, the buffer limits should be at least 3 Kbytes. In practice, a buffer size of 3 or 4 times the segment size improves performance even more. Where possible, buffering limits should be 4 times the segment size. Therefore, for this example, the sockbuf limit should be 4 Kbytes. If the buffer size that is calculated relative to the segment size differs from the buffer size that is calculated from the peer's buffer size, use the larger of the two sizes, if possible.

Finally, consider the possibility that the network connection is slow between the communicating peers. This has the effect of delaying the acknowledgment of data that comes from the receiver and also the notification that buffer space is available (data having been read by the user process). This delay could mean that the sender sent a full buffer of data and is waiting for an update, even though the receiver of the data may have sent the update. Ideally, it should take the sender the same amount of time to send a full buffer of data as it takes for the notification of available buffer space to get back to the sender. Assuming that you cannot do anything to increase the speed of the network, the solution is to make the receiver's buffer large enough to ensure that the sender does not have to wait for notification of available space. Of course, the sender's send buffer must be increased to take advantage of this. If you cannot change the buffer sizes on your systems that are not Cray Research systems, you might not be able to resolve the problems of a slow network. Fortunately, most local area networks are fast enough, so that this is not a problem.

In considering these factors, you should set the default TCP sockbuf size limits to the size required for your highest-performance connection. This is because all network applications use the default size that is compiled into the network kernel software, rather than each application using an optimal size for that particular connection. If you set the size limits smaller, the high-performance network connections do not work at their optimal performance level. Users expect large increases in performance over high-performance connections.

If your Cray Research system is in a network in which it does not have high-bandwidth connections, you can use lower default sizes in the kernel without decreasing performance.

You can change the sockbuf size limits on a per socket basis with the `setsockopt()` function. The `SO_SNDBUF` and `SO_RCVBUF` options are used to set the send sockbuf size limit and the receive sockbuf size limit, respectively. An example code fragment follows:

```
/* set sockbufs to 64k */
int sockbufsize = 65536;
/* set send sockbuf size limit */
setsockopt(sock, SOL_SOCKET, SO_SNDBUF, &sockbufsize, sizeof(sockbufsize));
/* set receive sockbuf size limit */
setsockopt(sock, SOL_SOCKET, SO_RCVBUF, &sockbufsize, sizeof(sockbufsize));
```

You can set the send and receive sockbuf size limits to varying values, if you want. However, this changes the buffer sizes for only a specific socket; no other sockets are affected.

2.3.2.2 A Network Example

This example illustrates how the Cray Research system can be configured to ensure that the optimal segment size is chosen. Remember that the segment size drops to the smaller of the two segment sizes that are suggested by the peer or calculated by the Cray Research system. TCP/IP on the Cray Research system should be set up to ensure that the segment size it calculates is as large as or larger than that suggested by the peer. A sample network configuration is shown in Figure 10.

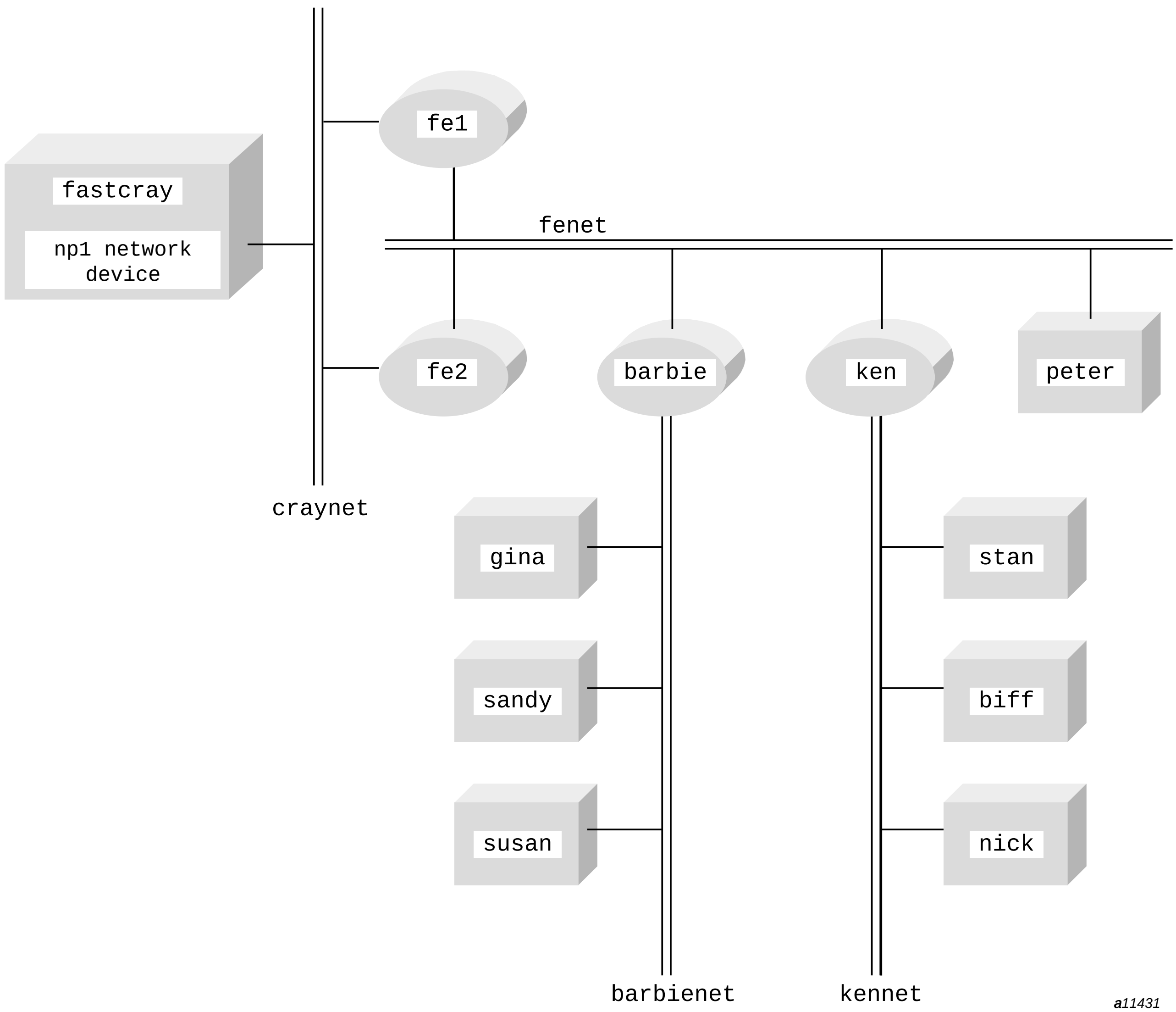


Figure 10. Sample network configuration

The system called `fastcray` is a Cray Research system, and `fe1` and `fe2` are front-end systems connected to it over HYPERchannel interfaces. `barbie` and `ken` are workstation servers, and `peter` is a stand-alone system. `fenet` is a 100-Mbit/s network medium with a 4478-byte mtu. `barbienet` uses the same medium and has the same characteristics as `fenet`, but `kennet` uses 10-Mbit/s medium with a 1500-byte mtu. These mtus are the size of the maximum datagram that can be transmitted, and network packet headers do not need to be considered.

Knowing the mtu of a network medium is not always enough. There are some situations in which an interface to a network cannot support the full mtu of the network. However, this is unusual and is not considered here. It is sufficient to note that if a network interface supports an mtu that is smaller than the mtu supported by the network medium, the interface mtu is the one that should be used.

2.3.2.2.1 Selecting the HYPERchannel Interface Mtus

The first step in configuring this network is selecting the mtu for the `fastcray` HYPERchannel interface. There are two mtus to consider: the mtu for outbound datagrams being transmitted on the interface, and the mtu for datagrams being read by the interface. The mtu for outbound datagrams is set to match the size of the datagrams that the peer interfaces can accept.

Calculating the inbound (read) mtu is important because driver read buffers are allocated in advance. The size of the buffers must be predetermined, and multiple buffers must be allocated in advance. If the buffers are larger than necessary, memory is wasted.

The default value for the read mtu on HYPERchannel interfaces is 16,432 bytes. This value can be changed on a per-interface basis with the `ifconfig`(8) command. The read mtu on an interface should be set to the size of the largest datagram that is expected through that interface.

Next, you must determine the interface mtus on `fe1` and `fe2`. Because the mtu on the HYPERchannel is not a fixed value, a reasonable value must be chosen; that is, the mtu must be set to a value that supports high transfer rates not only to `fe1` and `fe2`, but also to the other systems that use `fe1` and `fe2` as gateways to `fastcray`.

Because the HYPERchannel network does not suggest an mtu, you must consider other factors. For example, the mtu on other networks to which `fe1` and `fe2` are connected is important. You should also consider how the mtu affects the TCP segment size and the relationship of TCP segment size to socket buffering capacity. Obviously, the HYPERchannel mtus cannot be selected until the mtus of the other interfaces are established.

2.3.2.2.2 Selecting Mtus for the Other Networks

Consider the buffering and datagram-handling capacities of fe1 and fe2. You cannot send datagrams that are larger than the largest datagrams that fe1 and fe2 can process. Usually, the limit on datagram size is the same as the socket buffering limits. For more information, consult the documentation for your specific systems.

Suppose that the socket buffering and datagrams limits are 8 Kbytes for fe1 and 12 Kbytes for fe2. This places a hard limit on the size of the datagrams that can be transferred to these machines. The mtus must be selected so that the maximum size of datagrams sent to fe1 is 8192 bytes or less, and the maximum size of datagrams sent to fe2 is 12,288 bytes or less.

Next, consider the relationship of segment size to TCP socket buffering capacity. Section 2.3.2.1.4, page 141, explains why it is necessary for the socket buffer limits to be at least twice the segment size. Because of this, the mtu to fe1 and fe2 should be lowered to allow datagrams of only half the socket buffering capacity. This allows much higher performance on TCP connections between fastcray and the front-end systems. Therefore, selecting mtus for fe1 and fe2 of 4096 bytes and 6144 bytes, respectively, is reasonable.

2.3.2.2.3 Selecting Optimal Mtu Values

Using the values established in the previous section to determine the mtus for the front-end systems might not be sufficient for optimal performance. One consideration is that subnets can be used as local networks in the selection of TCP segment size.

In this example, if the SUBNETSARELOCAL kernel variable is not changed from its default value of true, and craynet, fenet, barbienet, and kennet are all subnets of the same network, the TCP segment size for hosts on those nets is selected as if the network mtu to those hosts were the same as the mtu to the gateway being used to communicate with the hosts. Therefore, if datagrams for barbie 's clients are routed through fe2, the TCP segment size is 6 Kbytes, and fe2 is forced to fragment the datagrams to send them out on fenet. Or, less desirable, if datagrams for ken 's clients are routed through fe2, fe2 fragments the datagrams to transmit them on fenet, and ken must fragment the fragments so that they can be transmitted on kennet. This is not optimal efficiency.

If subnets are not being used, or are being used but you use either the netvar(8) command or the sysctl(8) command to change the SUBNETSARELOCAL variable to false, the other networks need not be considered, because the mtu on the interface is not used for the TCP segment size for nonlocal connections.

Assume that this example network is configured so that all of the networks are local subnets. You can control the segment size used for the local subnets either by changing the mtu on the interface so that sufficiently small packets are transmitted, or by using the `-admmtu` option of the `route`(8) command to affect TCP segment size selection.

2.3.2.2.4 Changing the Interface Mtu

First, select an mtu that allows for the effects of local subnets. The mtu in `fenet` (and the maximum datagram size) is 4478 bytes. To avoid fragmentation, datagrams traveling through `fe1` or `fe2` should not exceed 4478 bytes. Assume that the mtu on the `fenet` interfaces for `barbie`, `ken`, and `peter` is also 4478 bytes; therefore, fragmentation is not a factor. The socket buffering and largest datagrams that `barbie`, `ken` and `peter` accept are 8 Kbytes, 8 Kbytes, and 6 Kbytes, respectively. These are large enough not to affect the mtus any further.

However, because you might want to set the mtu for `fe2` down to 4478 bytes (to avoid fragmentation), you should consider the effect on TCP performance of `barbie` 's, `ken` 's, and `peter` 's socket buffering. Decreasing the mtu to half the size of the smallest buffer implies that half of `peter` 's 6-Kbyte buffer is an appropriate size for the mtu. So, at this point, a 3-Kbyte mtu from `fastcray` to `fe1` and `fe2` appears correct.

Next, you should consider `barbie` 's and `ken` 's clients. Assume that `barbie` 's clients have the same characteristics as `barbie`, and, because they are connected to `barbie` through the same high-performance network medium as `fenet`, `barbie` 's clients have no further effect on mtu calculations. However, `ken` 's clients are connected to `ken` through a slower network with a smaller mtu. `kennet` 's mtu of 1500 bytes suggests that `fastcray` 's mtu to `fe1` and `fe2` should be dropped to 1500 bytes. Small datagram handling capabilities and socket buffering at `ken` 's clients might suggest an even smaller mtu.

Clearly, this is not an appropriate solution for selecting the mtu on the Cray Research system's network interface.

> **Note:** You cannot change the mtu size of the CRAY J90 system Ethernet or FDDI interfaces.

2.3.2.2.5 Using the `route` Command

By using the `route`(8) command to specify an mtu for a route, you can specify the TCP segment size for that route. Then you can override the interface mtu and avoid choosing the small value of `TCP_MSS`. When adding routes to `fenet`, `barbienet`, `kennet`, and `peter`, you can set the mtu on the route so that the TCP segment size is calculated to an appropriate value. For this example, use the following `route` commands:

```
/etc/route add fenet fe2 -admmtu 4478
/etc/route add peter fe1 -admmtu 3072
/etc/route add barbienet fe2 -admmtu 4478
/etc/route add kennet fe1 -admmtu 1500
```

For Model E based systems, the appropriate lines in the `/etc/hycf.np0` file are as follows:

```
direct fe1 4233 ff00 0 4478
direct fe2 4543 ff00 0 6144
```

This solution allows TCP segments of optimal size to travel to all hosts in the network.

2.3.2.2.6 Inbound Mtu

Because the other mtu values are established, determining the inbound mtu for `fastcray` 's HYPERchannel interface is very easy. Set this value to the largest outbound mtu for the interface. This is the largest packet that a directly connected host is sending to `fastcray`. Read buffers of this size are sufficient to hold the largest packets received. In this example, this value is 6144 bytes.

2.3.2.2.7 More Optimizing Considerations

Neither of the previously described solutions is completely optimal for all situations. Consider the advantages and disadvantages of each method, and you will see that both methods are useful.

The advantage of using the interface mtu to control datagram size is that this control applies to all protocols. Consequently, all TCP, UDP, NFS, and IP datagrams can be small enough to avoid fragmentation as they travel through the network. Fragmentation, especially at a busy gateway, can have a severe performance impact. The mtu set with the `route` command affects only the TCP segment size and has no effect on UDP, NFS, or IP datagrams.

The disadvantage of changing the interface mtu is that this approach lowers performance on all connections by limiting the datagram size to the optimal size required for the connection with the lowest performance.

The advantage of using the `route`(8) command to control TCP segment size is that you can tune performance to each host's and network's capabilities. TCP uses appropriate segment sizes for each of the routes in the routing table.

The disadvantage of using the `route`(8) command to control TCP segment size is that you affect only TCP segment size, as previously described. NFS transfers can be affected by significant fragmentation delays over lower performance connections.

The advantage of having these competing goals is that you can often use the route mtu (an option for only Cray Research systems) to optimize TCP transfers and also to use the large hardware mtu. This is because systems offering high performance transfers are typically connected to the high performance (and large mtu) networks.

2.3.2.2.8 Policy for Decisions

After you have considered several factors that affect decisions about mtu size on the Cray Research system's network interface, you can determine a policy that helps you make appropriate decisions.

First, for this example, consider how `fe1` and `fe2` are to be used. Consider whether they are actual systems that are going to be used for actual computing, or simply gateways to serve the remaining network. If they are gateways, all they must do is move datagrams quickly between `craynet` and `fenet`. If they do other work, consider the quality of network performance between them and `fastcray`.

Also, consider how `barbie`, `ken`, and `peter` are used. Their functions determine priorities in the quality of their connections. An NFS server that contains files that will migrate to and from the Cray Research system must have a high-quality connection with interface mtu sizes that are large enough to support large datagrams. A server for a group of clients can also benefit from high-bandwidth connections, but in this case, file transfer speed to the Cray Research system might not be as important. A machine that is used only to support dial-up lines and not to store much data probably will not require a high-performance connection at all; perhaps the only access it will require to the Cray Research system is `telnet`(1B) (to support logins to the Cray Research system).

In this hypothetical network, assume the following:

- fe1 is used primarily as a gateway.
- fe2 is a computer that supports many users, and therefore, it must not be overloaded with gateway work.
- barbie is a large fileserver, and it stores files that are used by many users from many locations.
- ken is a smaller server for its local clients.
- peter supports dial-up lines.

peter 's function as a telnet gateway to fastcray suggests that most transfers between peter and fastcray are small and they do not affect other decisions.

ken 's status is similar to peter 's; this machine supports telnet connections from clients and an occasional NFS transfer. Because there are no large transfers from ken 's clients (diskless clients), fragmentation is not an issue. Of course, when a user uses ftp(1B) to transfer a file, that user must log in to ken, either directly or through the proxy command, before transferring the file to fastcray. It only slows down performance if the file must be pulled from ken to the client (using NFS), and then over TCP to fastcray.

barbie 's status as a high-performance server suggests that it should have a high-performance connection for NFS transfers. This means that the datagrams that are transferred should be as large as possible.

Because fe1 is a gateway, the mtu to fe1 should be as large as fenet 's mtu; fe1 should not consider maximum datagram handling and socket buffering for datagrams that are larger than fenet 's mtu. All routes from fastcray to the remainder of the network should pass through fe1.

fe2 should support a high-performance connection to fastcray for TCP users.

For Model E based systems, use the following guidelines:

- The write mtu to fe1 in the hycf configuration file should be 4478 bytes; the write mtu to fe2 in the hycf configuration file should be 6144 bytes. The appropriate lines to put in the /etc/hycf.np0 file are as follows:

```
#direct MACH-NAME       TO                      MTU
direct  fe1             4233    ff00    0       4478
direct  fe2             4543    ff00    0       6144
direct  fastcray        c205    ff00    0
```

The inbound mtu for the `np0` interface is set to 6144 bytes (the largest outbound mtu) when the interface is initialized with the `ifconfig` command, as follows:

```
/etc/ifconfig np0 fastcray netmask 0xffffff00 mtu 6144
```

For GigaRing based systems, use the following guidelines:

- The write mtu to `fe1` in the `arp` route should be 4478 bytes; the write mtu to `fe2` in the `arp` configuration file should be 6144 bytes. The appropriate `route` commands are as follows:

  ```
  route add -interface fe1 -link hardware_address -admmtu 4478
  route add -interface fenet fe2 -link hardware_address -admmtu 6144
  ```

  The inbound mtu for the `ghippi0` interface is set to 6144 bytes (the largest outbound mtu) when the interface is initialized with the `ifconfig` command, as follows:

  ```
  /etc/ifconfig ghippi0 fastcray netmask 0xffffff00 mtu 6144
  ```

Appropriate routes to the world must be added. You should specify mtus for those routes on which TCP performance is improved by using a smaller segment size than the mtu allowed by the interface, as follows:

```
/etc/route add peter fe1 -admmtu 3072
/etc/route add fenet fe1
/etc/route add barbienet fe2
/etc/route add kennet fe1 -admmtu 1500
```

2.3.3 Network Routing

This section describes the `route`(8) command, but if you are using the UNICOS start-up procedures, you must use the `gated.conf` file, which offers the same functionality as the `route` command. See Section 2.2.9.8, page 119, for details concerning the use of the `gated.conf` file.

The `route`(8) command is useful for setting mtus and also gives you complete control of the routing table, allowing you to specify host, network, and default routes. The destination operand on the command line specifies whether you are adding a host, network, or default route. When a network address is given, a network route is added; otherwise, a host route is added. To determine this, the `route` command interprets a dot notation address (such as `174.200.84.132`), or it chooses between host or network based on which of `getnetbyname()` or `gethostbyname()` successfully resolves a symbolic name. `getnetbyname` is tried first; therefore, if you have a network and a host with the same name, you must use the `host` operand on the `route` command line to create a host route to that host. Similarly, the `net` operand indicates a network route. The `route` command also recognizes the destination name `default` as directing it to add a default route.

You can use your knowledge of how routing decisions are made (see Section 2.1.4.2, page 20) to affect these decisions. For example, a host-specific route always takes precedence over network and default routes. Also, after a route is found, no attempt is made to check for other possible routes. If a route that does not work appears in the table before a route that does work, the invalid route is used, and communication with that particular host or network is impossible.

You can configure the routing tables so that the routing algorithm chooses among multiple potential routes. However, not all network configurations are sufficiently complex to make this possible. Use the following techniques, when possible, to achieve specific goals:

- Force data destined for a particular host to take a different path from that of data going to other hosts on the same network.
- Use the path determined in item 1 to balance traffic between multiple gateways to one network.
- Restrict use of particular routes by groups (a feature only Cray Research supports).

Consider the network shown in Figure 11.

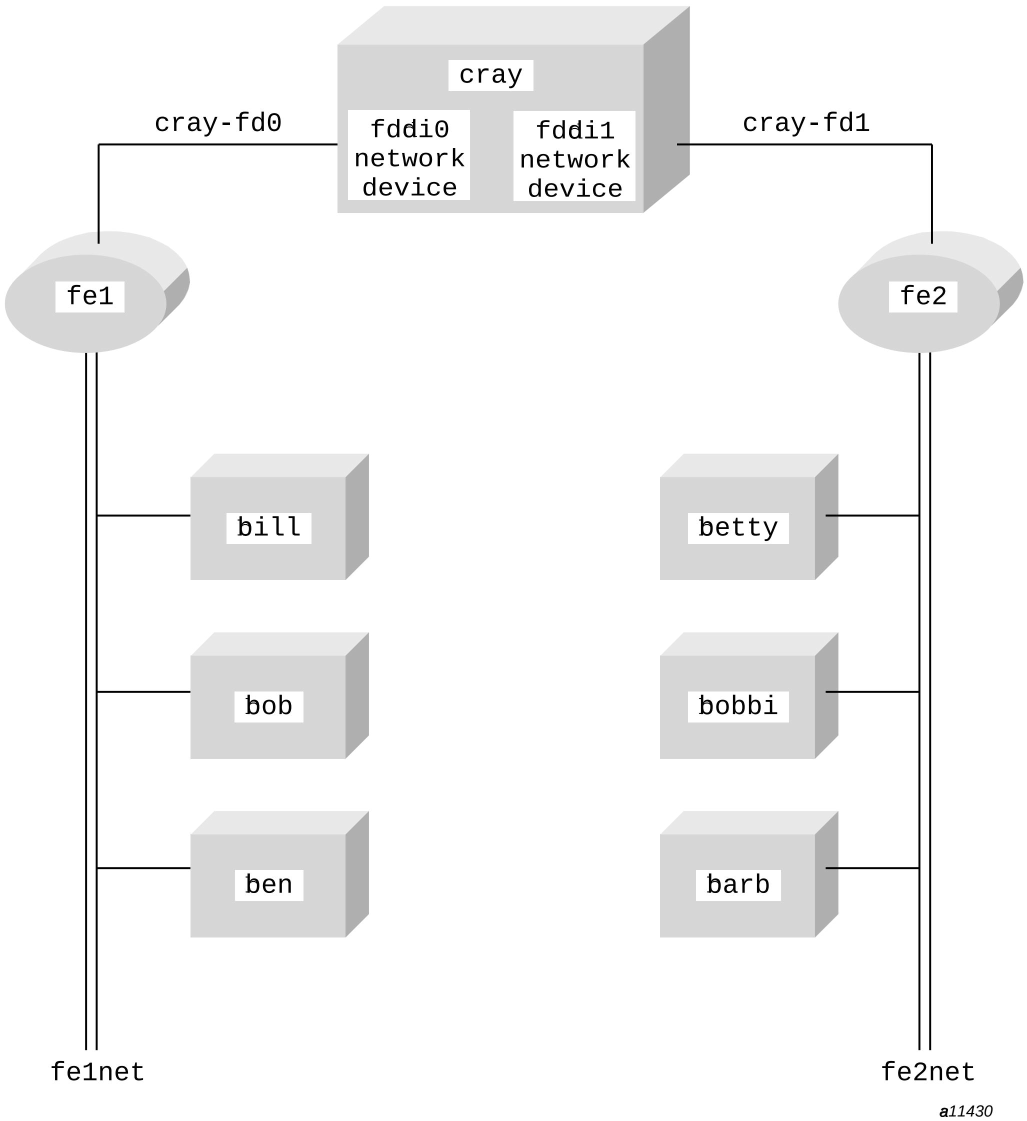


Figure 11. Network routing example configuration

Setting up this network is relatively simple. In your `/etc/tcpstart` script, you have `ifconfig`(8) commands to initialize network interfaces `np0` and `np1`. However, you must still add routes to the networks attached to each of the front-end systems. Therefore, the following route commands must be executed:

```
/etc/route add fe1net fe1
/etc/route add fe2net fe2
```

Of course, the routing tables on the front-end systems and the other hosts must be configured so that they can send datagrams to the Cray Research system.

2.3.3.1 Special Host Routing

You can use host-specific routes to cause data for a specific host to take a special route. Consider the example network shown in Figure 12.

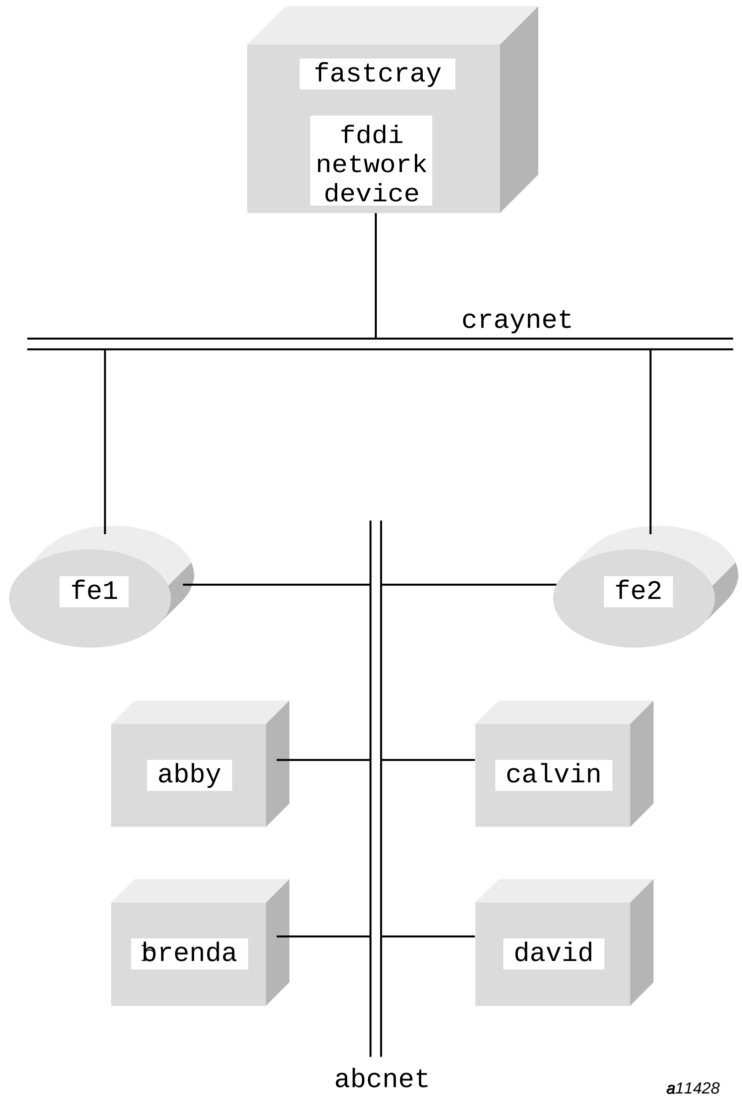


Figure 12. Special host routing example configuration

This network shows two front-end systems (fe1 and fe2) connected to the same network, abcnet. By using a combination of host and network routes, it is possible to make most network traffic route through front-end system fe1, but you must allow for traffic between `fastcray` and host `calvin` to route through front-end system `fe2`.

The following `route` command routes traffic from `fastcray` to `abcnet` through `fe1`:

```
/etc/route add abcnet fe1
```

The following `route` command routes traffic from `fastcray` to `calvin` through `fe2`:

```
/etc/route add calvin fe2
```

The second route specification overrides the first because it is a host route, and host routes are chosen before network routes. However, the route to `calvin` does not affect routing to the other hosts on `abcnet`.

Of course, `calvin` is probably sending datagrams back to `fastcray`. If its default route is to `fe1`, data it returns to `fastcray` is routed through `fe1`. You can override this with either a network route to `craynet` or a direct host route to `fastcray`, specifying `fe2` as the gateway to use. `calvin` 's `route` command can be one of the following:

- To add a host route:

  ```
  /etc/route add fastcray fe2
  ```

- To add a network route:

  ```
  /etc/route add craynet fe2
  ```

Adding the network route implies that all traffic from `calvin` to network `craynet` routes through `fe2`. Adding a host route directs traffic bound for `fastcray` through `fe2`. It is best to use a host route for this situation, because if a network route is used and network data is sent to `fe1`, it must still be sent through `fe2`, rather than directly to `fe1`.

Special host routing like this can be desirable for both testing and performance reasons. However, even though network traffic for `calvin` is moved from `fe1` to `fe2` (thus reducing the network load that `fe1` must carry), all network traffic for `abcnet` still goes through interface `np0` on the `fastcray` system.

2.3.3.2 Load Balancing

If you want to balance the load on the `craynet` network, consider having two interfaces on `craynet`. You can then route the traffic over separate networks, balancing the load between them. Consider the example network shown in Figure 13.

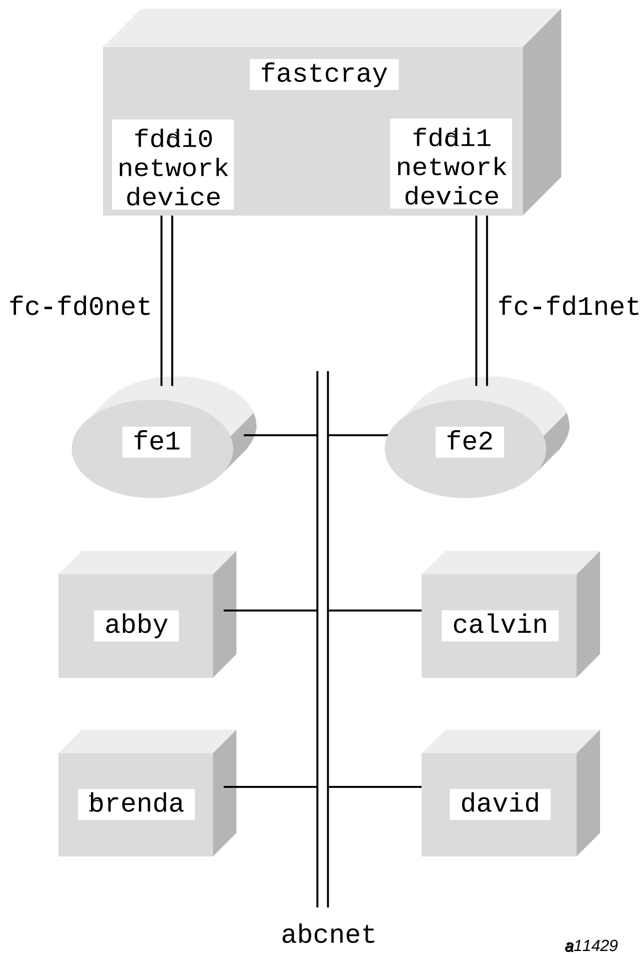


Figure 13. Load balancing example configuration

After using the `ifconfig`(8) command to initialize the interface, use the `route`(8) command to add the following routes:

```
/etc/route add abcnet fe1 (abcnet traffic through fe1)
/etc/route add calvin fe2 (calvin's traffic through fe2)
```

The `route` commands used to route traffic back from host `calvin` would be changed to one of the following to allow for the new network:

`/etc/route add np1int fe2` (*to add a host route*)
`/etc/route add fc-np1net fe2` (*to add a network route*)

It is best to use the host route.

Using this special host routing between gateways and networks can be an effective method of balancing network loads through front-end systems. You can also add special host routes for more than one host so that traffic for multiple special hosts is routed through specific gateways.

Of course, this balancing is limited by the bandwidth of the destination network. And even though the network load may be balanced between `fastcray` network interfaces and the front-end systems, the previous examples show all network traffic still traveling through `abcnet`, which may not have sufficient bandwidth to support it. In other examples, when the destination network has high bandwidth relative to the front-end systems, this form of load balancing can be very useful.

Having multiple interfaces on a Cray Research system, as shown in Figure 13, page 160, also reveals new routing problems. Front-end systems `fe1` and `fe2` have separate direct connections to `fastcray`. Therefore, all traffic from a front end to `fastcray` travels over the direct connection. However, this is not always true; datagrams travel over the connections on which they are routed.

Suppose that `fe1` is intended as the primary front end for the `fastcray` system, and the name `fastcray` is specified as the alias for `np0int`. This means that, when the name `fastcray` is resolved to an Internet address, the address of the `np0int` interface is returned. Routing decisions are then made based on this Internet address.

In this example, `fastcray` is the name with which most users are familiar. Therefore, a user on `calvin` might specify `fastcray` to access the `fastcray` system, and (because of the previous `route` commands) expect datagrams to travel from `calvin` to `fe2` and then to the `fastcray` system. However, because `fastcray` is an alias for `np0int`, datagrams route through `fe1` (if a route is set up to send default or `fc-np0net` traffic that way), or in the worst case, cannot connect.

Therefore, `calvin` must have routes to all of the `fastcray` system's interfaces through `fe2` to ensure that datagrams travel that path. You must add a route to `calvin` 's routing table for each of the `fastcray` system's network interfaces, as follows:

```
/etc/route add np0int fe2
/etc/route add np1int fe2
```

However, you must consider other issues. `fe2` might not know anything about the `fastcray` system's `np0` interface and either cannot route datagrams or sends them on to another gateway (`fe1`). Therefore, you must add a route to connect to `fe2`, as follows:

```
/etc/route add np0int np1int
```

This route sends `fastcray` traffic for `np0int` through the direct connection to `np1int`. It is apparent to the network software on the `fastcray` system that the incoming datagrams have reached their destination, and no more hops are necessary.

2.3.3.3 Controlling Routing by Group IDs

The `route`(8) command lets you specify particular groups that have permission (*inclusive* routing) or do not have permission (*exclusive* routing) to use a particular route; this is a special Cray Research feature.

Groups are defined by the entries in the `/etc/group` file; see `group`(5). When a group list is specified for a route, the routing algorithm is changed slightly. In this example, when a route is selected, the routing algorithm checks to determine whether the user accessing the route is permitted to use it. If not, the routing algorithm continues looking for a route to the desired destination. Thus, it is possible to prevent some groups (and the users in those groups) from using particular routes, and to allow some groups to have access to special routes. This feature can also be used to prevent groups from accessing some networks and hosts completely.

Consider again the network shown in Figure 13, page 160, and the two `route` commands that follow it. If the second `route` command is changed as follows, only users in group `specialgroup` have network traffic from `fastcray` to `calvin` routed through `fe2`.

```
/etc/route add calvin fe2 -gid +specialgroup
```

This does not affect traffic from `calvin` to `fastcray`. Traffic from other groups travels from `fastcray` to `calvin` through `fe1`.

2.3.3.4 Controlling Access

With UNICOS security, the `admin` option of the `ifconfig`(8) command marks an interface as restricted to privileged users only. Creating a socket with

PRIV_ADMIN effective on privilege-based systems, or with UID root on PRIV_SU systems enables a socket for communication on this interface. In a future release, an additional setsockopt system call will be required to enable communication on the socket. The admin option also prevents forwarding of IP packets to and from the interface.

2.3.3.5 Diagnosing and Fixing Routing Problems

When the TCP/IP network software is initialized, the routing tables are set up. Routes are created by the ifconfig(8), route(8), and gated(8) commands.

The ifconfig command creates a route only for the interface being configured and is not used to manipulate the routing table. The gated command can configure many routes from one configuration file and can dynamically change the routing tables. The route command is your primary tool for manually changing the routing tables. For more information on how to use these commands, see Section 2.2, page 23.

Diagnosing a routing problem requires checking the routing tables on all hosts involved to see how each host is routing datagrams between peers. Often, it is necessary for you to trace the route that is specified. You should be aware that routes are not symmetrical; that is, having a route between two hosts in one direction does not imply that there is a route back.

2.3.3.5.1 Using the netstat(8) Command to Inspect Routing Tables

You cannot tell from the routing table where a datagram will go after it has reached a gateway; therefore, you must inspect the routing table at the gateway to determine the next hop a datagram takes. You can inspect the routing table being used by the Cray Research system at any time by using the -r option of the netstat(1B) command. Options -n, -s, and -v can be used with -r to obtain more information about the routing table (see netstat(1B) for more information).

The netstat -r command prints out each routing table entry on one line. Host names are printed instead of Internet addresses, but you can request Internet dot addresses (such as 192.34.89.12) by using the netstat -rn command.

The netstat -r command lists the routes in the order that the routing algorithm searches them. If the routes are not in a satisfactory order, use the delete and add options of the route(8) command to rearrange them. When the system is initialized, you should add the routes in the order desired. The output from `netstat -r` also tells you exactly how datagrams are being routed out of a host. Consider the following example output from `netstat -r`:

```
% netstat -r
Routing tables
Destination       Gateway             Flags    Refs   Use        Interface

Route Tree for Internet protocols
default           router-001          UG      63     103861      fd0
localhost         localhost           UH       9       1036      lo0
libe-ows          libe-ows-030        UGH      0          3      np0
vogonnet          fagin-ip-dev        UG       0         81      np1
torc-hyp          libe                U       12      20525      np1
torc-fddi         libe-fddi           U        8       1043      fd0
libe-030net       libe-030            U        6       6838      fd0
224.0.0.9         localhost           UH       0         10      lo0
%
```

Following is some of the information that this output provides:

- Destination `224.0.0.9` is a multicast address used by `gated`. It is an address for RIP Version 2 routers, `RIP2-ROUTERS.MCAST.NET`.
- Datagrams for host `libe-ows` are sent on interface `np0` in packets addressed to gateway `libe-ows-030`, because the route is a host route (host routes have an `H` in the `Flags` column) for host `libe-ows`.
- Datagrams bound for hosts on `vogonnet` travel through interface `np1` to gateway `fagin-ip-dev`. The `G` in the `Flags` column is set, which marks this as an indirect route.
- Datagrams destined for hosts on network `torc-fddi` are sent in packets directly to their destination, because the gateway flag is not set.

When inspecting the routing table, specifically notice the up flag (the `U` in the `Flags` column), because a route that is not up cannot be selected for use.

The `netstat -r` command (or its equivalent) is available on several systems other than Cray Research systems. Use the command that is appropriate for a particular computer to use to inspect that computer's routing table.

2.3.3.5.2 Tracing a Route between Two Hosts

Diagnosing a problem often requires tracing a route. The sample network in Figure 14 shows the route that datagrams take between two hosts. In this section the route is traced to point out why some hosts in the network cannot access a Cray Research system. This section also explains that an inefficient route is set up, and shows how to change it.

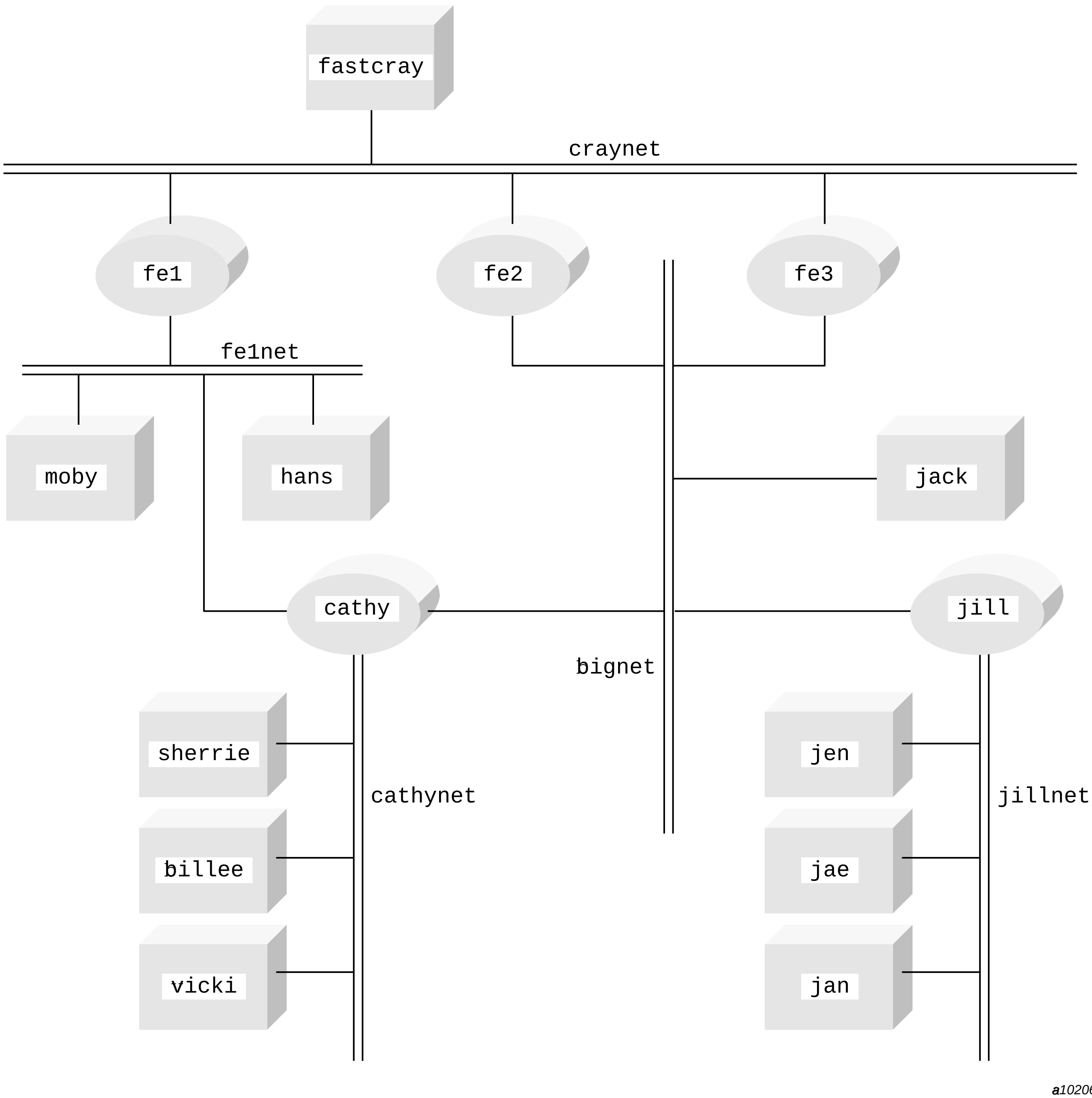
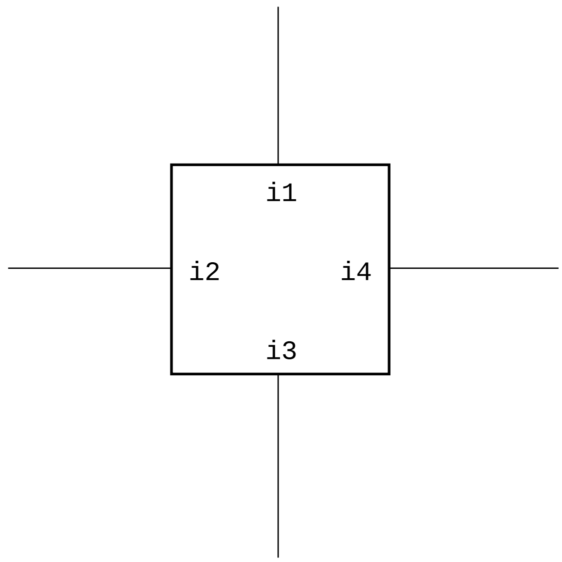


Figure 14. Route tracing example configuration

For simplicity, the following diagram does not show interface names. Assume the following conventions for interface names, relative to the position of the connection to a host's box:



Suppose that `jill` is a server, and `jen`, `jae`, and `jan` are workstation clients. A user at workstation `jae` wants to use `telnet`(1B) to access the Cray Research system `fastcray` and cannot get a connection (`telnet` prints a `Host unreachable` or `Network unreachable` error message). Because `jae` can `telnet` to `jack`, and `jack` can `telnet` to `fastcray`, all the network interfaces must be operating properly. Following the routes on each of the systems lets you determine why datagrams are not getting from `jae` to `fastcray`. First, check `jae` 's routing table.

```
# jae's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
jillnet         jae             U       i4
default         jill            UG      i4
```

From `jae` 's routing table you can see that datagrams for `fastcray` go to `jill`; therefore, you must now check `jill` 's routing table.

```
# jill's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
jillnet         jill            U       i3
bignet          jill            U       i2
default         cathy           UG      i2
```

From `jill`'s routing table, you can see why `jae` can communicate with `jack`. Because `jack` is on `bignet`, datagrams from `jae` to `jack` go through `jill` and then directly to `jack`. But there are no useful routes to `fastcray`; consequently, datagrams are sent to `cathy` over the default route. Therefore, you must go to `cathy` to see where the datagrams go from there.

```
# cathy's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
cathynet        cathy           U       i3
bignet          cathy           U       i4
fe1net          cathy           U       i2
jillnet         jill            UG      i4
craynet         fe1             UG      i2
```

`cathy` does not have a default route. Because `cathy` is connected to all networks in this internetwork, a default route is redundant. `cathy` is the default router for all the other computers in the network. `cathy` passes `jae`'s datagrams for `fastcray` on to `fe1`, because that is where `cathy` routes datagrams for hosts on `craynet`. Next, check `fe1`'s routing tables.

```
# fe1's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
fe1net          fe1             U       i3
craynet         fe1             U       i1
default         cathy           UG      i3
```

`fe1`'s routing table suggests that it forwards datagrams for `fastcray` directly to `fastcray`. Because you have traced datagram flow from `jae` to `fastcray`, you can be sure that datagrams can get from `jae` to `fastcray`. However, this does not ensure that datagrams can return to `jae` from `fastcray`. Therefore, the next step is to follow the path back, first by checking `fastcray`'s routing table.

```
# fastcray’s routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
craynet         fastcray        U       i3
fe1net          fe1             UG      i3
cathynet        fe1             UG      i3
bignet          fe3             UG      i3
default         fe2             UG      i3
```

As shown here, `fastcray` is connected to all networks except `jillnet`. Because `jae` is on `jillnet`, datagrams for `jae` are routed to `fe2`, the default route. Check `fe2` ’s routing table.

```
# fe2’s routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
craynet         fe2             U       i1
bignet          fe2             U       i3
fe1net          fe1             UG      i1
cathynet        cathy           UG      i3
```

This routing table shows part of the problem. `fe2` appears to be configured as a master router for `fastcray`, but it does not have a route to `jillnet` or a default route. Consequently, when `fastcray` sends a packet for `jae` to `fe2`, `fe2` does not know how to get the packet to `jae`, and discards it. You can fix this problem by adding a route to `fe2` ’s routing table; add either a default route to `cathy` or a network route to `jillnet`.

In this example, you can easily choose which route to add by considering that each hop a datagram takes lowers the overall performance over a network connection; that is, the fewer the hops, the better the performance. Therefore, the network route to `jillnet` should be added to `fe2` ’s routing table.

However, a problem still exists with the routing tables. Datagrams from `jae` to `fastcray` travel through `cathy` and `fe1`, rather than taking the more efficient route through `fe2` or `fe3`. Performance is improved by adding a network route to `craynet` through `fe2` to `jill` ’s routing table. `fe2` is chosen because datagrams from `fastcray` to `jillnet` are going the same route. However, using `fe3` as `jill` ’s gateway to `craynet` also works. After these changes, `jill` ’s and `fe2` ’s routing tables contain the following:

```
# jill's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
jillnet         jill            U       i3
bignet          jill            U       i2
craynet         fe2             UG      i2
default         cathy           UG      i2

# fe2's routing table:

Destination     Gateway         Flags   Interface
localhost       localhost       UH      loop
craynet         fe2             U       i1
bignet          fe2             U       i3
fe1net          fe1             UG      i1
cathynet        cathy           UG      i3
jillnet         jill            UG      i3
```

Now the routing tables are fixed so that `jill`'s workstation clients can communicate with the Cray Research system; an inefficiency in the routing tables is also fixed so that datagrams between `fastcray` and `jill`'s clients take the shortest path.

2.3.3.5.3 Using Traceroute to Trace Routes

The UNICOS system provides `traceroute`, a tool to help you trace routes without checking the routing tables on all systems involved. See `traceroute`(8) for syntax details.

The `traceroute` command is a useful for tracing the route datagrams take through a network; it is very useful for tracing routes over networks outside of your local administrative domain. However, `traceroute` relies on aspects of proper implementation of the IP protocol that do not exist in some environments; thus, it is not a complete substitute for tracing routes by examining the relevant tables.

If you were to use `traceroute` to trace the route from `fastcray` to `jae`, as shown in the sample network in Figure 14, page 166, before fixing the routes, you would see the following output:

```
# traceroute jae
traceroute to jae (132.162.155.14), 30 hops max, 56 byte packets
 1  fe2 (132.162.80.124)  11 ms  11 ms  11 ms (11.0/11.000)
 2  fe2 (132.162.80.124)  11 ms !N  11ms !N  11ms !N (11.0/11.000)
#
```

This output from `traceroute` shows that `fe2` cannot forward packets to `jae` (as indicated by the `!N` after the times for the probe packets). Quick inspection of `fe2` 's routing table shows immediately that `fe2` has neither a route to `jae` 's network (`jillnet`) nor a default route to try. After a route to `jillnet` is added to `fe2` 's routing table, the output of `traceroute` looks like the following:

```
# traceroute jae
traceroute to jae (132.162.155.14), 30 hops max, 56 byte packets
 1  fe2 (132.162.80.124)  11 ms  11 ms  11 ms (11.0/11.000)
 2  jill (132.162.90.17)  12 ms  13 ms  12 ms (12.0/12.334)
 3  jae  (132.162.91.8)  14 ms  14 ms  13 ms (14.0/13.667)
#
```

The `traceroute` command lets you trace routes from your Cray Research system to other computers, but if your other computers do not support `traceroute` or a similar facility, you cannot trace datagrams going to the Cray Research system. Then, manual inspection of routing tables is still necessary.

2.3.3.5.4 Using Snmproute to Trace Routes

The UNICOS system also provides `snmproute`, which is another tool to help you trace routes without checking the routing tables on all of the systems involved. This command uses the simple network management protocol (SNMP) to obtain the information (see RFC 1155). See `snmproute`(8) for syntax details.

The `snmproute` command is very useful for tracing the route that IP datagrams take between two nodes by using the Simple Network Management Protocol (SNMP). The `snmproute` command also provides other useful information about the interfaces.

The `snmproute` command performs a search of the routing table of the source node to determine the next IP node in the route. This process is repeated for each successive node in the route until the target node is found.

Thus, like `traceroute`, `snmproute` is not a complete alternative to examining routing tables. Unlike `traceroute`, however, `snmproute` can trace a route in both directions, providing a more complete view of the routing picture. `snmproute` also provides information about the network interfaces used to traverse the route.

For `snmproute` to determine a complete route to a target node, each node along the route must be running an SNMP agent listening at standard port 161. In addition, the SNMP agents must be configured to respond to the SNMP community name used by the snmproute command (the default community name is `public`). The `-c` option can be used to specify a different community name to be used by the `snmproute` command.

If intermediate hosts do not have an SNMP agent running, or if the community name is not known, `snmproute` provides routing information only up to the host which is not running the agent.

The following example assumes that SNMP agents are listening at port 161 and are configured to respond to community `public` for all of the nodes involved. If you were to use `snmproute` to trace the route from `hosta` to `hostb`, you would see the following output:

```
% snmproute hosta hostb
Tracing route from hosta(138.142.82.48) to hostb(138.142.82.27)

Out of 138.142.82.48 (hosta.cray.com) I/F 18 (fd0) MTU 4352
Into 138.142.82.27 (hostb.cray.com)
Reached 138.142.82.27 (hostb.cray.com)
```

Here is an example in which a gateway between the source and target nodes is not configured to respond to queries for community `public`:

```
% snmproute hosta hostc
Tracing route from hosta(138.142.82.48) to hostc(138.142.21.90)

Out of 138.142.82.48 (hosta) I/F 18 (fd0) MTU 4352
Into 138.142.84.100 (router1)
No SNMP Response from router1
```

2.3.3.6 Labeling Route Entries with IP Type-of-Service (TOS)

Routes that you create with the `route`(8) command can be labeled with an IP Type-of-Service (TOS) value that can be used during routing lookups. When a routing lookup is performed in the kernel, the TOS that is assigned to the socket is passed as part of the lookup key. The look-up procedure attempts to find a route that is labeled with the exact TOS that is requested. If none is available, the procedure accepts the best fit. Of course, if there is no route for the particular destination, the lookup fails. If the route entry is marked for exact TOS matching (using the `-tosmatch` option on the `route`(8) command), every TOS bit that is set in the route must be set in the request.

TOS labels on routes can be used in a variety of ways. If your network has routers or bridges that can direct packets that are based on the TOS field in the IP header, you can use TOS labeling. You can also use TOS labeling to route packets to different gateways. For example, the `ftp` command can use TOS for its network connections. The command connection selects a low-delay bit in the IP TOS field by using the `delay` argument of the `-S` option; `ftp` data connections select the high-throughput bit in the IP TOS field by using the `throughput` argument of the `-S` option. Suppose you entered the following `route` commands:

```
route add bobo slowpoke
route add bobo quicky -S delay
route add bobo speedy -S throughput
```

The `ftp` command traffic to `bobo` goes to gateway `quicky` (`ftp` command connections use low-delay TOS), and `ftp` data traffic goes to gateway `speedy` (high-throughput TOS). The way in which the packets are routed beyond the first hop gateway depends on the remainder of the network and how it is configured. With this configuration, none of the FTP traffic is sent to `slowpoke`; however, other applications that do not use TOS use `slowpoke`.

You must also configure multiple route entries if you are using the `-tosmatch` option on the `route` command. For example, suppose your `route` entry has a TOS label, as follows:

```
route add soho mist -S delay
```

The only route to `soho` is through `mist`. All traffic for `soho` is sent to `mist`. However, suppose the `-tosmatch` option were specified on the `route` command line, as follows:

```
route add soho mist -S delay -tosmatch
```

Only sockets that have specifically requested low-delay TOS can send packets to soho. Other traffic needs another route entry to get to soho. The -tosmatch flag also means that sockets that specify high throughput cannot use a route that specifies low delay. However, a socket that specifies high throughput and low delay can use an exact match route entry for either high throughput or low delay (assuming that no route entry with both high throughput and low delay is available). Therefore, when adding a route entry with the -tosmatch option, it is advisable to add another route without a TOS entry, as follows:

```
route add soho mist -S delay -tosmatch
route add soho lake
```

If you are diagnosing a routing problem on a system in which TOS is being used, use the -rv option when running netstat so that you can see the TOS labels on routes. Using the netstat command with only the -r option does not display the TOS labels. You could be misled into thinking that a route is available when it is not because exact TOS matching is preventing some applications from using that route. Look in the flags column for the T flag when diagnosing this problem.

2.3.3.7 Preventing the Cray Research System from Becoming a Gateway

By forwarding packets, any host on the network can act as a gateway. Even when a host has only one network interface, routes can be configured so that the host receives datagrams to forward to another gateway. However, forwarding datagrams uses processing power; therefore, this is not an appropriate function for a Cray Research system. Other computers in the network should perform this function.

There are three ways to prevent your Cray Research system from becoming a gateway:

1. Ensure that none of the other computers in the network have gateway routes to the Cray Research system.
2. Mark some or all of the routes in the Cray Research system's routing table as being not forwarding. This is a feature specific to Cray Research systems. You can mark a route as being not forwarding by using the noforward option of the route(8) command when you add the route. Using the -rv option with the netstat(1B) command displays the NOFORWARD flag on a route if that route is marked not forwarding. If you choose this method, routes that are added by other commands (such as ifconfig(8)) must be deleted and then added again by using the route command.

3. Use the `netvar`(8) or the `sysctl`(8) command to turn off forwarding for all routes. These commands let you toggle the flag that activates forwarding (the `ipforwarding` flag) within the kernel. The `ipforwarding` flag is on by default, so that IP datagrams can be forwarded through the Cray Research system. The command to turn off forwarding is as follows:

   ```
   netvar -f off
   ```

   You can also use `netvar` in interactive mode to turn off IP datagram forwarding.

   Note: When you are running the Cray ML-Safe configuration of the UNICOS system, the `ipforwarding` flag must be turned off. This is to prevent transmission of packets in violation of the MAC policy, which could happen because forwarding would be done at a layer below label processing.

   You must be a super user to use `netvar` to change kernel variables. If you want to configure your Cray Research system so that forwarding is always turned off, you can use the `Configure System -> Network configuration -> TCP/IP configuration -> Kernel parameters` menu to change the `netvar.conf` file so that `netvar -f off` is executed at system startup.

When all routes on the Cray Research system are marked as being not forwarding, or forwarding is turned off with the `netvar` command, the Cray Research system cannot forward datagrams (a route that is marked as not forwarding is not selected for datagrams that need to be forwarded). If forwarding is attempted, an error is returned to the sender of the datagram, and the user sees this as a `Network unreachable` error. You must then trace the route the datagrams are taking, and fix the routing tables on the computers involved so that they are not trying to use the Cray Research system as a gateway.

2.4 Troubleshooting

Networking problems can be difficult to diagnose because of the number of individual elements that are involved in maintaining an entire network. Communication between the Cray Research system and an end user can be affected by problems in TCP/IP on the Cray Research system, hardware problems, bugs in the remote system's software, and bugs in other systems on the network. This section provides information to assist you in resolving these problems. It describes commands and tools, and it includes specific information about some of the daemons and network services.

This information assists you with your debugging problems, but it also is intended to help you test network changes before they are put into production. This information does not replace the information found in the appropriate man pages, but it only highlights what is available. Refer to the man page documentation for complete descriptions of the commands described in this section.

The following topics are covered:

- Troubleshooting tools
- Basic problem-solving strategy
- Network problems and solutions

Note: RFC 1147 provides detailed information about monitoring and debugging TCP/IP networks.

2.4.1 Troubleshooting Tools

This section contains a description of the tools that are available to you for resolving network problems. The following categories of tools are discussed:

- Hardware diagnostics
- Network monitoring
- Network testing and diagnosing
- Network services

2.4.1.1 Hardware Diagnostics

Diagnostic tools should be used when you suspect that a network problem is caused by the actual networking hardware or UNICOS device drivers (including the IOS for Model E based systems, and MPN and HPN for GigaRing based systems). If a problem exists in any of these components, TCP/IP cannot communicate on the network. (But, TCP/IP's failure to communicate on the network does not always indicate a hardware problem.) These tests can be used to determine whether a problem is in TCP/IP, or in the hardware and its associated device drivers.

The commands that are listed in this section test and verify that the UNICOS driver (including the IOS driver for Model E based systems, and MPN and HPN for GigaRing based systems) and networking hardware are functioning properly. These diagnostic tools are a subset of all the tools available, and do not include the tools that are available with OLNET products. For a full description of all available diagnostic tools and the information they can provide, consult the appropriate hardware manual and software command documentation.

2.4.1.1.1 The `hit`(8) Command

The `hit`(8) command tests a Cray Research low-speed channel cabled in loopback mode, or an NSC A-series adapter and HYPERchannel connection.

> **Note:** In the Cray ML-Safe configuration of the UNICOS system, special steps must be taken to run the `hit`(8) command (see *General UNICOS System Administration*, publication SG–2301, for more details on non-TCB software and UNICOS security).

2.4.1.1.2 The `nx`(8) Command

This command tests an NSC adapter (either A-series or N-series) and a HYPERchannel connection. The diagnostic can test communication over the HYPERchannel to the remote adapter.

2.4.1.1.3 The `scytest` Command

The `scytest` command tests a Cray Research low-speed channel cabled in loopback mode, the FEI-3 interface cabled in loopback mode from the front end, VME-based system, or the FEI-3 interface between the Cray Research system and the front-end system. This diagnostic also verifies the front-end driver when testing the FEI-3 interface cabled in loopback mode, or when testing the interface between the Cray Research system and the front-end system. `scytest` is available through the supplier of the FEI-3 driver for your front-end, VME-based system.

For the fy driver, use the diagnostics that Cray Research supplies instead of this test.

> **Note:** CRAY J90 systems do not support the `scytest` command.

2.4.1.1.4 The `vht`(8) Command

The `vht`(8) command tests a HIPPI channel that is either in loopback mode or connected to another host.

> **Note:** In ML—Safe UNICOS systems, special steps must be taken to run the `vht`(8) command (see *General UNICOS System Administration*, publication SG–2301, for more details on non-TCP software and UNICOS security).

2.4.1.2 Network Monitoring

You can use the commands listed in this section to determine the activities that are occurring over the network and in TCP/IP on the Cray Research system.

2.4.1.2.1 The `hyroute`(8) Command

The `hyroute`(8) command creates, displays, and verifies the information that TCP/IP is using to resolve hardware addresses. This display also includes the mtu value that TCP/IP is using for directly connected hosts.

2.4.1.2.2 The `arp`(8) Command

The `arp`(8) command creates, displays, and verifies the information that TCP/IP is using to resolve hardware addresses.

2.4.1.2.3 The `netstat`(1B) Command

The `netstat`(1B) command displays the contents of various network-related data structures. This information is valuable when determining the current status of the TCP/IP components of a given host. The following options are a subset of those available by using the `netstat`(1B) command. For a full description of the options, see the man page.

Option	Description
`-i`	Displays all of the available interfaces on a given host, and some specific information about them.
`-iv`	Displays the status of the queues for each interface, the number of packets discarded, and the flags.
`-is`	Displays statistics about the interfaces.
`-m`	Displays statistics associated with TCP/IP mbuf usage.
`-r`	Displays the routing information TCP/IP is using, in the order that the routes are being searched. See Section 2.3.3, page 154, for details about network routing.
`-A`	Displays information about all active connections.
`-a`	Displays information about all open sockets. This includes information about all available services on the host (the last column of the display indicates whether the socket is in the `LISTEN` state).

-s Displays statistics associated with TCP/IP and packets received and sent.

Adding -n to any of these netstat options prevents netstat from translating numbers (that is, port numbers or Internet addresses) to their associated names.

2.4.1.2.4 The nslookup(1B) Command

The nslookup(1B) command provides an interface to the name server; nslookup displays the actual host name and Internet address that is associated with a specified name or address. This information is used by the network components that require the official host name or Internet address that is mapped to any given alias or address. This command interfaces only with the Berkeley Internet name domain (BIND) server. It is particularly useful if you are configuring and installing named(8) on a Cray Research system. By using nslookup, you can verify whether named is configured properly.

2.4.1.2.5 The ping(8) Command

The ping(8) command transfers a packet to a remote host and requests an echo. It is useful for verifying the connection between any two systems.

2.4.1.2.6 The snmproute(8) Command

The snmproute(8) command traces the route IP takes from the local system to the given remote host, and also the route back. snmproute can perform tracing on all hosts that are running SNMP (simple setwork management protocol) on the route between the local system and the remote host.

2.4.1.2.7 The traceroute(8) Command

This command traces the route IP uses when sending a packet from the local system to the given remote host. (It does not trace the route from the remote host to the local system.) traceroute continues until the remote host is reached. This command depends on aspects of IP that do not exist in every environment; therefore, it does not display hops through a system whose IP does not support this feature; instead, those hops are displayed as * (asterisks).

2.4.1.3 Network Testing and Diagnosing

The commands that are listed in this section provide information that is useful for testing and diagnosing TCP/IP problems.

2.4.1.3.1 The nettest(8) and nettestd(8) Commands

The nettest(8) and nettestd(8) commands perform client and server performance tests for the various types of network connections that the TCP/IP kernel code supports. This includes UNIX domain, TCP, and UDP socket connections.

The nettest command performs the client side of the test; the nettestd command performs the server side of the test.

Note: With the Cray ML-Safe configuration of the UNICOS system, special steps must be taken to run the nettest(8) and nettestd(8) commands (see *General UNICOS System Administration*, publication SG–2301, for more details on non-TCP software and UNICOS security).

2.4.1.3.2 The trcollect(8) and trformat (8) Commands

The trcollect(8) and trformat(8) commands collect and format, respectively, packets received and sent by TCP/IP on the Cray Research system. They accept options that determine which packets are traced. These commands provide information about network activities at the lowest possible level. See Section 2.5, page 214, for details.

2.4.1.4 Network Services

This section presents information about the following network services, which are available on the Cray Research system:

- inetd(8)
- telnet(1B)
- ftp(1B)
- sendmail(8)
- gated(8)

This information is useful when you are testing, debugging, planning to make changes to your system, or configuring a new service. These services are the ones most commonly used on Cray Research systems. For more information on these services, and other available services, see Section 2.2, page 23.

2.4.1.4.1 The inetd Daemon

The inetd(8) daemon listens for incoming requests on the configured ports and then starts up the appropriate program to process the request. As an administrator, you must add entries to the /etc/inetd.conf file to specify port numbers, commands to be executed, and so on. See Section 2.2.8.7, page 102, for a complete explanation of the file fields. If you do not have an /etc/telnetd entry in the file, and a user tries to use telnet(1B) to access the Cray Research system, inetd refuses the connection and issues a Connection refused message.

You can use the /etc/inetd.conf file to execute test versions of the various services before putting them into production. For example, adding the following line to the file lets you run another telnet daemon at port number 3200:

```
3200  stream  tcp  nowait  root  /usr/src/tcp/usr/etc/telnetd  telnetd
```

Putting this line in the /etc/inetd.conf file lets you test out the latest telnet daemon before installing it into /etc/telnetd. That is, after upgrading to a new level of the UNICOS system, you could try using telnet to access the Cray Research system from the various front-end systems at your site, and verify that the new telnet daemon does not introduce any new problems. To use this telnet daemon, execute the following command on your front-end system:

```
telnet cray 3200
```

You can set up a test version of a service for any of the programs that are started by inetd. You can also use inetd to start your own special network services. inetd rereads its configuration file if you send it a SIGHUP signal (that is, if you execute kill -HUP *process_id*; *process_id* is the process ID of the running inetd).

2.4.1.4.2 The telnet(1B) Command

The telnet(1B) command provides user access to the Cray Research system. A wide variety of telnet implementations are used to gain access to the Cray Research system, and Cray Research tries to accommodate as many variations as possible. As a result, the telnet daemon that is supported under the UNICOS system is sensitive to changes; that is, attempting to correct one problem can introduce other problems. This section assists you in resolving this type of problem.

When telnet is executed, the telnet client and telnet daemon negotiate the handling of both the data and the terminal. The user can monitor and manipulate this negotiating environment by using various `telnet` subcommands. The following subcommands are particularly useful for monitoring:

Subcommand	Description
`status`	Lets you obtain a printout of the current status of the `telnet` session, including whether `telnet` is in line-by-line or character-at-a-time mode.
`toggle` *options*	Lets you obtain, from the `telnet` client, a printout of all option negotiation that occurs between the `telnet` client and the remote daemon.
`toggle netdata`	Lets you obtain a printout, from the `telnet` client, of the hexadecimal representation of all data that is both sent to and received from the remote daemon.

All of the subcommands in the preceding list must be executed at the `telnet` prompt. To get this prompt, either execute `telnet` (rather than `telnet` *host_name*), or at any time during the logon session, enter the `telnet` escape sequence that is displayed during the connection sequence (usually ^]).

> **Note:** The subcommands described in this section apply to the version of `telnet` that is running on Cray Research systems. For a list of the correct subcommands for the version of `telnet` that you are running, execute `help` at the `telnet` prompt.

Several subcommands are available to use to manipulate this environment. For example, the `mode character` command ensures that `telnet` operates in character-at-a-time mode (rather than line-by-line mode). See Section 2.2.8.7.6, page 108, for a description of the environment manipulation subcommands that are available.

When attempting to debug a `telnet` session, you must first isolate the failing component. Users sometimes try to access the Cray Research system through intermediate hosts. That is, rather than accessing the Cray Research system directly from their workstations, they access another host (or even several), and then try to access the Cray Research system. Attempting to access the Cray Research system through various combinations of hosts can help to isolate the failing component.

Typing the escape character returns the user to the original `telnet` environment. To monitor a second or even third `telnet` session, the user must first change the escape character in all previous sessions. This ensures that ^] escapes to the `telnet` session you want to monitor.

2.4.1.4.3 The `ftp`(1B) Command

The `ftp`(1B) command provides user access to the Cray Research system. The following information describes methods for obtaining debug information from both the `ftp` and the `ftpd`(8) daemon when a problem is encountered.

Executing `ftp` puts the user in an environment that the `ftp` client sets up. In this environment, several subcommands are available. For example, `put` and `get` let the user send and retrieve files, respectively; `debug` lets the user see the commands that the `ftp` client is sending to the remote host.

The `ftp` protocol specifies which commands the client can send to the remote host, and also the meaning and format of the server's responses. Commands and responses are grouped in pairs. As a result, you can monitor the communication, and thus control the connection between the local client and the remote server.

You can obtain other information to assist in debugging `ftp` by specifying the following options to `ftpd`:

`-d` or `-v` If these options are specified, `ftpd` logs debugging information to the system log, `auth`, defined in the `/etc/syslog.conf` file.

`-l` If this option is specified, `ftpd` logs general information to the system log, `auth`, defined in the `/etc/syslog.conf` file.

Information in `syslog` is useful when determining the activities that are occurring on the server side of the connection.

2.4.1.4.4 The `sendmail`(8) Command

The `sendmail` program provides several modes of operation. One of the most useful modes is invoked by specifying the following:

```
/usr/lib/sendmail -bt
```

The `-bt` option lets you view the values that `sendmail` is using to interpret the configuration file (option `-C` *file* can be specified to instruct `sendmail` to use *file* as the configuration file). For an explanation of how `sendmail` interprets the configuration file, see the example on Section 2.4.3.2.2, page 208.

Another valuable `sendmail` mode is invoked by specifying the following:

`/usr/lib/sendmail -v -d`*x.y addressee*

Using this option rather than executing `mail` *addressee* lets you send email and print debug messages from the code in the numeric range *x* to *y*. For example, specifying `-d8.99` prints all debug messages that have a value greater than `8`. The output from this process assists you when determining the location of the problem.

2.4.1.4.5 The `gated`(8) Command

When `gated` is executed (typically by the `/etc/netstart` script), it can be given the argument of the name of a file to which it should log any tracing information during its run. For example, `gated` can be executed by using the following command line:

```
/etc/gated /usr/tmp/gated_log
```

This command causes `gated` to log information to the `/usr/tmp/gated_log` file, as directed by the `traceoptions` statement in the `/etc/gated.conf` file. The trace flags specified on the `traceoptions` statement specify the desired level of tracing output. At a minimum, the trace flags that are recommended are `general` and `mark`. See the `gated`(8) man page for a full listing of trace flags.

When `gated` is executed, logging of information to the file can be stopped and started dynamically by a signal sent to the running `gated` process. To make sending this signal convenient, `gdc`(8) is provided. `gdc` provides a user-oriented interface for the operation of `gated`.

The following signals have the identified effects on `gated`:

Signal	Description
`1 (SIGHUP)`	Causes `gated` to reread its configuration file to update specific pieces of information. See the `gated`(8) man page for details.
`2 (SIGINT)`	Causes `gated` to schedule a dump of its memory contents to the `/usr/tmp/gated_dump` file; this dump includes the status of all interface configurations and routes that are known to `gated`.
`3 (SIGUSR1)`	Causes `gated` to stop logging information (when currently logging information) or start logging

information (when not currently logging information) to the log file that is specified when `gated` is executed.

2.4.2 Basic Problem-solving Strategy

This section describes a basic strategy for resolving network-related problems. This strategy can be used to isolate a failing network component. It also isolates the part of the network that is causing the problem. Because the ultimate resolution of any problem requires specific expertise in the failing area, this approach enables you to know whom to contact if you cannot resolve the problem yourself.

2.4.2.1 TCP/IP in a Cray Research Environment

This section describes the manner in which TCP/IP components interact with each other; it does not describe how TCP/IP is configured on a Cray Research system. It is assumed that you are familiar with the following concepts:

- Addressing networks in a UNICOS environment (that is, the fact that a *network address* consists of the identification of a physical device and a logical path). See Section 2.1.1, page 5.
- Assigning Internet addresses for Cray Research systems. See Section 2.1.2, page 8.
- Mapping Internet addresses to their hardware equivalent. See Section 2.1.3, page 13.
- Determining logical paths on Cray Research systems. See Section 2.1.4, page 15.
- Enabling and disabling network interfaces. See Section 2.2.9, page 110.
- Specifying routing information. See Section 2.2.9.8, page 119.

Figure 15 illustrates the interaction of TCP/IP components that run on Cray Research systems.

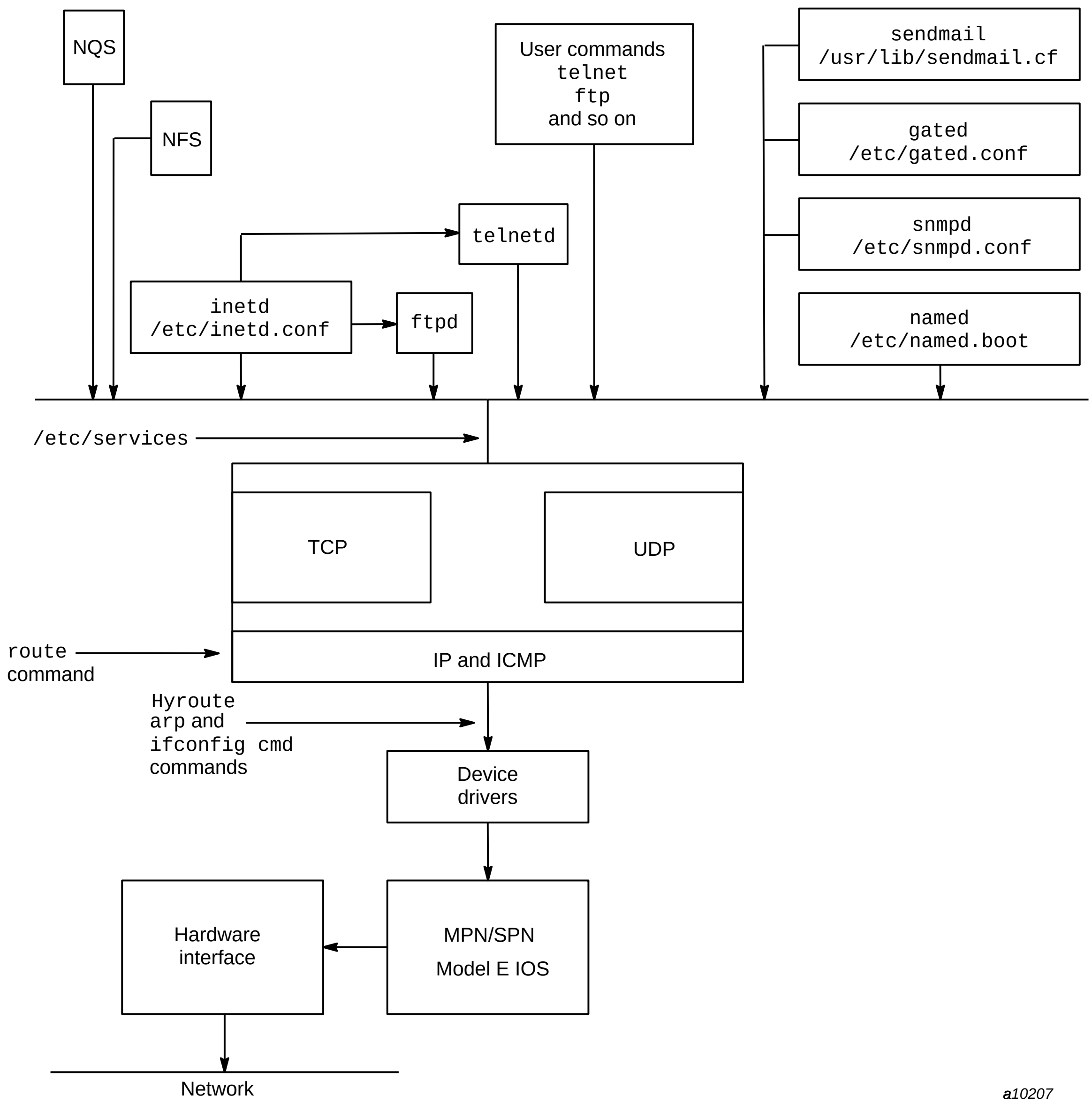


Figure 15. TCP/IP component interaction

Also shown in Figure 15, page 186 are the configuration files that some of the daemons use. For example, `inetd` reads in the `/etc/inetd.conf` file and uses this information to determine the network processes for which it listens.

The commands and files shown outside the boxes in Figure 15, page 186 indicate (with an arrow) which TCP/IP components or interfaces they affect. For example, the `/etc/services` file affects the interface between network applications and TCP/IP by using names to map applications to their port and network protocol.

Not identified on the chart are the `/etc/hosts` and `/etc/networks` files. These files map names (either host names or network names, respectively) to their Internet addresses. This mapping is used by all network components.

> **Note:** When the `/etc/hosts.usenamed` file exists (its contents are meaningless), the mapping of names to Internet addresses is provided by the name server (that is, `named`) rather than the `/etc/hosts` file.

Assume that you are trying to determine why TCP/IP cannot communicate with any of the hosts connected to a certain hardware interface. The `ping`(8) command indicates that the remote hosts are not responding, and no other commands work by using this interface. Knowing that the `ping` command sends an Internet control message protocol (ICMP) `Echo` packet to another host, you can see in Figure 15, page 186 that at least one of the functions, which is located in the section from the bottom of the chart to the part of the chart that shows ICMP, is probably not working. That is, the problem exists in the hardware, device drivers, or the routing between the hosts.

Given the list of commands and components that are tested by the `ping` command, you can check to determine whether each is functioning properly. When `ping` indicates no response, you must check to ensure that `hyroute` and `ifconfig` commands are set up to configure the given interface correctly. The problem can range from the network interface not being enabled (that is, `ifconfig` was never executed to initialize the interface), to an error in the actual networking hardware.

After the problem is isolated to higher-level software, an increased amount of debugging information is available. Because each higher-level network service consists of a client program that is communicating with a server, another level of investigation is required to determine whether the problem exists on the client or the server side of the connection. The information provided in the documentation that accompanies the hardware can offer additional information to further isolate the problem.

For security issues, see "Security administration basics," Section 2.6, page 218.

2.4.2.2 Monitoring and Controlling System Changes

Because any change in a component on the network increases the probability that a problem will occur, it is important that you monitor any network changes. It is also important to ensure, whenever possible, that any change made to any component on the network can be reversed. In this way, problems that are introduced by network changes can be resolved quickly.

For example, assume that users begin to encounter problems when they use `telnet` to access the Cray Research system. If you do not know what change occurred in the network, you must begin resolving the problem by trying to determine which component introduced the problem.

The task of resolving the problem can be simplified if changes can be reversed. Assume that you know that the `telnet` daemon on the Cray Research system was changed in the upgrade to a new bugfix release of the UNICOS system. If the previous version of the daemon was not deleted in the upgrade, you can replace the new version of the daemon with the old one and determine whether the problem disappears. If this corrects the situation, the appropriate analyst should be contacted to fix the current version of the daemon.

2.4.2.3 Isolating the Failing Component

When a network service is in use, several components are interacting with each other. These components can be grouped as follows:

- Components that comprise the networking software, such as routing, flow control, and so on
- Components that provide the physical connection, such as hardware and device drivers
- Components that provide the user interface, such as server and client programs

When attempting to isolate the network component that is causing a problem, you must first identify all components that are involved. For example, when a user uses `ftp` to transfer files between a front-end system and the Cray Research system, all of the networking code and hardware that exists between the front-end system and the Cray Research system, and also the client `ftp` program on the front end and the server `ftp` daemon on the Cray Research system, are involved. From this point, you can begin to use the various tools available to isolate the component that is causing the problem.

2.4.2.4 Isolating the Daemon and Client

To isolate a problem, you must first determine whether communications exist between the Cray Research system and the front-end system that has the problem. A very useful tool for determining this is `ping`(8). If `ping` is executed and shows that no packets are being lost, you know that data can be exchanged between the two systems, and that the problem must be in the higher-level software. If `ping` indicates that packets are being lost, data is not being exchanged between the two systems, and the problem is either in the networking software or in the actual hardware.

If data is being exchanged between the two systems, the problem is either in the client program or in the daemon program. One method of further isolating the problem is to try various combinations of client programs with the daemon program: the sequence of events that produces the problem should be tried from various front-end systems, because each front end has a different client program. Similarly, you can use one client program and vary the daemon programs. Then the sequence of events that produces the problem should be tried from one front-end system to varying remote systems.

See the client and server commands man pages for additional information.

2.4.2.5 Isolating the Hardware

Any problems that are encountered in the hardware and/or device drivers appear in data not being delivered between the Cray Research system and the host that is directly connected to the Cray Research system over the given physical hardware. The following tools are useful to determine whether the hardware is functioning properly between the Cray Research system and a directly connected host:

- The `ping`(8) command can be used to determine whether the Cray Research system can communicate over the physical hardware to the host to which it is directly connected.
- The `netstat`(1B) command with the `-i` or `-iv` option can be used to determine whether packets are being sent or received on the interface or whether errors are occurring.
- The various diagnostics that are available for the given type of hardware can be used.

The results from using these tools can be used to determine whether the problem is in the actual hardware or in the interface between TCP/IP and the device drivers. If the hardware diagnostics do not function properly (see the appropriate documentation on how to use the hardware diagnostics), the problem exists either in the device drivers or in the actual hardware itself. To further isolate the problem, you should consult an analyst who is familiar with the type of hardware you are using.

If the hardware diagnostics function properly, but `ping` indicates 100% packet loss, a problem exists in the interface between TCP/IP and the device drivers. By executing `ping` from both the Cray Research system and the directly connected host, and then reviewing the output from the `netstat` command, you can determine the following:

- Whether the Cray Research system is sending data that is not being received by the remote system
- Whether the remote system is sending data that is not being received by the Cray Research system
- Whether the Cray Research system or the remote host is experiencing I/O errors when attempting to use the interface

The following items should be checked if you suspect the problem to be in the interface between TCP/IP and the hardware:

- Whether the Cray Research system is sending data to the correct hardware address of the remote host. This includes verifying that the Cray Research system is sending data to the correct logical path that TCP/IP has open on the remote system.
- Whether the remote system is sending data to the correct hardware address (including logical path) of TCP/IP on the Cray Research system.
- Whether the correct interface type is specified in the `ifconfig`(8) command.
- Whether valid mtu values are specified in the `hycf` file used by `hyroute`(8) when configuring the interface.
- Whether the interface in the IOS is initialized.

2.4.2.6 Isolating the Networking Software

If the Cray Research system can communicate with the hosts that are connected directly to its interfaces, but data is not being exchanged between the Cray Research system and other systems, the problem exists in the networking software on one of the hosts in the path between the Cray Research system and those remote systems. You must identify the host that is introducing the problem. The following tools are useful for determining whether the problem exists within TCP/IP on the Cray Research system or on another host:

- The `traceroute`(8) and `snmproute`(8) commands can be used to determine the route that packets are taking to allow the Cray Research system to communicate with the remote system.
- The `netstat`(1B) command can be used to determine the status of TCP/IP on the Cray Research system. Use this command to view various items such as mbuf usage, the current state of all active connections, and routing information.
- The `trcollect`(8) and `trformat`(8) commands can be used to trace packets going into and out of the Cray Research system.

Using these tools will help you determine where on the network the problem is occurring. Check the following items when you suspect that the problem is in the networking software:

- Whether the Cray Research system is running short of memory (that is, `netstat` with the `-m` option indicates that requests for memory are being denied).
- Whether a route exists from the Cray Research system to the remote host and from the remote host to the Cray Research system.
- Whether all hosts are up on the route between the remote system and the Cray Research system.
- Whether data, if any, is being exchanged between the remote system and the Cray Research system.
- Whether valid mtu values are specified on the `route`(8) command for this remote system.
- Whether the correct group restrictions are used on the `route` command for this remote system.
- Whether the interface is configured for privileged use only with UNICOS security (as in `ifconfig admin`).

2.4.3 Examples of Network Problems and Solutions

This section describes troubleshooting guidelines and shows several examples of networking problems and approaches you can take to resolve them. The solutions tell how the failing component is isolated and how the problem was ultimately resolved. These examples give you some ideas in resolving network-related problems; they do not describe a step-by-step method of resolving problems.

2.4.3.1 Troubleshooting Guidelines

Use the following guidelines to help you troubleshoot reported problems:

- Understand exactly what the users are attempting to do and ask them for the exact syntax of their commands. For example, you should have the following information: Does the path involve a gateway? Are colons and periods in the right places? Are binary or ASCII files being transferred? Is case sensitivity an issue?
- Determine the remote host configuration. You must identify the operating system of the remote host and the networking product currently being run (because some products support a different set of protocols), identify the types of interfaces involved, and determine whether the remote host is the client or the server for the command.
- Determine whether the problem is specific to the local TCP/IP host or to the remote host. For example, if the user receives the error message `Connection refused`, are any of the following actions possible?
  - Can you perform a `telnet`(1B) operation back to the local TCP/IP host by using your Internet address?
  - Can you perform a `telnet` operation to any other remote host on the network?
  - Can anyone else perform a `telnet` operation to the problem host?
  - Can the remote host perform a `telnet` operation back to itself?
- Determine whether this is a recent or an ongoing problem.
- Determine whether changes were made to the system.
- Determine whether privilege is an issue; that is, is the command available only to the super user (or limited to certain categories with UNICOS security)?

The following are common problems that you might encounter:

- The remote or local interface is down.
- An incorrect address for the remote host exists in `/etc/hosts`.

- There is a conflict between the Internet address specified for a remote host in `/etc/hosts` and the address associated with it (as specified by the `ifconfig`(8) command).
- The `/etc/hosts` file has duplicate entries for the host name. Because this file is searched sequentially, the first entry is used.
- The user is not aware of case sensitivity associated with certain commands.
- Daemons are down.
- Routes were deleted or incorrectly entered with the `route`(8) commands.
- The gateway is down.
- The `/etc/hosts.bin` file is out of date.

2.4.3.2 Troubleshooting Examples

This section describes the most common problems that are encountered on the network and provides suggestions for solving them.

2.4.3.2.1 Connection Problems

The following problems can occur when a user is trying to connect to a remote host. In this section, the message is given (message text is shown in bold monospace font), followed by a description of the problem, the probable cause, and a possible solution. Some of the problems have more than one probable cause and possible solution listed.

> **Note:** There are several reasons for prohibiting connections with UNICOS security. See `spnet`(8) for an explanation of the NAL, WAL, and IPSO map tables and their effect on network connections. See `ifconfig`(8) regarding labels on interfaces and limiting the use of an interface to privileged processes. See "Restricting access to network interfaces," Section 2.6.3.4, page 227, for more details of these restrictions.

`Connection closed by remote host`

Problem:

A user has established a connection to a remote host, and the connection closes before the user logs out.

Cause:

This usually occurs because the remote host performed a shutdown and severed the connection, or the user process for the associated daemon was terminated.

Solution:

Use the `ping`(8) command to determine whether the host is running. Determine whether the remote host is down by contacting the host network administrator. If the host is not down, use `telnet`(1B) to reestablish the connection.

`Connection refused`

Problem:

Users cannot connect to a remote host. The remote host is up, and the interface is up, but a connection cannot be established.

Several possible causes and solutions for the problem follow.

Cause:

The wrong port number for the program is listed in the `/etc/services` file on the local or the remote host.

Solution:

Check the protocol's port number in the network services file (`/etc/services`) on the local host. It must agree with the port number shown in the default network services file (see an example of a network services file on page 37). If these numbers match, ask the network administrator on the remote host to perform the same check. Assume that the result of the check is as follows:

```
&Network services, Internet style
#
telnet   25/tcp
```

The `telnet` daemon should have port number `23` instead of `25`; therefore, the `/etc/services` file that is in error must be edited accordingly. The `/etc/services` data file should always keep the standard protocol port numbers. When the client program is started (that is, a user initiates a command), it opens `/etc/services`, obtains a port number, and looks for a daemon program that is listening on that remote host port.

When the daemon program is started (at boot time or when the network administrator starts it separately), the daemon opens `/etc/services`, obtains a port number, and listens for a request on that port. Therefore, if someone changes the port number in /etc/services on the client, the client will request a port number other than the one on which the standard daemon program is listening. If the daemon program is listening on a nonstandard port number, it does not recognize a client's request on a standard port number. A connection cannot be established unless both port numbers agree.

If it is necessary to use a nonstandard port number (this is often done for testing), use the following procedure to start a daemon or client program on a different port number without interfering with the standard network programs and daemons:

1. To start a telnet server on port 35, add another line to the /etc/inetd.conf file, as follows:

   ```
   35 stream tcp nowait root /etc/telnetd telnetd
   ```

   This line enables two telnet servers, one at port 23 (default) and the other at port 35. (You can test a trial version of telnet by enabling two telnet servers.)

2. To connect to the telnet server on port 35, the client telnet(1) program from a remote host issues the following commands:

   ```
   # telnet
   telnet> open hostname 35
   ```

Now the two servers are talking because the port numbers agree. (If a server is not invoked by inetd (for example lpd or sendmail), these commands can be entered directly from the command line.)

In an implementer's own programs, the port number is sometimes embedded in the code. If this is the case, check the source code.

For information about the syntax and format of the /etc/inetd.conf file, see Section 2.2.8.7, page 102.

Cause:

The /etc/inetd daemon is down.

Solution:

If TCP/IP users cannot connect to any of the networking services on a particular host, contact the network administrator for the remote host to determine whether inetd is operating.

If remote users cannot connect to the local TCP/IP host, enter the `ps`(1) command with the `-ae` options to determine whether `inetd` is running. For example, the following `ps -ae` output indicates that `inetd` is not running, because `inetd` is not listed:

```
# ps -ae

81   ?   0:00     lpd
83   ?   0:00     sendmail
```

The following dialog activates `inetd` on the TCP/IP host and verifies that the daemon is now running:

```
# /etc/inetd

# ps -ae

 81   ?   0:00     lpd
 83   ?   0:00     sendmail
 85   ?   0:00     inetd
```

Cause:

The server is not enabled by `/etc/inetd.conf`.

Solution:

If TCP/IP users can connect with other network services but cannot connect with a particular service on a host, contact the network administrator for the remote host to determine whether the daemons on the host are operating.

If remote users cannot connect to a particular service, but can connect to other services on the local TCP/IP host, your `/etc/inetd.conf` file is probably not set up correctly. Enter the `netstat` command with the `-a` option to determine whether the remote service is running.

The following output from `netstat -a` verifies that the `telnetd` service is not listening because `telnet` is not listed:

```
# netstat -a

Active connections (including servers)
Proto   Recv-Q   Send-Q   Local Address   Foreign Address   (state)
tcp       0        0      *.smtp          *.*               LISTEN
tcp       0        0      *.exec          *.*               LISTEN
tcp       0        0      *.shell         *.*               LISTEN
```

```
tcp       0        0      *.login        *.*               LISTEN
tcp       0        0      *.finger       *.*               LISTEN
tcp       0        0      *.ftp          *.*               LISTEN
```

If the `telnetd` service is not listening, view the `/etc/inetd.conf` file to determine whether the `telnet` service is enabled. If not, add the `telnet` entry to the `/etc/inetd.conf` file and issue a `SIGHUP` signal to the `inetd` process.

Use `netstat -a` again to verify that the daemon is now running:

```
# netstat -a

Active connections (including servers)
Proto   Recv-Q   Send-Q   Local Address   Foreign Address   (state)
tcp       0        0      *.smtp         *.*               LISTEN
tcp       0        0      *.exec         *.*               LISTEN
tcp       0        0      *.shell        *.*               LISTEN
tcp       0        0      *.login        *.*               LISTEN
tcp       0        0      *.finger       *.*               LISTEN
tcp       0        0      *.ftp          *.*               LISTEN
tcp       0        0      *.telnet       *.*               LISTEN
```

Connection timed out

Problem:

The local host is trying to connect to the remote host but is not making an active connection. The `telnet`(1B) program sent a packet to a specific address, but no hosts are responding. The `telnet` client program times out if a connection is not made within a certain time limit (usually between 30 and 75 seconds).

Example:

Assume that the user from the local TCP/IP host issued the following command:

```
# telnet hostname
telnet ....... connection timed out
```

Several possible causes and solutions for the problem follow.

Cause:

The remote host or network is down.

Solution:

If you suspect that the remote host or network is down, contact the network administrator for the host and request the host's status.

Cause:

With UNICOS security, there is not a NAL entry that authorizes access by your host or at your security label. The remote host appears to be down.

Solution:

If you suspect that the remote host or network is down, contact the network administrator for the host and request the host's status.

Cause:

An incorrect Internet address is specified for the remote host.

Solution:

A conflict in the Internet address can arise from the following situations:

- A user entered an incorrect Internet address on the command line. The user should retry the command, using the official host name or alias (to avoid reentering an incorrect Internet address).
- A network administrator changed the Internet address of the remote host without informing the other hosts on the network. The address associated with the host is different from that in the local `/etc/hosts` table. The network administrator for the host should verify that the address is correct.
- The local host table contains varying entries for the remote host. Only the first entry is used, regardless of which one is correct. Therefore, if multiple entries for a remote host appear in your `/etc/hosts` file, ensure that the first one is correct and delete the others.

Cause:

There is a hardware problem.

Solution:

Check the connections between the Cray Research system and the network hardware. (Use the `hit`(8) command to determine whether the network hardware is working.)

Note: In the Cray ML-Safe configuration of the UNICOS system, special steps must be taken to run the `hit`(8) command (see *General UNICOS System Administration*, publication SG–2301, for more details on non-TCP software and with UNICOS security).

Cause:

The remote host's interface is down. (If the network hardware interface on the local TCP/IP host is down, the error message `Network is unreachable` appears.)

Solution:

If you suspect that the remote host's network interface is down, contact the network administrator and request the host's status.

Cause:

Nonexistent or incorrect routes are set up.

Solution:

If you suspect that the remote host's `route`(8) commands are configured incorrectly, contact the network administrator and request the host's status. If the `route` entry on the local TCP/IP host is at fault, the error message `Network is unreachable` appears.

`Login incorrect`

Problem:

A user is attempting to issue the `rlogin`(1B) command and receives the error message `Login incorrect`.

Cause:

The error message is returned from the remote host because the user entered an invalid user name or password for the host. When an invalid user name is specified, or an autologin is impossible because `/etc/hosts.equiv` or `$HOME/.rhosts` is not set up to allow an autologin, the user receives a prompt for a login and password.

Solutions:

- Set up the `/etc/hosts.equiv` or `$HOME/.rhosts` file correctly so that the user is not prompted for a password. See Section 2.2.5.3, page 37, and Section 2.2.11.2, page 126, for more information.

- Users must know their valid accounts and passwords on the remote hosts.

The .netrc file not correct mode

Problem:

A user attempts to use `ftp`(1B) with autologin to a remote host. The user's `$HOME/.netrc` file is set up properly with *machine*, *username*, and *password* entries, but the error message is returned, and `ftp` aborts.

Cause:

The file has read permissions set for someone other than the owner. Because of the sensitivity of information in `$HOME/.netrc`, the `$HOME/.netrc` file should be accessible only to the owner.

Example:

The following permissions are incorrect:

```
-rw-r--r--   1 peter other         24 Dec 26 14:14 /usr/peter/.netrc
```

Solution:

Change the access mode of the `.netrc` file to `600`, as follows:

Example:

```
#  chmod 600 /u2/peter/.netrc
```

The following dialog verifies that the mode was changed:

```
# ls -la .netrc
-rw-------   1 peter other         24 Dec 26 14:14 /usr/peter/.netrc
```

Network is unreachable

Problem:

The user attempts to connect to a host outside the local area network (LAN) and cannot establish the connection. Both hosts are known to be up.

Cause:

- The local network hardware interface is down. If the remote interface is down, the error message `Connection refused` is returned.

- The local network hardware interface is up, but the Internet address associated with it is incorrect. The interface is on a network that is different from the one for which it was intended.
- The route was deleted for the local interface.
- A route was not set up for the destination host.
- An incorrect route was set up for the destination host.
- The configuration file specified for `/etc/hyroute` does not properly map Internet addresses to hosts, or it does not properly list gateways to other low-speed channels.

Solution:

1. If users cannot perform a `telnet`(1B) operation back to themselves (using the local host name rather than loopback), the problem is in the interface.

   Example:

   User `peter` on `crayhost` issues the following command:

   ```
   # telnet crayhost
   Trying.....
   network is unreachable
   ```

   Enter the `netstat` command with the `-i` option to determine whether the local interface board is up, as follows:

```
# netstat -i

Name   Mtu   Network   Address     Ipkts  Ierrs  Opkts  Oerrs  Collis
np0*   1500  twgnet    crayhost    59803  0      45458  0      0
lo0    1536  Loopback  localhost   5601   0      5601   0      0
```

   The asterisk following `np0` indicates that the interface is down. Use the `ifconfig`(8) command to initialize the interface, as follows:

   ```
   ifconfig np0 crayhost up
   ```

   The following output from `netstat -i` verifies that the interface is up:

```
#  netstat -i

Name   Mtu   Network   Address     Ipkts  Ierrs  Opkts  Oerrs  Collis
np0    1500  twgnet    crayhost    59803  0      45458  0      0
lo0    1536  Loopback  localhost   5601   0      5601   0      0
```

Try again to perform a `telnet` operation back to the local host. If you are unsuccessful, check the `hyroute`(8) command in `/etc/netstart`. The `hyroute` command should always be run before `ifconfig`.

Determine the name of the configuration file that is specified on the `hyroute` command line and examine the file. Ensure that the correct network hardware address for the user's host interface is properly mapped to the user's host name. Make any necessary corrections and try again to perform a `telnet`(1B) operation back to the local host.

2. If users can perform a `telnet`(1B) operation to themselves, but not to anyone else on the local network, verify the address of the local interface.

   Example:

   User `peter` is on `crayhost` (local network `32`) and is trying to perform a `telnet` operation to `cray2`, as follows:

```
#  telnet cray2
Trying ...
network is unreachable
```

   Enter the `netstat -ni` command:

```
# netstat -ni

Name   Mtu   Network   Address      Ipkts  Ierrs  Opkts  Oerrs  Collis
np0    1500  31        31.0.18.121  1373   0      753    0      0
lo0    4608  127       127.0.0.1    394    0      394    0      0
```

   Although `peter` thought his network hardware interface was configured on network `32`, it was actually configured on network `31`. Therefore, `peter` must perform the following steps:

   First check the Internet address in the `/etc/hosts` table for the interface. The following dialog shows that `crayhost` was set to an incorrect address:

```
#  cat /etc/hosts

31.0.18.121   crayhost
32.0.0.2      cray2
```

   Change the Internet address in this host file, and reassign the new address to the interface, using the following `ifconfig`(8) command (first ensure that you change the Internet address in the `/etc/hosts` file). Verify by using `netstat -ni`. The dialog follows:

```
# ifconfig np0 down
# ifconfig np0 crayhost up

Name   Mtu   Network     Address      Ipkts   Ierrs   Opkts   Oerrs  Collis
np0    1500  32          32.0.18.121  1373    0       753     0      0
lo0    4608  127         127.0.0.1    394     0       394     0      0
```

If the host table appears to be correct, check the `ifconfig` command in `/etc/netstart`. This command should use the official host name instead of the Internet address.

A common error occurs when users add their official host name to the loopback line (`127.0.0.1`). When they initialize the network, their interface board is assigned to `127.0.0.1` rather than to the intended Internet address in `/etc/hosts`.

Try again to perform a `telnet`(1B) operation to a host on the local network.

3. If users can perform a `telnet`(1B) operation to themselves and to anyone on the local network, but not to a host on another network, the route is the problem.

   For example, `peter` is on network `32` (local host `crayhost`) and wants to perform a `telnet` operation to `cray3` on network `68`.

   Enter `netstat -nr` to verify the following routes that are set up, as follows:

   ```
   # netstat -nr

   Routing tables
   Destination     Gateway       Flags   Refs     Use    Interface
   32              32.0.18.121   UG      4        1129   np1
   127             127.0.0.1     U       0        0      lo0
   ```

   This route table shows that `peter` can get to only networks `32` and `127` (loopback). `peter` must set up a route for network `68`. For example, if host `kit` on his network were the gateway to network `68`, `peter` would add the route as shown in the following example.

   ```
   # route add net 68 kit
   # netstat -nr

   Routing tables
   Destination     Gateway     Flags   Refs     Use   Interface
   ```

```
68              32.0.0.4    UG      0        354   np0
32              32.0.18.121 UG      4        1129  np0
127             127.0.0.1   U       0        0     lo0
```

Because `kit` is the gateway to network `68`, it contains two addresses: one for network `68`, and one for local network `32`. Because `crayhost` is on network `32`, the gateway host address that should be used is the same as that of `crayhost` (for example, `32.0.0.4`).

When multiple gateways are involved, another problem occurs with routes. Then you must determine which intermediate gateway is set up with improper routes.

If the fault does not lie with the routing commands, determine the name of the configuration file invoked by the `hyroute`(8) command, and examine the file. Ensure that the remote host has a gateway configured for it, and that the correct hardware address for the gateway has been properly mapped to its host name. Make any necessary corrections and try again to perform a `telnet`(1B) operation to the remote host.

`Ruserok: permission denied`

Problem:

A user is trying to use the `rsh`(1), `remsh`(1B), `rcp`(1), or `rlogin`(1B) command and receives the error message.

Example:

User `peter` on `crayhost` attempts a remote shell (`rsh` or `remsh`) command on a given host through `sue` 's account, and issues the following command:

```
$ rsh hostname -l sue who
ruserok:  permission denied
```

Several possible causes and solutions follow:

Cause:

The `$HOME/.rhosts` file on the remote host does not exist or is not set up to allow access to the user.

Example:

User `sue` 's `$HOME/.rhosts` file is not set up to allow `peter` to use her account; the contents of her `$HOME/.rhosts` file are as follows:

```
crayhost sally george
```

In this example, sue has authorized access for sally and george, but not for peter.

Solution:

Create or update the $HOME/.rhosts file on the remote host to allow access.

Example:

User sue 's $HOME/.rhosts file should be modified as follows:

```
crayhost sally george peter
```

Cause:

The $HOME/.rhosts file on the remote host is not owned by the user who owns $HOME.

Example:

User sue 's $HOME/.rhosts file is owned by anne, as shown in the following ls(1) output:

```
$ ls -l .rhosts
-rw-------   1 anne     users         22 Dec 16 15:09 .rhosts
```

Solution:

The super user must change the owner of the $HOME/.rhosts file to the owner of $HOME.

Example:

The super user uses the chown(1) utility to change the file's ownership, as follows:

```
# chown sue .rhosts
# ls -l .rhosts
-rw-------   1 sue      users         22 Dec 16 15:09 .rhosts
```

Cause:

The host name is not specified.

Example:

Host `birch` has two names corresponding to two IP addresses. The `$HOME/.rhosts` file should include both names to ensure a name that matches the address used is found.

Cause:

The `$HOME/.rhosts` file on the remote host is publicly writable.

Example:

Other users can modify user `sue` 's `$HOME/.rhosts` file, as the following `ls` output shows:

```
$ ls -l .rhosts
-rw-rw-rw-   1 sue      users         22 Dec 16 15:09 .rhosts
```

Solution:

Change the permissions on the `$HOME/.rhosts` file to `600`.

Example:

Use the `chmod`(1) utility to change the file's permissions, as follows:

```
$ chmod 600 .rhosts
$ ls -l .rhosts
-rw-------   1 sue      users         22 Dec 16 15:09 .rhosts
```

Unknown host

Problem:

A user tries to connect to another host and receives the error message. This error is generated from the client side.

Example:

```
# ftp otherhost
hostname: Unknown host.
ftp>
```

Cause:

There is an invalid entry in `/etc/hosts`. Each host to which the user wants to connect must have a valid entry in the local `hosts` file unless the user specifies the Internet address of the destination host. The remote host does not need an entry for the user in the `hosts` file, because the IP header contains the source address.

Solution:

Check the entry in `/etc/hosts` for the host name to which the user is trying to connect. Ensure that no comment indicator (#) precedes the entry.

Problem starting up /etc/netperf

Problem:

The user cannot start `netperf`(8).

Several possible causes and solutions follow.

Cause:

The display workstation does not support the X Window System (X) server; consequently, the following message is displayed, indicating that the X server is not enabled:

```
Connection refused
```

Solution:

You must run `netperf` on a bit map display workstation that supports X.

Cause:

The setting of the `DISPLAY` environment variable (after the user logs on to the Cray Research system) does not specify the displaying workstation.

Solution:

Set the `DISPLAY` environment variable, as follows:

`setenv DISPLAY` *myworkstation*`:0`

Ensure that the displaying workstation has the Cray Research system in its `Xhosts` list, which is a list of the hosts that can display X output.

2.4.3.2.2 Sendmail Problems

This section discusses error messages that can occur when a user is trying to use the `sendmail` facility. It offers guidelines for analyzing and resolving the error message problems.

Host unknown

A user attempts to send email from the Cray Research system, and the email is returned as undeliverable. This problem started only recently. The following is an example of a message returned by the system:

```
>From root Thu May 24 07:45 GMT 1990
Return-Path: <MAILER-DAEMON>
Received:  by myhost.domain.name
        id AA07406; 5.61/CRI-7.0; Thu, 24 May 90 02:45:18 -0500
Date: Thu, 24 May 90 02:45:18 -0500
From: Mail Delivery Subsystem <MAILER-DAEMON>
Full-Name: Mail Delivery Subsystem
Message-Id: <9005240745.AA07406@myhost.domain.name>
Subject: Returned mail: Host unknown
To: yourid

   ----- Transcript of session follows -----
550 yourid@yourhost... Host unknown

   ----- Unsent message follows -----
Received:  by myhost.domain.name
        id AA07404; 5.61/CRI-7.0; Thu, 24 May 90 02:45:18 -0500
Date: Thu, 24 May 90 02:45:18 -0500
From: John Doe <yourid>
Full-Name: John Doe
Message-Id: <9005240745.AA07404@myhost.domain.name>
To: yourid@yourhost

This is the message I wanted to send to you.
```

The `Host unknown` message indicates that `sendmail` could not find the name `yourhost` in the table of host names. This table provides the mapping of names to Internet addresses.

Using the preceding information, you can conclude that one of the following problems exists:

- The `sendmail` program contains an error.

- The sendmail.cf file is not configured properly.
- The routine that performs the host mapping function (/etc/hosts or the name server, depending on which one your site is using) is not correct, which causes the output that is returned by gethostbyname(3) to be in error.

The reason for this conclusion is that these are the only components involved in determining valid host names. The part of the sendmail program that creates destination addresses is suspected because the destination address cannot be found. The process of resolving valid host names is suspected because the error message indicates that the host name is unknown.

To isolate the cause of this problem, look at the changes that are made to these components on the Cray Research system. For this example, assume that you have upgraded the version of TCP/IP that is running, you have changed from using the /etc/hosts file to using the name server, and you have changed the sendmail configuration file.

First, check to determine whether the problem was introduced by the change from the /etc/hosts file to the name server. To test this possibility, you must go back to using /etc/hosts. Because the existence of the /etc/hosts.usenamed file indicates that the name server is being used, delete this file.

Next, attempt to send a test message to yourid@yourhost. If the email is delivered to yourid@yourhost, the /etc/hosts file is not in error.

Using this information, you can conclude that the problem is either with the method that sendmail used to interface with the name server or with the name server itself. Change back to the name server, and look at the tools available to assist in debugging the name server. The program nslookup(1) is a tool that queries the name server and displays the results. Following is a sample nslookup dialog:

```
prompt> nslookup
Default Server:  myhost.domain.name
Address:  128.162.75.1

> yourhost
Server:  myhost.domain.name
Address:  128.162.75.1

Name:    yourhost.domain.name
Address:  128.162.154.12
```

```
> ^D
prompt>
```

The output from `nslookup` indicates that the name server does know about host `yourhost`. Therefore, the problem must be with the method that `sendmail` used to interface with the name server. To determine the host name that `sendmail` is using when communicating with the name server, execute the following:

```
prompt> /usr/lib/sendmail -bt
ADDRESS TEST MODE
Enter <ruleset> <address>
> 0 yourid@yourhost
rewrite: ruleset  3   input: "yourid" "@" "yourhost"
rewrite: ruleset  8   input: "yourid" "@" "yourhost"
rewrite: ruleset  8 returns: "yourid" "@" "yourhost"
rewrite: ruleset  3 returns: "yourid" "<" "@" "yourhost" ">"
rewrite: ruleset  0   input: "yourid" "<" "@" "yourhost" ">"
rewrite: ruleset  3   input: "yourid" "@" "yourhost"
rewrite: ruleset  8   input: "yourid" "@" "yourhost"
rewrite: ruleset  8 returns: "yourid" "@" "yourhost"
rewrite: ruleset  3 returns: "yourid" "<" "@" "yourhost" ">"
rewrite: ruleset  0 returns: "^V" "tcp" "^W" "yourhost" "^X" "yourid" "@" "yourhost"
> ^D
prompt
```

The output shows that `sendmail` attempts to establish a TCP/IP connection with host `yourhost` (that is, the name following `"^W"`). This appears to be correct because `yourhost` is known to the name server. At this point, all you know is that `sendmail` is using the alias `yourhost` when it queries the name server, rather than using the official host name (`yourhost.domain.name`) that is displayed in the output from `nslookup`.

Next, look at the `sendmail.cf` file, and find the rule that produces the results returned by ruleset 0, as follows:

```
R$*<@$+>$*            $#tcp $@$2 $:$1@$2
```

The results returned by ruleset 0 are indicated on the right side of this rule. For example, `tcp` indicates a TCP/IP connection, shown as `"^V" "tcp"` in the output; `$2` represents the token that indicates the destination host's name, shown as `"^W" "yourhost"` in the output; and `$1@$2` represents the token that indicates the recipient's email address, shown as `"^X" "yourid" "@"`

"yourhost" in the output. The character strings $1 and $2 represent the tokens that are created by the left side of the rule.

To ensure that sendmail always uses the official host name, change the rule to the following:

```
R$*<@$+>$*          $#tcp $@$2.$D $:$1@$2.$D
```

After making this change to the configuration file, you can send email addressed to yourid@yourhost, and it now works properly.

Cannot reply to e-mail originating from the Cray

A user attempts to reply to email received from a user on the Cray Research system, and the reply is returned as undeliverable. This problem started to occur only recently.

Using this information, you can conclude that one of the following problems exists:

- The sendmail program that exists on the Cray Research system contains an error.
- The sendmail program is not configured properly on the Cray Research system.
- The official host name for the Cray Research system is not being used.
- The sendmail program on the remote system contains an error.
- The sendmail program is not configured properly on the remote system.
- The routine that performs the host mapping function (/etc/hosts or the name server, depending on which one your site is using) is not correct, which causes the output that is returned by gethostbyname(3) to be in error.

The problem must be either with the method the Cray Research system uses to build its return address or with the method the remote system uses to return the email. (However, communication might be denied because of UNICOS security label policies.)

To isolate the cause of this problem, look at the changes that have been made in the components on the Cray Research system. For this example, assume that the only factor that has changed is that you now use the name server rather than the /etc/hosts file. Currently, you do not know what has changed on the remote system, but after you eliminate the possibility of an error in the Cray Research components, you can begin to look at the remote system.

Because the sendmail program is not changed, and this problem is new, you can assume that the sendmail program that exists on the Cray Research system is not in error. The next step is to determine which address this sendmail program is using as its return address. Either the official host name for the Cray Research system is not set up correctly, or the configuration file incorrectly constructs the name it is given.

The following example is a sendmail debugging tool that produces the sequence of events that sendmail executes when it delivers email to the remote system:

```
prompt> /usr/lib/sendmail -d8.99 -v yourid@yourhost
To: yourid@yourhost
From: u3441
asdf
u3441@yourhost... Connecting to yourhost.domain.name (tcp)...
220 yourhost.domain.name Sendmail 3.2/CRI-3.12 ready at Thu, 24 May 90 04:54:16 CDT
>>> HELO myhost.domain.name.domain.name
250 yourhost.domain.name Hello myhost.domain.name.domain.name, pleased to meet you
>>> MAIL From:<u3441@myhost.domain.name.domain.name>
250 <u3441@myhost.domain.name.domain.name>... Sender ok
>>> RCPT To:<u3441@yourhost.domain.name>
250 <u3441@yourhost.domain.name>... Recipient ok
>>> DATA
354 Enter mail, end with "." on a line by itself
>>> .
250 Mail accepted
>>> QUIT
221 yourhost.domain.name delivering mail
u3441@yourhost... Sent
prompt>
```

The -d option produces debug messages; the -v option requests a verbose execution method.

> **Note:** When using this method to execute sendmail, you must enter the To: and From: lines, and the message text you are sending.

In the preceding output, the Cray host (that is, myhost) is telling the remote system (that is, yourhost) that its host name is actually myhost.domain.name.domain.name. This cannot be correct, because the domain name should appear only once. To determine whether the problem is in the method used to configure sendmail (that is, in the sendmail.cf file), you must first determine the method `sendmail` uses to construct this return address.

Then you can either consult the `sendmail` documentation or contact an analyst who is familiar with `sendmail`. Either way, `sendmail` uses the `$j` macro to define the local host's name, and thus, its return address. So you must locate the line in the `sendmail.cf` file that defines how `$j` is to be constructed. Locate the following line in the `sendmail.cf` file:

```
Dj$w.$D
```

The values that are returned from the `$w` and `$D` macros are concatenated with a period (.) between them. The `$w` macro is the official host name of the local host, and the `$D` macro is the local domain name.

To determine the name that is being returned as the official host name for the Cray Research system, you can execute `nslookup`. The following is a sample session:

```
prompt> nslookup
Default Server:  myhost.domain.name
Address:  128.162.75.1

> myhost
Server:  myhost.domain.name
Address:  128.162.75.1

Name:    myhost.domain.name
Address:  128.162.75.1

> ^D
prompt>
```

The `$w` macro returns `myhostname.domain.name`, which causes the `sendmail` configuration file to add incorrectly the value of `$D` (that is, the domain name) to the official host name.

Therefore, to resolve this problem, change the construction of the local host name in the `sendmail.cf` file by changing the line `Dj$w.$D` to `Dj$w`.

2.5 Trace Facility

This section describes the trace facility, which retrieves trace information from the TCP/IP and NFS kernel codes, and stores trace information in a file. This information can be formatted and used for program analysis and debugging.

A `socket`(2) system call that has the address family `AF_TRACE` creates a trace socket. A `connect`(2) system call, with appropriate options, connects this trace socket to the entries that are to be traced. The following types of parameters are accepted:

Parameter types	Description
Generic	Connects to a generic protocol or system layer, and all trace entries from that layer are sent to the user. The type field in the `sockaddr_trace` structure specifies `generic`; the mask field determines the layer. The following layers are supported:

`if, ip, rawip, icmp, tcp, udp, nfs, idmap`

TCP specific	Connects to a specific TCP connection (defined by foreign and local addresses and ports). The `sockaddr_trace` type field specifies `tcp`; the `str_in` structure determines a connection.
UDP specific	Connects to a specific UDP connection. The options are similar to TCP specific tracing.
Interface specific	Connects to a specific interface. The interface name is provided in the `if_str` field of the `sockaddr_trace` structure.

Because they might be needed to trace multiple entries at one time, multiple connects are allowed on the trace socket. It is also possible for more than one user to trace one entry.

After the socket is created and connections are specified, three mbufs are queued up on the socket. Then the entities to be traced begin posting trace entries into these mbufs. When the mbuf is full, it is queued onto the socket-received space. The user can read the data by issuing a `read`(2) system call on the socket. The `close`(2) system call frees up the socket, the mbufs, and all structures related to the socket.

Each trace entry is prepended by a header that contains information that is used for formatting and data verification. The header includes the following fields:

Field	Description
`magic`	Magic cookie to use for synchronization if data is lost
`str`	Eight-character ASCII string, or an integer that the formatter can use
`id`	Unique ID for each trace entry
`type`	Type of entry (for example, `if`, `ip`, and so on)
`len`	Length of trace entry data
`subtype`	Used by the formatter
`rtc`	Real-time clock value of when the trace entry is made

For security reasons, only `root` is allowed to obtain trace information. Furthermore, because of the specialized nature of this socket type, only the following socket system calls are valid:

- `socket`
- `connect`
- `read`
- `close`
- `setsockopt`
- `getsockopt`

2.5.1 Collecting Trace Information

The `trcollect`(8) command collects TCP/IP and NFS trace information from the kernel. The syntax is as follows:

`trcollect` [*general options*] [*tcp/udp/interface options*][*generic options*]

The following general options are accepted:

`-f` *tracefile* — Specifies a trace file in which trace output is stored. Redirecting standard output to a file has the same effect.

`-b` *buffersize* — Specifies the buffer (mbuf) size for the trace socket. Three mbufs per socket are queued. Note that the socket receive space must be greater than three times the buffer size. The default buffer size is 1 Kbyte.

`-r` *recvspace*	Specifies the socket receive space. The default socket receive size is 32 Kbytes.
`-s` *timeout*	Specifies a time-out on read processes. By default, if no read occurs during the interval, after every 5 seconds the program flushes the current mbuf from the socket queue onto the receive space.

The following TCP/IP and UDP options are accepted:

`-t` *connectioninfo*
Specifies a TCP connection to be traced. The following options are accepted for *connectioninfo*:

`-fa` *faddress*	Specifies foreign address.
`-la` *laddress*	Specifies local address.
`-fp` *fport*	Specifies foreign port.
`-lp` *lport*	Specifies local port.

Note: Any options that are not specified are wildcarded. At least one option is required to trace TCP/IP connections.

`-u` *connectioninfo*	Specifies a UDP connection. The *connectioninfo* options are the same as those for the `-t` option.
`-i` *interface*	Specifies an interface to be traced (for example, `-i np0` traces all entries that go through the `np0` interface).

The following generic options are accepted:

`if`	Traces information on all interfaces.
`ip`	Traces information in the IP layer.
`tcp`	Traces all TCP/IP sockets in which the `SO_DEBUG` flag has been set.
`udp`	Traces all UDP sockets in which the `SO_DEBUG` flag has been set.

`icmp`	Traces information through the ICMP layer.
`rawip`	Traces information through the `rawip` layer.
`nfs`	Traces information through NFS.
`idmap`	Traces information through the NFS ID mapping scheme.

2.5.2 Formatting Trace Information

The `trformat`(8) program formats the trace information that is collected through the `trcollect`(8) command. The syntax is as follows:

`trformat [`*options*`] [`*types*`]`

The following options are accepted:

`-h`	Displays only the trace entry header information. The data part of the trace entries is skipped.
`-c`	Checks the sequences in the entries to ensure that entries are not missing.
`-f` *filename*	Specifies the trace file that is to be formatted. Redirecting from standard input has the same effect.
`-v`	Specifies that detailed information is to be printed.
`-x`	Specifies that trace entry data is to be printed in hexadecimal format.
`-n`	Specifies that addresses are to be displayed in dot format, and that ports are to be displayed as integers.
`-m hex_bitmap`	Specifies the types of ID map entries to be formatted.
`-s hex_bitmap`	Specifies the types of NFS entries to be formatted.

The *type* option lets the user select entries of the specified type. The options for this field are the same as for the *generic options* field of the `trcollect` command.

2.5.3 Obtaining Trace Socket Status

You can use the `netstat`(1B) command to view the status of a trace socket. `netstat -f trace` displays all active trace sockets. Following is an example of output from this command:

```
Active trace connections
Trace.ID Recv-Q State Msize Que    Rds/Flsh  Tracing
     133      0  CONN  1024   3    11/0      ip(generic)
```

Following is a description of the fields:

Field	Description
`Trace.ID`	Current trace ID.
`Recv-Q`	Amount of data (in bytes) in the socket receive queue.
`State`	Connection state. `CONN` indicates that a socket is connected to a tracing entity.
`Msize`	Size of the mbufs queued on the trace socket.
`Que`	Mbuf queue length.
`Rds`	Number of reads (not including flushes) on the socket.
`Flsh`	Number of times buffers were flushed from the socket queue to the receive buffer space.
`Tracing`	Shows data that is currently being traced by this socket.

2.6 Security Administration Basics

This section presents information about security administration that you must know to administer the Cray Research system on an ML-Safe network. The following aspects are described:

- Network security functional overview
- Identification and authentication
- Network security configuration
- Error messages

It is assumed that the reader is familiar with UNICOS security and the Cray ML-Safe configuration of the UNICOS system. For details of security administration, see *General UNICOS System Administration*, publication SG–2301.

2.6.1 Network Security Functional Overview

To provide secure communications, the Cray ML-Safe configuration of the UNICOS system and UNICOS security require hosts and networks to be defined in a network access list (NAL), thereby providing the security administrator or a system administrator a means to control networked accesses. The NAL describes the security labeling values associated with each remote host. This information is used to enforce the mandatory access policy on a network address basis.

UNICOS ML-Safe network operation is based upon protection at two levels: the interface to the network and the application interface.

Two mechanisms work at the network-interface level. These are the NAL and network interface label ranges. The NAL provides the system with detailed information about the capabilities of all remote hosts and networks with which the UNICOS system operates. The network-interface-label ranges ensure that communication is carried out only over network media that provide the correct level of assurance in accordance with the sensitivity of the data being transferred.

Each incoming or outgoing Internet Protocol (IP) datagram has a security label associated with it. This label can be implicit (as defined in the NAL) or explicit (as transmitted in IP security options). The datagram label is used to enforce the restrictions imposed by the NAL and the network-interface-label range and to ensure that data is delivered only to applications with the proper active label.

For incoming and outgoing datagrams, the datagram label must fall within the label range of the network interface that is used and within the label range specified in the NAL entry associated with the remote host.

At the application level, the UNICOS ML-Safe network services provide protection by requiring positive identification and authentication for all network transactions (except those that provide public information). In addition, the workstation access list (WAL) optionally controls application access based on user ID and/or group ID and the host from which access is desired.

Incoming and outgoing security violations and integrity errors are recorded in the security log, and Internet control message protocol (ICMP) responses are issued in accordance with the security rules defined in the Request For Comments (RFCs) for the particular IP security option.

The `spnet`(8) command manipulates the NAL, WAL, and Internet Protocol Security Options (IPSO) mapping tables in kernel memory. A properly authorized user may add, delete, and list entries in all three tables. The `/etc/config/spnet.conf` file is the repository for the contents of these tables. The `spnet.conf` file is a free-form text file, which the site administrator can maintain by using the installation tool or by editing directly.

2.6.1.1 Network Access List (NAL)

The network access list (NAL) contains information about remote hosts (or networks) that are authorized to connect to the local UNICOS system to perform sensitive processing or to access sensitive information. The NAL resides in kernel memory and is maintained through the use of the `spnet` command.

Each NAL entry can apply to either a single host or an entire network. The structure of the NAL is similar to the structure of the routing tables in the kernel. When a search for a host is performed, an exact match is tried first. If no exact match is found, it searches the network portion of the address. Finally, if no network entry is found, it uses the optional default NAL entry.

Each entry in the NAL consists of the following information about the remote host:

- Minimum security label
- Maximum security label
- Send and receive message authorization modes
- Security class
- Security option support (IP basic security option (BSO), Common IP Security Option (CIPSO), or none)
  - Domain of interpretation for CIPSO
  - Protection authority (in and out) for IP BSO

The `spnet`(8) command creates and maintains the NAL, which is stored in the `/etc/config/spnet.conf` file.

If you are using the UNICOS ICMS, you can set up the NAL by using the `Configure system -> Multilevel security (MLS) configuration`

`-> Network security options -> MLS Network access list (NAL) sets` menu.

2.6.1.2 IPSO Mapping Entries

With UNICOS security or the Cray ML-Safe configuration of the UNICOS system, using connections that support Internet Protocol Security Options (IPSO), every incoming and outgoing packet has its security label information translated through a designated IPSO map. The map is designated in the NAL entry for the remote host on the network to which the UNICOS security or the Cray ML-Safe configuration of the UNICOS system is communicating.

To conserve space in the IP protocol, security levels and compartments are represented by numbers rather than by their ASCII equivalent. IPSO maps are translation tables that allow the security administrator to control the numeric network representations and to adjust for differences in the implementation of labels among hosts on the network. Every incoming and outgoing packet from a UNICOS system to a particular host on the network has its label information translated through a designated IPSO map.

IPSO maps are numbered and, optionally, named. The map number, known as the Domain of Interpretation (DOI) number, is a 32-bit quantity that is included in every IP packet. A DOI is a collection of hosts that share a common definition of label values and meanings. The UNICOS system validates the DOI number against the DOI value in the NAL entry for the remote host. When the IPSO attribute in the NAL is set to basic, the DOI number is 0 implicitly. You can use the map domain name as a convenience within an `spnet` input file for associating NAL entries with maps. The UNICOS ICMS requires this name, but a default name is generated automatically when the `spnet` input file is imported, if it is missing.

When you are creating an IPSO map, you must consider the following issues:

- The host-internal numeric level values range as follows: `syslow`, 0 to 16, `syshigh`.
- The host-internal numeric compartment values are each a power of 2 ranging from 2**0 to 2**62.
- The numeric network representations for levels range from 0 to 255, and for compartments, from 0 to 65534.
- Each local level or compartment value must correspond to only one network value.

- Each network level or compartment value must correspond to only one local value.
- Network administrators must ensure that network-wide mappings are nonpermuting; that is, a translation from host A to host B to host C to host A would result in the original label.
- DOI 0 supports four levels and no compartments.

2.6.1.3 IP Security Options

An IP datagram always has an associated security label that is either implicit in the NAL definition or is explicitly carried with the packet that uses an IP security option in the options portion of the IP header. UNICOS security supports two explicit labeling types: the IP basic security option (IP BSO) (defined in Internet RFC 1108), and the Common IP Security Option (CIPSO) (defined in draft 2.2 of the Trusted Systems Interoperability Group (TSIG) document, "The Common IP Security Option").

Both of these options represent security labels in a network representation that differs from the UNICOS internal representation. UNICOS security allows mapping table definitions that are used to translate between the network and host representations, and can adjust for differences in representations between hosts.

2.6.1.3.1 IP Basic Security Option (IP BSO)

The IP BSO is limited to providing the following sensitivity levels and no compartments:

- Unclassified
- Confidential
- Secret
- Top secret

By default, these levels map to the UNICOS levels 0, 1, 2 and 3, respectively. A site can override this default mapping, if required (see Section 2.6.3.6.5, page 236).

The IP BSO also carries a bit mask that represents a set of protection authorities. Network interfaces are marked with the valid protection authorities for which data can be sent or received on that interface. The NAL entries for hosts that use the IP BSO specify the protection authorities required on packets received from each host and the protection authorities that will be placed on datagrams destined for each host (see ‘‘Section 2.6.3.6.3, page 231).

2.6.1.3.2 Common IP Security Option (CIPSO)

The CIPSO allows the representation of one of 256 levels and several of 65,535 compartments on each datagram. A Domain of Interpretation (DOI) identifies a mapping from a defining authority's level and compartment names to the network numerical representation. A DOI is identified by a 32-bit number, thus allowing for 232 possible DOIs.

No default mapping exists between UNICOS labels and CIPSO labels. To use the CIPSO, you must define an IP mapping table for each DOI with which communication is to occur, and load it into the kernel.

Each host that uses the CIPSO is identified with one particular DOI, which is specified in the NAL (see Section 2.6.3.6.3, page 231).

2.6.1.4 Workstation Access List (WAL)

The workstation access list (WAL) provides access control authorization for application-layer services. An entry in the WAL can apply to hosts or to an entire network. You can also create an optional default entry.

A WAL entry consists of a list of user/group pairs and the services for which those users and groups are allowed access. The user and/or the group can be wildcarded. The login user ID and primary group of the subject are used to perform WAL permission checks. First, a check is performed for the specific user and group, or for the user and a wildcard group. If no match occurs, a check is performed for the group. Finally, if no match has occurred, the *.* entry is used.

2.6.2 Identification and Authentication

Every subject (user) must be authenticated before being allowed access to UNICOS system services and sensitive data. For remote access, most subject authentications are initiated by `telnetd`(8) or `rlogind`(8), which connect to the `login`(1) process or by `ftpd`(8), which performs user validation. The NFS daemon conducts the authentication of subjects for NFS services. The NQS daemon conducts the authentication of subjects for NQS services.

2.6.2.1 Login Authentication

Each login request is based on a valid password entry (or SecurID value). Security clearances assigned are determined by the most restrictive set that is specified by the user database (UDB) in the `/etc/udb` file, the NAL, and the network interface over which the connection is made. The subject clearances that are granted for an authenticated user include the following:

- Active security label
- Minimum and maximum security label

When running one of the IPSOs, and when running the Cray ML-Safe configuration of the UNICOS system, the active security label of a session cannot be changed.

2.6.3 Network Security Configuration

This section describes the configuration operations for the UNICOS UNICOS network security. All of the information in Section 2.2, page 23, is applicable for a successful TCP/IP with UNICOS security enabled, and it should be read and followed prior to the UNICOS security configuration.

2.6.3.1 UNICOS Security Configuration Guidelines

The security configuration guidelines for the UNICOS security network software recommend that operations be performed in the following order:

1. Install the UNICOS operating system as released.
2. Install the network software as released.
3. Verify that the system operates correctly.
4. Verify the UNICOS security was installed with the default option settings.
5. Change the default options set for the UNICOS release, as necessary.

Note: The `named`(8) name server is not allowed under the Cray ML-Safe configuration of the UNICOS system.

When `named` is used with UNICOS security, there are special considerations. When the UNICOS system is put into multiuser mode, the `spnet`(8) command defines the NAL entries that allow socket communications. It reads the text version of the NAL from the `/etc/config/spnet.conf` file and translates the host names to host addresses. The `named` service will not be operating at this time because localhost sockets have not yet been allowed by a NAL entry. This means that name-to-address translations will be done from the /etc/hosts file (or /etc/hosts.bin, if it exists), which must be current and contain all of the hosts named in the spnet.conf file. The same is true for networks named in the spnet.conf file and translations from the /etc/networks files.

2.6.3.2 Network Security Options

The UNICOS security software for networks is activated when the security feature is enabled for the UNICOS operating system. This setting is maintained in low memory. See Section 2.6.3.6, page 230, for installation details.

Your site can alter the network security options described in the following sections to modify certain aspects of the operation of the ML–Safe network software. You can change these options by using the installation tool or by editing the kernel source file config.h. If you change any of these options, you must rebuild the UNICOS kernel.

Each configuration option is represented by a bit in the SECURE_NET_OPTIONS macro in the config.h file. To turn on an option, the option bit is OR'ed into SECURE_NET_OPTIONS.

Warning: When you are running the Cray ML-Safe configuration of the UNICOS system, some of the options described in this section require specific values. These options are noted where appropriate.

2.6.3.2.1 Strict B1 Networking: NETW_STRICT_B1

The NETW_STRICT_B1 kernel option, when enabled, requires that all IP datagrams be unambiguously labeled. This means that hosts that do not use IP security options cannot have differing minimum and maximum labels in the NAL. If the system is configured as the Cray ML-Safe configuration of the UNICOS system, this option is turned on by default and must remain on in order to meet the requirements of the evaluation.

Note: When you are running the Cray ML-Safe configuration of the UNICOS system, the NETW_STRICT_B1 configuration option must be turned on.

2.6.3.2.2 Multilevel Socket Compatibility: NETW_SOCK_COMPAT

The NETW_SOCK_COMPAT option, when enabled, automatically makes a socket created by an ML-Safe process into a multilevel socket. Set this option only if there are existing site-supplied ML–Safe processes that expect this socket behavior. Use of this option is strongly discouraged. If the system is running the Cray ML-Safe configuration of the UNICOS system, this option is turned off by default and must remain off in order to meet the requirements of the evaluation.

An ML-Safe process has `PRIV_SOCKET` in a privilege assignment list (PAL) system or an ID of `root` in a `PRIV_SU` system. When the socket becomes connected, the socket's active label is frozen. When the socket is created, its minimum and maximum labels are set to the process minimum and maximum labels.

> **Note:** When you are running the Cray ML-Safe configuration of the UNICOS system, the `NETW_SOCK_COMPAT` configuration option must be turned off.

2.6.3.2.3 `r` Command Compatibility: `NETW_RCMD_COMPAT`

The default behavior when UNICOS security is running is to require a host to be identified in both the `/etc/hosts.equiv` file and the user's `.rhosts` file, and the user must have the same ID on both systems. To operate with the traditional behavior, which requires a host to be identified in either the `/etc/hosts.equiv` file or the user's `.rhosts` file, set the `NETW_RCMD_COMPAT` option. This option can be set by using the installation tool or by editing the `cf/config.h` file.

2.6.3.3 NFS Configuration Options

Network file system (NFS) configuration options are maintained in low memory. The options are as follows:

Option	Description
NFS secure export	When enabled, this option indicates that `NFS` is permitted to export file systems that are labeled with security levels and/or compartments. This option is enabled with the UNICOS release. It is maintained in the `nfs_secure_export_ok` variable in the `config.h` file. A nonzero value indicates that exporting file systems that are labeled with security levels and/or compartments is permitted.
NFS remote read/write	Indicates that NFS is permitted to import remote file systems in read/write mode. This option is enabled with the UNICOS release. It is

	maintained in the `nfs_remote_rw_ok` variable in the `config.h` file. A value of 0 indicates read-only mode; a nonzero value indicates read/write mode.
UID mapping	See Section 3.1.6.8, page 273, and Section 3.1.6.9, page 275, respectively, for details of these options.

If you are using the UNICOS ICMS to select NFS export and import restrictions, use the `Configure system -> Multilevel security (MLS) configuration -> Network security options` menu with the `OK to export unclassified data via NFS` or `OK to import unclassified data via NFS` selections.

2.6.3.4 Restricting Access to Network Interfaces

UNICOS security supports a configuration option for restricting access to network interfaces to privileged processes. This option can be used to limit access to the OWS-E, MWS, and SWS workstations. To enable this option, invoke the `/etc/ifconfig` command with the `admin` keyword, as in the following example. To disable, use the `-admin` keyword.

```
# /etc/ifconfig np0 admin
# /etc/ifconfig np0
np0: flags=2041<UP,RUNNING,ADMIN> iftype vme
        inet 223.255.25.5 netmask ffffff00
level0-level16 compart 0-07777777777777777777
```

Note: When you are running the Cray ML-Safe configuration of the UNICOS system, the OWS-E interface must have the `admin` option set.

2.6.3.5 Labeling Network Interfaces

The network security installation process also includes setting the proper labels on network objects such as network interfaces. When the system is up and running, you can set these labels manually or you can use the UNICOS ICMS. For more information, refer to Section 2.2.9.6, page 113. To perform this task in multiuser mode, the administrator must be running as `root` in a `PRIV_SU` system, and/or have the appropriate security category active in a PAL system.

The network interfaces are labeled with minimum and maximum security labels.

Note: System daemons must be able to access the loopback interface at any label. Set the label range of the loopback interface the same as the system range. When the system is configured to enforce system high/system low labels, the label range must be `syslow` to `syshigh`.

2.6.3.5.1 Network Interface Label

Use the following command to assign a security label to a network interface:

`/etc/ifconfig` *ifname* `level` *min-max* `compart` *min-max*

Use the following command to display the security label of a network interface:

`/etc/ifconfig` *ifname*

In the following example the security label of network interface `np0` is displayed, and the label range of the loopback interface is set:

```
# /etc/ifconfig np0
np0: flags=41<UP,RUNNING>
        inet 201.201.201.2 netmask ffffff00
level level0-syshigh compart 0x0-0x9
# /etc/ifconfig lo0 level syslow-syshigh
        compart 0-07777777777777777777
```

2.6.3.5.2 Network Security Configuration Example

The commands typically used when installing network security are as follows: `ifconfig`(8), `netstat`(1B), `spget`(1), and `spset`(1). This section contains a configuration example for a UNICOS security network (see Figure 16) and describes the installation commands that can be used. The example is UNICOS security with several hosts connected. Assume the following information:

- The UNICOS security host is a CRAY Y-MP system with a serial number of 1007.
- Hosts connected to the `b-net` network support the BSO.
- Hosts connected to the `c-net` network support the CIPSO.

  Note: It is always advisable to install and verify the released UNICOS system (with default option settings) before changing any default options.

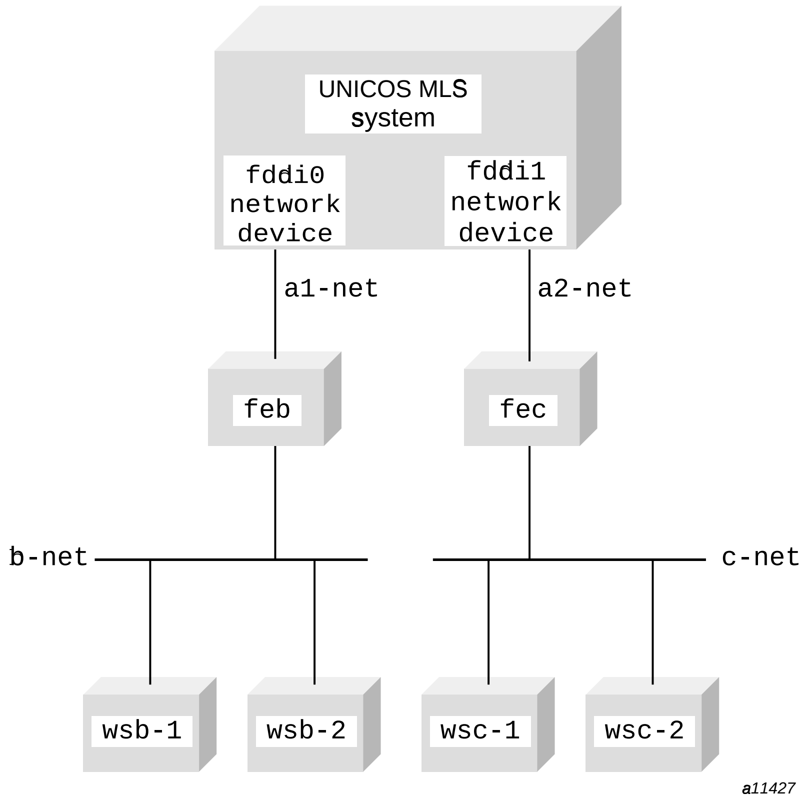


Figure 16. Configuration example

To initialize the network interfaces `np0` and `np1`, set up the `/etc/config/interface` file as follows:

```
np0 - inet crayb netmask 0xffffff00
np1 - inet crayc netmask 0xffffff00
```

To establish the routes shown in the example, use the following `route` commands:

```
/etc/route add b-net feb      *** b-net traffic thru feb
/etc/route add c-net fec      *** c-net traffic thru fec
```

To see how the network interfaces are configured, use the `netstat -i` command. Following is an example of a partial display:

```
# netstat -i

Name    Mtu     Network    Address

np0     32880   a1-net     crayb
np1     32880   a2-net     crayc
```

To obtain information and security labels for the network interface `np0`, use the `ifconfig np0` command.

To observe network route information, use the `netstat -rv` command.

2.6.3.6 Network Security Configuration Procedures

This section describes each of the steps you must follow for proper network security configuration. The steps are as follows:

1. Set options.
2. Check the system label.
3. Create the NAL.
4. Create the WAL.
5. Create the label map tables.
6. Label the network interfaces.

2.6.3.6.1 Step 1 - Setting Options

If you are going to use the UNICOS system without changing the installation options, you can skip the rest of this step and go directly to step 2.

When the UNICOS system has been installed as released and UNICOS security has been verified to operate correctly, you can make any changes to the released default configuration options (see Section 2.6.3.2, page 225).

You can use the UNICOS ICMS to set the configuration options through a menu presentation. After these options have been set, the UNICOS kernel must be rebuilt, shut down, and restarted.

If you are not using the UNICOS ICMS to set the installation options, you must set the options by making changes to the source in the `/usr/src/uts/cf.`*sn* `/config.h` file. After these options have been set in the source files, the

UNICOS kernel must be rebuilt, shut down, and restarted. When the startup of the system is complete, proceed to the next step.

2.6.3.6.2 Step 2 - Checking the System Label

Because the system security label sets the security ranges for the UNICOS security environment, you should understand these security values before you label network interfaces and define the security ranges to be established for the remote hosts in the NAL. In some network configurations it might be necessary for ML–Safe daemons to communicate over the network (for example, when the Data Migration Facility (DMF) operates on one host and uses storage media on another host). In a case like this you must establish a range in the NAL and on the interface for the communication path to allow the `syshigh` label. To avoid run-time security violations, you should restrict the security label ranges applied to network objects to be within the system boundaries. However, a range that ends with `syshigh` includes all of the levels that are higher than the beginning of the range. Because of this effect, the use of `syshigh` in a label range should be minimized.

To see the current security label for UNICOS security, enter the `spget -s` command. This command produces the following sample output:

```
# spget -s

system minimum level is  0
                level0
system maximum level is 16
                level16
valid system compartments are 0777777777777777777777
                comp24
                comp39
                comp63
```

The names associated with the levels and compartments are configured in the site's `cf.` *nnnn* `/seclab.c` file. Remember the system's minimum and maximum security label when you label the network interfaces and when you set security labels for remote hosts in the NAL. Refer back to this step as necessary when you perform subsequent steps.

2.6.3.6.3 Step 3 - Creating the NAL

Before you create the network access list (NAL), identify the hosts and networks with which you want to communicate, and decide if you want a default entry (if you configured the NETW_EXEMPT_NAL flag in prior releases, you will probably want to do this). For each host or network identified, do the following:

- Determine the host classification. The host classification designates the capabilities and level of trust assigned to a remote host. The class value is one of the following: D, C1, C2, B1, B2, B3 and A1. By default, a host is classified as B1.

  Note: The class is used only as an indication of function, it does not necessarily indicate the evaluated rating of the host.

  Hosts classified as D are not trusted to perform any of the functions of mandatory access control (MAC), discretionary access control (DAC), auditing, or identification and authentication (I&A). However, a class D host must be administratively or physically protected such that it does not receive packets for another destination, and it must ensure that the correct source address is placed in all outgoing packets. A class D host can operate at only a single security label.

  Hosts classified as C1 satisfy the class D requirements and also provide I & A and DAC functionality. Despite the additional functionality, the UNICOS system treats class C1 and class D hosts the same, because C1 hosts do not perform auditing.

  Hosts classified as C2 satisfy the class D and class C1 requirements and also provide audit functionality. In addition, a C2 host must restrict TCP and UDP reserved port numbers (those less than 1024) to ML–Safe users with the required privilege. The UNICOS system allows the relegation of I&A to C2 hosts by allowing assertion of identity on these reserved ports. You might choose this class for workstations even when they do not provide auditing, so that they can provide I&A information to the UNICOS system. However, this classification is not allowed with the Cray ML-Safe configuration of the UNICOS system.

  Note: For r-series commands, such as rlogin, rcp, and rsh, the host must be listed as class C2 or higher to establish a connection. This is also true for remote line printing through lpd, and for NFS clients.

  Hosts classified as B1, B2, B3 or A1 satisfy all the D, C1, and C2 requirements and also enforce MAC policy. Thus, a host designated with B1, B2, B3, or A1 classification is allowed to have minimum and maximum labels that differ. If the NETW_STRICT_B1 configuration is selected, such a host must use an IP security option.

- Determine whether IP security options are to be used. Either the BSO or the CIPSO can be used. In the case of the BSO, the allowed (incoming) and required (outgoing) protection authorities must be identified. For CIPSO, the DOI must be identified.
- Determine the appropriate label range. For multilabel systems (the minimum and maximum labels are not the same), the class must be B1 or higher, and an IP security option must be used (BSO or CIPSO). The security option is not required when the `'Strict B1 evaluation rules'` option is not configured. This option is found in the `Configure system -> Multilevel security (MLS) configuration -> Network security options` menu in the installation tool.

  Note: The `localhost` NAL entry is an exception. It must have a label range that is the same as the system range and a class equal to B1, but it must not have an IP security option. When the system is configured to enforce system high and low security labels, the label range for local host must be `syslow` to `syshigh`.

- Determine the access modes. Specifying `send` allows TCP connections from the local system to the remote system to complete. Specifying `receive` allows TCP connections from the remote system to the local system to complete. If set to `none`, no communication is allowed with the remote host. If omitted, the mode attribute defaults to `send` and `receive`.

The NAL configuration data is located in the `/etc/config/spnet.conf` file. It is identified by the `nal` keyword, followed by the NAL data, enclosed in curly braces. The following code shows an example of the NAL portion of the `spnet.conf` file:

```
nal {
    ip host localhost  {
        class = B1;
        min label = syslow;
        max label = syshigh, 07777777777777777777777;
    }
    ip net default {
        min label = 0;
        max label = 0;
        class = D;
    }

    ip net basic-net { !default class = B1
        min label = 0;
        max label = top_secret;
```

```
        ipso = basic;
        auth-in = 0x8;!DOE
        auth-out = 0x8;!DOE
    }

    ip net cipso-net { !default class = B1
        min label = 0;
        max label = level16, software, accounting, engineering;
        ipso = cipso;
        doi = 1;
    }

    ip non-cipso-host { !default ipso = none
        min label = 0;
        max label = 0;
        class = C2;
    }
}
```

In the preceding example, two local networks use IP security options. One uses BSO and the other uses CIPSO. A default entry is defined, which allows any other hosts to access the UNICOS system at level 0 only. In addition, one host on the `cipso-net` network `non-cipso-host` does not use the `cipso` option; therefore, a host entry is defined with the minimum and maximum labels of 0.

The range of the local host entry must be equivalent to the system range. The range should be from `syslow` to `syshigh` on systems with the `SECURE_MAC` configuration parameter set.

NAL entries become active when they are loaded at start-up time, or they are loaded manually by using the `spnet add -nal` command.

If you are using the UNICOS ICMS, you can set up the NAL by using the `Configure system -> Multilevel security (MLS) definitions -> MLS Network security options -> Network Protocol Security Configuration -> MLS Network Authorization List (NAL) Sets` menu.

For more information on the NAL configuration and the operation of the `spnet` command, see the `spnet`(8) man page.

2.6.3.6.4 Step 4 - Creating the WAL

The workstation access list (WAL) controls application access authorization by host, user, and group identification.

The WAL configuration data is located in the `/etc/config/spnet.conf` file. It is identified by the keyword `wal`, followed by the WAL data, enclosed in curly braces. The following code shows an example of the WAL portion of the `spnet.conf` file:

```
wal {
    ip net default {
        *.* = all;
    }

    ip net network-a {
        0.* = none;
        fred.* = ftp;
        *.* = all;
    }

    ip host-b {
        *.* = none;
        sally.* = login, ftp;
        *.red = ftp;
        *.blue = login;
    }
}
```

In this example, a default entry, a network entry, and a host entry are defined. By default, all users in all groups are granted access to all WAL-controlled applications. On the network called `network-a`, user `root` is not allowed access, user `fred` is allowed only `ftp` access, and everyone else is allowed access to all WAL-controlled applications. For host `host-b`, user `sally` is allowed `login` and `ftp` access, users in group `red` are allowed `ftp` access, users in group `blue` are allowed `login` access, and everyone else is denied access.

WAL entries become active when they are loaded at start-up time, or when the `spnet add -wal` command is used to load them manually.

If you are using the UNICOS ICMS, you can set up the WAL by using the `Configure system -> Multilevel security (MLS) configuration -> MLS Network security Definitions -> Network Protocol`

`Security Configuration-> MLS Workstation access list (WAL) Sets` menu.

For more information on the WAL configuration and the operation of the `spnet` command, see the `spnet`(8) man page.

2.6.3.6.5 Step 5 - Creating Translation Tables

This section describes creation of translation tables for hosts that support the IP basic security option (BSO) and for hosts that support CIPSO. The IP security option mapping tables are defined in the `/etc/config/spnet.conf` file. Multiple maps might be defined. They are identified by the keyword `map`, followed by map definitions, inside curly braces.

The following code shows an example of map definitions in the `/etc/config/spnet.conf` file:

```
map {
     basic {
        levels {
            0 = 0;
            1 = 1;
            2 = 2;
            3 = 3;
        }
    }

    cipso 1 {
        levels {
            public = 0;
            private = 1;
            proprietary = 2;
            syslow = 063;
            syshigh = 066;
        }
        compartments {
            accounting = 1;
            software = 2;
            engineering = 3;
        }
    }
}
```

In this example, two maps are defined. The first map defines the mapping for the basic security option. For the purpose of defining the map, network levels 0, 1, 2, and 3 correspond to the following basic levels, respectively: unclassified, confidential, secret, and top secret.

The `cipso` map definition defines a mapping for CIPSO domain of interpretation 1.

Translation tables become active when they are loaded at start-up time, or when the `spnet add -map` command is used to load them manually.

If you are using the UNICOS ICMS, you can set up the `cipso` map by using the `Configure system -> Multilevel security (MLS) configuration -> MLS Network security Definitions -> Network Protocol Security Configuration -> CIPSO Map Domain Sets` menu.

For more information on map configuration and the operation of the `spnet` command, see the `spnet`(8) man page.

2.6.3.6.6 Step 6 - Labeling the Network Interfaces

After UNICOS security is installed and operating, the security label of the network interfaces can be changed or set.

To set a security label on the network interfaces `lo0`, `np0`, and `np1` in the configuration example shown in Figure 16, page 229, enter the following commands:

```
/etc/ifconfig lo0 level syslow-syshigh compart 0-7777777777777777777777
/etc/ifconfig np0 crayb netmask 0xffffff00 level 0-6 compart 0-7
/etc/ifconfig np1 crayc netmask 0xffffff00 level 0-syshigh compart 0-777
```

To verify the security label settings, display the security label of a network interface by entering the `ifconfig` *ifname* command, as follows:

```
# /etc/ifconfig np0

np0: flags=41<UP,RUNNING>
        inet 128.162.82.1 netmask ffffff00
level0-level6 compart 0x0-0x7
```

2.6.3.7 `inetd` Operation

The `inetd` operation has been modified so that it can be used safely in a UNICOS security environment. `inetd` opens each listen socket as a multilabel socket capable of receiving requests at any label that is valid for the user that is requesting a service. When a TCP connection request or UDP datagram is received, `inetd` forks the server at the same label as the incoming connection or datagram, and passes it as a single-label socket at that label.

On a system that uses privilege assignment lists (PALs), `inetd` leaves the `system` category active. ML–Safe servers should have a PAL that grants them the necessary privilege.

> **Warning:** When you are running the Cray ML-Safe configuration of the UNICOS system, you cannot add ML–Safe servers to `/etc/inetd.conf` other than those supplied.

2.6.4 Error Messages

This section lists the error messages that are presented to the user when security violations are detected. The conditions that can produce the error messages are summarized, and the general corrective measures are stated.

These error messages can be presented for error conditions other than network security violations; therefore, this section also describes a method for searching for IP audit records in the security log. The administrator must analyze the security log entries to determine the actual security violation.

Finally, this section describes the steps you can use to isolate and correct the problems reported. These network security debugging guidelines should be applied in addition to those in Section 2.4, page 175.

2.6.4.1 Network Access Violations

The security violations detected for network access operations are always recorded in the security log and reported to the user with an error message. For the detected security violations, the administrator should further investigate the error messages reported to the user either by analyzing the security log or by checking for the conditions that are associated with the error message. To obtain the exact violation condition, the administrator must use the `reduce`(8) command to extract the actual network security violation. See Section 2.6.4.2, page 241, for more information on using this command.

> **Note:** UNICOS NFS does not record all detected security violations in the security log.

The error messages presented to the user are as follows:

- `Connection timed out`
- `Host is unreachable`
- `Login incorrect`
- `Network is unreachable`
- `Permission denied`
- `Software caused connection abort`

This section describes the possible security violations that could generate each message.

2.6.4.1.1 `Connection timed out`

This message is usually displayed at the remote host when UNICOS security detects a security violation with the incoming request from the remote host. This message is presented when one of the following security violation conditions are sensed:

- The security label of the incoming datagram does not fall within the security label range of the UNICOS security host.
- An entry for the remote host does not exist in the NAL.
- The remote host specified in the NAL is not authorized to receive datagrams from this UNICOS system.
- The remote connection requires an IP security option and the incoming IP datagram does not contain the IP security option.
- A network-security-label to host-security-label translation error occurred.
- The remote host requires the CIPSO and a translation table is not available on UNICOS security for the remote host's domain of interpretation.

The `connection timed out` responses for the most common commands are as follows:

```
ftp sn7007
ftp: connect: Connection timed out
```

```
ping sn7007
sn7007 not responding
```

```
rlogin sn131
sn131: Connection timed out

telnet sn7007
Trying 128.162.82.1
telnet: Unable to connect to remote host:
Connection timed out
```

The `Connection timed out` message usually indicates a problem with the NAL entry for the remote host when it attempts to access the UNICOS security host. Your first isolation step should be to check the NAL values for the remote host. The security log for `netip` record type might also provide additional information.

2.6.4.1.2 `Host is unreachable`

This message can be displayed when routing by group ID fails.

2.6.4.1.3 `Login incorrect`

This message is issued by a user validation process (for example, `ftp` or `login`) when it detects that user access from the given remote host or to the requested service is not authorized in the WAL. Some of the network services that require authorization are `ftp` and `telnet`.

For a UNICOS system, the WAL can be used to allow or to disallow the use of the following services:

- `ftp`
- `login` (`telnet`, `rlogin`, and `rsh` without a command)
- `nfs`
- `nqs`
- `rexec`
- `rsh`

The other conditions that initiate the `Login incorrect` message are as follows:

- Login is denied because of a WAL violation

- Login process request to set the user's security values (through the `setusrv` system call) failed
- Maximum number of attempts to login were exceeded

2.6.4.1.4 `Network is unreachable`

This message can be displayed when the security label of incoming datagram does not match the network interface.

This message is usually issued when an IP datagram has a security label that does not fit within the security label range for the network interface. Your first isolation step should be to check the security labels of the network interfaces.

2.6.4.1.5 `Permission denied`

This error message is typically issued because of an error or security violation detected for an outgoing transmission request from a UNICOS security process; it is displayed when one of the following security violations is detected:

- The security label of the outgoing request does not fit within the security label range of the remote host in the NAL or on the interface.
- An entry for the remote host does not exist in the NAL.
- The remote host specified in the NAL is not authorized to receive datagrams from this UNICOS system.
- A security label mapping error was detected for an outgoing datagram.

The `Permission denied` message usually indicates a problem with the NAL entry for the remote host that the UNICOS security host process is attempting to access. Your first isolation step should be to check the NAL values for the remote host.

2.6.4.1.6 `Software caused connection abort`

This message is displayed when the security label of the incoming datagram is not within the security label range of the socket connection.

2.6.4.2 `reduce`(8) Command

The `reduce`(8) command provides detailed information on network security violations. For information about the security log, see the description of the

UNICOS security feature in *General UNICOS System Administration*, publication SG–2301.

2.6.4.3 Problem Isolation Guidelines

This section describes solutions for problems that occur because of changes in the UNICOS security configuration or inconsistencies in the applied security privileges.

2.6.4.3.1 Session Hangs

When an interactive or batch session hangs, you receive no response to commands. This situation can occur when the NAL entries defined for your remote host were altered after your session started. If a NAL entry for your remote host changed to exclude your session's label from the entry's range, your UNICOS session no longer communicates with your remote host or workstation.

The session hang condition can also occur if network interfaces are altered such that the UNICOS process can no longer access the network.

2.6.4.3.2 Security Log Entries

The security log contains records of security violations detected by the kernel. Use the `reduce` command to recover network security violations recorded in the security log. For more security log information and examples, see the description of the UNICOS security feature in *General UNICOS System Administration*, publication SG–2301.