TCP/IP and Data Communications Administration Guide

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Contents

Preface

This manual explains how to set up, maintain, and expand a network running the Solaris™ implementation of the TCP/IP protocol suite. The manual

- Defines networking concepts used when working with TCP/IP
- Describes tasks necessary for setting up a new network
- Presents information for maintaining the network
- Explains how to expand the existing network by using routers to create an internetwork
- Describes how to use Point-to-Point Protocol (PPP) to allow remote machines to connect to the network
- Explains how to set up communications with remote machines through the UNIX-to-UNIX Copy Program (UUCP)
- Introduces the Dynamic Host Configuration Protocol (DHCP) and describes both the client and server side of the protocol

Who Should Use This Book

This manual contains information for network administrators with a wide range of experience. The text assumes that you are already familiar with the Solaris environment and have administered local machines and peripheral devices such as modems.

If you are setting up a new network, read this manual before going on to the other books in the Solaris 2.5 System Administrator set. If you are administering or expanding an existing network, refer to the specific chapters related to the tasks that you want to perform.

Note - If you need to set up a brand new network at a site that has never had a Solaris or other UNIX-based network, read Chapter 3 before installing the Solaris software. This chapter provides important information that supplements the installation tasks in *Solaris Advanced Installation Guide.*

Reading the chapters in sequence is not required, but each chapter assumes that you are familiar with the contents of previous chapter.

Before You Read This Book

You should be familiar with the information contained in the following books before continuing with this manual:

- *Solaris Advanced Installation Guide*
- *Solaris 2.3 Advanced User's Guide*
- *Mail Administration Guide*
- *System Administration Guide, Volume I*

How This Book Is Organized

This manual contains the following chapters.

Chapter 1 describes the tasks a network administrator is likely to perform and introduces basic networking concepts.

Chapter 2 introduces the protocols composing the TCP/IP protocol suite.

Chapter 3 presents the issues that you need to consider when designing a new network, such as Internet Protocol (IP) addressing, network topology, and so forth.

Chapter 4 contains procedures for setting up the machines on the new network.

Chapter 5 explains how to expand the network through use of routers.

Chapter 6 explains how to use the tools available for diagnosing and fixing TCP/IP-related problems.

Chapter 7 introduces the PPP data link protocol that enables you to expand a network through use of modems and phone lines.

Chapter 8 explains issues that you need to consider when designing a particular PPP configuration.

Chapter 9 contains procedures for configuring two basic types of PPP links.

Chapter 10 explains how to diagnose and fix problems related to PPP.

Chapter 11 contains information for setting up more complex PPP links.

Chapter 12 explains how to set up the UUCP database files.

Chapter 13 explains how to start up UUCP and troubleshoot problems on UUCP links.

Chapter 14 introduces the Dynamic Host Configuration Protocol, which allows a host to get an Internet Protocol (IP) address and other Internet configuration parameters without any need for preconfiguration by the system administrator.

Chapter 15 describes the differences between DHCP and earlier protocols and how to migrate from these protocols to DHCP.

Chapter 16 explains how to set up a network running DHCP, determine a lease time policy, add BOOTP relay agents, and create macros within some of the databases used by DHCP.

Chapter 17 describes how to troubleshoot problems you may have while using DHCP.

Appendix A contains troubleshooting techniques that are specific to PCNFSpro running as the Windows client.

Related Books

After you have set up the network, you probably will want to add the network services provided by the Solaris operating environment. They are described in the following books that are part of your System Administration Document Set:

- *NFS Administration Guide*
- *Solaris Naming Administration Guide*
- *Solaris Naming Setup and Configuration Guide*
- *NIS+ Transition Guide*

You can also find invaluable information for managing heterogeneous TCP/IP networks in the following books:

- Bart Anderson, Bryan Costales, and Harry Henderson. *UNIX Communications*. Howard W. Sams & Company, 1987.
- William R. Cheswick and Steven M. Bellovin. *Firewalls and Internet Security*. Addison Wesley, 1994.
- Craig Hunt. *TCP/IP Network Administration*. O' Reilly & Associates, Inc., 1993)
- Ed Krol. *The Whole Internet User's Guide and Catalog*. O' Reilly & Associates, Inc., 1993.

- Tim O' Reilly and Grace Todino. *Managing UUCP and Usenet*. O' Reilly & Associates, Inc., 1992.
- W. Richard Stevens. *TCP/IP Illustrated, Volume 1, The Protocols*. Addison Wesley, 1994.

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- For a list of documents and how to order them, see the catalog section of SunExpress™ Internet site at `http://www.sun.com/sunexpress`

What Typographic Changes and Symbols Mean

Table P–1 describes the type changes and symbols used in this book

TABLE P–1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `machine_name% You have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`machine_name%` **`su`** `Password:`

TABLE P–1 Typographic Conventions *(continued)*

Typeface or Symbol	Meaning	Example
AaBbCc123	Command-line placeholder: replace with a real name or value	To delete a file, type `rm` *filename.*
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in *User's Guide.* These are called *class* options. You *must* be root to do this.

Shell Prompts in Command Examples

Table P–2 shows the default system prompt and superuser prompt for the C shell, Bourne shell, and Korn shell.

TABLE P–2 Shell Prompts

Shell	Prompt
C shell prompt	`machine_name%`
C shell superuser prompt	`machine_name#` *System Administration Guide, Volume I*
Bourne shell and Korn shell prompt	`$`
Bourne shell and Korn shell superuser prompt	`#`

PART I

Setting Up and Administering TCP/IP Networks

Part 1 explains how to set up a network that will run the Solaris implementation of TCP/IP. The text assumes that you are familiar with UNIX and have some experience administering local UNIX systems. It does not assume that you are an experienced network administrator.

CHAPTER 1

Overview of Network Administration

This chapter introduces the role of the network administrator. If you are a new network administrator, the topics covered give you an idea of the tasks you might perform. The chapter then presents fundamental networking concepts that you need to know as you progress through this book. If you are an experienced network administrator, consider skipping this chapter.

Responsibilities of the Network Administrator

As a network administrator, your tasks generally fall into four areas:

- Designing and planning the network
- Setting up the network
- Maintaining the network
- Expanding the network

Each task area corresponds to a phase in the continuing life cycle of a network. You may be responsible for all the phases, or you may ultimately specialize in a particular area; for example, network maintenance.

Designing the Network

The first phase in the life cycle of a network involves creating its design, a task not usually performed by new network administrators. Designing a network involves making decisions about the type of network that best suits the needs of your organization. In larger sites this task is performed by a senior network architect: an experienced network administrator familiar with both network software and hardware.

Chapter 3 describes the factors involved in network design.

Setting Up the Network

After the new network is designed, the second phase of network administration begins, which involves setting up and configuring the network. This consists of installing the hardware that makes up the physical part of the network, and configuring the files or databases, hosts, routers, and network configuration servers.

The tasks involved in this phase are a major responsibility for network administrators. You should expect to perform these tasks unless your organization is very large, with an adequate network structure already in place.

Chapter 4 contains instructions for the tasks involved in this phase of the network life cycle.

Maintaining the Network

The third phase of network administration consists of ongoing tasks that typically constitute the bulk of your responsibilities. They might include:

- Adding new host machines to the network
- Network security
- Administering network services, such as NFS®, name services, and electronic mail
- Troubleshooting network problems

Chapter 4 explains how to set up new hosts on an existing network. Chapter 6 contains hints for solving network problems. For information on network services, refer to the *NFS Administration Guide*, the *Solaris Naming Administration Guide*, the *NIS+ Transition Guide*, and the *Mail Administration Guide*. For security-related tasks, refer to the *System Administration Guide, Volume I*.

Expanding the Network

The longer a network is in place and functioning properly, the more your organization might want to expand its features and services. Initially, you can increase network population by adding new hosts and expanding network services by providing additional shared software. But eventually, a single network will expand to the point where it can no longer operate efficiently. That is when it must enter the fourth phase of the network administration cycle: expansion.

Several options are available for expanding your network:

- Setting up a new network and connecting it to the existing network using a machine functioning as a router, thus creating an internetwork
- Configuring machines in users' homes or in remote office sites and enabling these machines to connect over telephone lines to your network
- Connecting your network to the Internet, thus enabling users on your network to retrieve information from other systems throughout the world
- Configuring UUCP communications, enabling users to exchange files and electronic mail with remote machines

Chapter 5 contains procedures for setting up an internetwork. explains how to set up networking connections for nomadic computers. explains how to use UUCP to exchange information between your machine and other UUCP systems.

What is TCP/IP?

A network *communications protocol* is a set of formal rules that describe how software and hardware should interact within a network. For the network to function properly, information must be delivered to the intended destination in an intelligible form. Because different types of networking software and hardware need to interact to perform the network function, designers developed the concept of the communications protocol.

The Solaris operating environment includes the software needed for network operations for your organization. This networking software implements the communications protocol suite, collectively referred to as *TCP/IP*. TCP/IP is recognized as a standard by major international standards organizations and is used throughout the world. Because it is a set of standards, TCP/IP runs on many different types of computers, making it easy for you to set up a heterogeneous network running the Solaris operating environment.

TCP/IP provides services to many different types of computers, operating systems, and networks. Types of networks range from local area networks, such as Ethernet, FDDI, and Token Ring, to wide-area networks, such as T1 (telephone lines), X.25, and ATM.

You can use TCP/IP to construct a network out of a number of local-area networks. You can also use TCP/IP to construct a wide-area network by way of virtually any point-to-point digital circuit.

TCP/IP and its protocol family are fully described in Chapter 2.

Types of Hardware That Make Up a Solaris Network

The term *local-area network* (LAN) refers to a single network of computers limited to a moderate geographical range, such as the floor of a building or two adjacent buildings. A local-area network has both hardware and software components. From a hardware perspective, a basic Solaris LAN consists of two or more computers attached to some form of local-area network media.

Local-Area Network Media

The cabling or wiring used for computer networks is referred to as *network media.* Figure 1–1 shows four computers connected by means of Ethernet media. In the Solaris LAN environment, Ethernet is the most commonly used local-area network media. Other types of local-area network media used in a Solaris LAN might include FDDI or Token Ring.

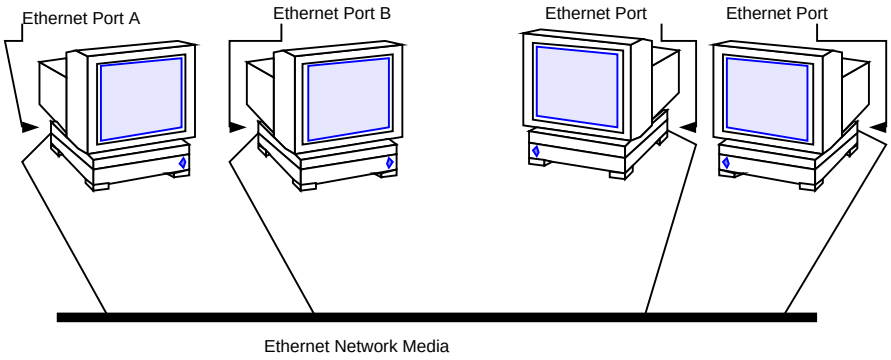


Figure 1–1 A Solaris Local Area Network

Computers and Their Connectors

Computers on a TCP/IP network use two different kinds of connectors to connect to network media: serial ports, and the ports on the network interface.

Serial Ports

Each computer has at least two *serial ports*, the connectors that enable you to plug a printer or modem into the computer. The serial ports may be attached to the CPU board, or you may have to purchase them. You use these ports when attaching a modem to the system to establish a PPP or UUCP connection. PPP and UUCP actually provide wide-area network services, since they may use telephone lines as their network media.

Network Interfaces

The hardware in a computer that enables you to connect it to a network is known as a *network interface*. Many computers come with a preinstalled network interface; others may require you to purchase the network interface separately.

Each LAN media type has its own associated network interface. For example, if you want to use Ethernet as your network media, you must have an Ethernet interface installed in each host to be part of the network. The connectors on the board to which you attach the Ethernet cable are referred to as *Ethernet ports*. If you plan to use FDDI, each prospective host must have an FDDI network interface, and so on.

This book refers to the default network interface on a host as the *primary network interface*.

Note - Installing network hardware is outside the scope of this guide. Refer to *System Administration Guide, Volume I* for instructions for configuring serial ports and manuals accompanying network media for installation instructions.

How Network Software Transfers Information

Setting up network software is an involved task. Therefore, it helps to understand how the network software you are about to set up will transfer information.

Figure 1–2 shows the basic elements involved in network communication.

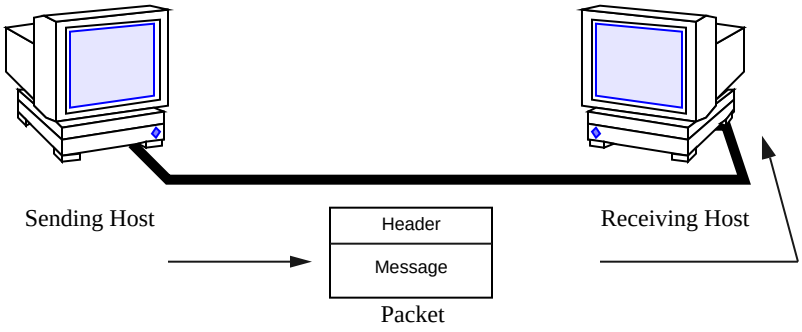


Figure 1–2 How Information Is Transferred on a Network

In this figure, a computer sends a packet over the network media to another computer attached to the same media.

How Information Is Transferred: The Packet

The basic unit of information to be transferred over the network is referred to as a *packet*. A packet is organized much like a conventional letter.

Each packet has a *header*, which corresponds to the envelope. The header contains the addresses of the recipient and the sender, plus information on how to handle the packet as it travels through each layer of the protocol suite.

The *message* part of the packet corresponds to the letter itself. Packets can only contain a finite number of bytes of data, depending on the network media in use. Therefore, typical communications such as email messages are sometimes split into packet fragments.

Who Sends and Receives Information: The Host

If you are an experienced Solaris user, you are no doubt familiar with the term "host," a word often used as a synonym for "computer" or "machine." From a TCP/IP perspective, only two types of entities exist on a network: routers and hosts.

A *router* is a machine that forwards packets from one network to another. To do this, the router must have at least two network interfaces. A machine with only one network interface cannot forward packets; it is considered a *host*. Most of the machines you set up on a network will be hosts.

It is possible for a machine to have more than one network interface but not function as a router. This type of machine is called a *multihomed* host. A multihomed host is directly connected to multiple networks through its network interfaces. However, it does not route packets from one network to another.

When a host initiates communication, it is called a *sending* host, or the sender. For example, a host initiates communications when its user types `rlogin` or sends an email message to another user. The host that is the target of the communication is

called the *receiving* host, or recipient. For example, the remote host specified as the argument to `rlogin` is the recipient of the request to log in.

Each host has three characteristics that help identify it to its peers on the network. These characteristics include:

- Host name
- Internet address, or *IP address,* the form used in this book
- Hardware address

Host Name

The *host name* is the name of the local machine, combined with the name of your organization. Many organizations let users choose the host names for their machines. Programs such as `sendmail` and `rlogin` use host names to specify remote machines on a network. *System Administration Guide, Volume I* contains more information about host names.

The host name of the machine also becomes the name of the primary network interface. This concept becomes important when you set up the network databases or configure routers.

When setting up a network, you must obtain the host names of all machines to be involved. You will use this information when setting up network databases, as described in Chapter 4.

IP Address

The *IP address* is one of the two types of addresses each machine has on a TCP/IP network that identifies the machine to its peers on the network. This address also gives peer hosts a notion of *where* a particular host is located on the network. If you have installed the Solaris operating environment on a machine on a network, you may recall specifying the IP address during the installation process. IP addressing is a significant aspect of TCP/IP and is explained fully in "Designing Your IP Addressing Scheme" on page 34.

Hardware Address

Each host on a network has a hardware address, which also identifies it to its peers. This address is physically assigned to the machine's CPU or network interface by the manufacturer. Each hardware address is unique.

This book uses the term *Ethernet address* to correspond to the hardware address. Because Ethernet is the most commonly used network media on Solaris-based networks, the text assumes that the hardware address of your Solaris host is an Ethernet address. If you are using other network media, such as FDDI, refer to the documentation that came with your media for hardware addressing information.

Reaching Beyond the Local-Area Network—the Wide-Area Network

As your network continues to function successfully, users may need to access information available from other companies, institutes of higher learning, and other organizations not on your LAN. To obtain this information, they may need to communicate over a *wide-area network* (WAN), a network that covers a potentially vast geographic area and uses network media such as leased data or telephone lines, X.25, and ISDN services.

A prime example of a WAN is the Internet, the global public network that is the successor to the WANs for which TCP/IP was originally developed. Other examples of WANs are *enterprise networks*, linking the separate offices of a single corporation into one network spanning an entire country, or perhaps an entire continent. It is entirely possible for your organization to construct its own WAN.

As network administrator, you may have to provide access to WANs to the users on your local net. Within the TCP/IP and UNIX community, the most commonly used public network has been the Internet. Information about directly connecting to the Internet is outside the scope of this book. You can find many helpful books on this subject in a computer bookstore.

Security

Connecting a LAN to a WAN poses some security risks. You must make sure your network is protected from unauthorized use, and control access to data and resources. An overview of security issues is provided in the *System Administration Guide, Volume I*. Further help can be found in *Firewalls and Internet Security* by William R. Cheswick and Steven M Bellovin (Addison Wesley, 1994).

You can also become informed by subscribing to `majordomo@greatcircle.com`, citing `subscribe firewalls` in the text. If you prefer the shorter version, cite `firewalls_digest` in the text.

TCP Large Window Support

TCP large windows provides the support described in RFC1323. This support is designed to improve performance over large bandwidth or delay networks such as ATM or satellite networks by using windows that exceed the normal 65535 limit.

This support expands the amount of data that can be outstanding in a TCP session from 65,535 bytes to approximately 1 Gigabyte.

TCP large window supports a number of TCP configuration parameters which allow a system administrator to enable the use of enhanced send and receive window sizes and the RFC1323 timestamp option, without having to modify the applications. These changes can be made on a system-wide basis or can be customized for

particular hosts or networks. This is especially useful when using standard network utilities such as `ftp` and `rcp` which do not provide facilities to increase the buffer sizes they use.

TCP Large Window Parameters

The configuration parameters are associated with the TCP device, /dev/tcp, and may be inspected or modified using **ndd**(1M). Normally, these parameters would be set in one of the shell scripts executed by **init**(1M) when the system is booted (see **init.d**(4) for information on how to add a new script).

A list of the available parameters and their meaning are.

tcp_xmit_hiwat — Specifies the default value for a connection's send buffer space. The default is 8K.

tcp_recv_hiwat — Specifies the default value for a connection's receive buffer space; that is, the amount of buffer space allocated for received data (and thus the maximum possible advertised receive window). The default is 8K.

tcp_wscale_always — If this parameter is nonzero, a window scale option is always sent when connecting to a remote system. Otherwise, the option will be sent if-and-only-if the user has requested a receive window larger than 64K. The default is zero.

Regardless of the value of this parameter, a window scale option is always included in a connect acknowledgment if the connecting system has used the option.

tcp_tstamp_always — If this parameter is nonzero, a timestamp option is always sent when connecting to a remote system. The default is zero.

Regardless of the value of this parameter, a timestamp option is always included in a connect acknowledgment (and all succeeding packets) if the connecting system has used the option.

tcp_tstamp_if_wscale — If this parameter is nonzero, the timestamp option is sent when connecting to a remote system if the user has requested a receive window larger than 64K (that is, if a window scale option with a nonzero scale is being used). The default is zero.

tcp_max_buf

Specifies the maximum buffer size a user is allowed to specify with the SO_SNDBUF or SO_RCVBUF options. Attempts to use larger buffers fail with EINVAL. The default is 256K. It is unwise to make this parameter much larger than the maximum buffer size your applications require, since that could allow malfunctioning or malicious applications to consume unreasonable amounts of kernel memory.

tcp_host_param

This parameter is a table of IP addresses, networks, and subnetworks, along with default values for certain TCP parameters to be used on connections with the specified hosts. The table can be displayed with the ndd command as follows:

```
example# ndd /dev/tcp tcp_host_param
Hash HSP     Address         Subnet Mask     Send       Receive    TStamp
027 fc31eea4 129.154.000.000 255.255.255.000 0000008192 0000008192      0
131 fc308244 129.154.152.000 000.000.000.000 0000032000 0000032000      0
133 fc30bd64 129.154.152.006 000.000.000.000 0000128000 0000128000      1
```

Each element in the table specifies either a host, a network (with optional subnet mask), or a subnet, along with the default send buffer space and receive buffer space, and a flag indicating whether timestamps are to be used.

The default values specified in the table are used for both active and passive connections (that is, both `connect()` and `listen()`). The most applicable match found is used; first the full host address, then the subnet, and finally the network. For subnet recognition to work properly, there must be an entry for that subnet's network which specifies the subnet mask.

The example table above specifies that:

- Connections with host 129.154.152.6 uses send and receive buffer sizes of 128000 bytes, and will use timestamps.
- Connections with other hosts on the 129.154.152 subnet uses send and receive buffer sizes of 32000 bytes.
- Connections with other hosts on the 129.154 network uses send and receive buffer sizes of 8192 bytes.

Elements are added to or removed from the table with ndd as follows:

```
ndd -set /dev/tcp tcp_host_param '<command>'
```

where <command> is either:

```
<ipaddr> [ mask <ipmask>] [ sendspace <integer> ]
    [ recvspace <integer> ] [ timestamp { 0 | 1 } ]
```

or

```
<ipaddr> delete
```

For example, the table above was created by:

```
example# ndd -set /dev/tcp tcp_host_param
'129.154.0.0 mask 255.255.255.0 sendspace 8192 recvspace 8192'

example# ndd -set /dev/tcp tcp_host_param
'129.154.152.0 sendspace 32000 recvspace 32000'

example# ndd -set /dev/tcp tcp_host_param
'129.154.152.6 sendspace 128000 recvspace 128000  timestamp 1'
```

It could be removed by:

```
example# ndd -set /dev/tcp tcp_host_param '129.154.152.6 delete'

example# ndd -set /dev/tcp tcp_host_param '129.154.152.0 delete'

example# ndd -set /dev/tcp tcp_host_param '129.154.0.0  delete'
```

Networks and subnets are specified by leaving the host bits zero. The same syntax used to add entries can also be used to modify existing entries.

The send and receive space values from the `tcp_host_param` table will only be used if they are larger than the values set by the user (or obtained from `tcp_xmit_hiwat` and `tcp_recv_hiwat`). This is so that the user can specify larger values for improved throughput and not have them erroneously reduced.

If timestamp value in the `tcp_host_param` table is 1, the timestamp option will be sent to the selected host or hosts when a connection is initiated. However, if the

value is 0, the timestamp option may still be sent, depending on the settings of the `tcp_tstamp_always` and `tcp_tstamp_if_wscale` options.

TCP Selective Acknowledgment Support

The TCP selective acknowledgment (TCP SACK) provides the support described in RFC 2018 to solve the problems related to congestion and multiple packet drops especially in applications making use of TCP large windows (RFC 1323) over satellite links or transcontinental links. See RFC 2018 for complete details on TCP SACK.

The configuration parameter is associated with the TCP device, `/dev/tcp`, and can be inspected or modified using **ndd**(1M). Normally, this parameter would be set in one of the shell scripts executed by **init**(1M) when the system is booted (see **init.d**(4) for information on how to add a new script).

The available parameter and its meaning is.

tcp_sack_permitted — Specifies whether SACK is permitted. The default is 1. The available options are as follows:

- **0** — TCP does not accept or send SACK information.
- **1** — TCP does not initiate a connection with `SACK_PERMITTED` option. If the incoming request has `SACK_PERMITTED` option, TCP responds with `SACK_PERMITTED` option.
- **2** — TCP initiates and accepts connections with `SACK_PERMITTED` option.

For additional information see **tcp**(7P) man page.

CHAPTER 2

TCP/IP Protocol Suite

This chapter introduces the Solaris implementation of the TCP/IP network protocol suite. The information is particularly geared to network administrators who are unfamiliar with the TCP/IP. (For an introduction to basic network concepts, see Chapter 1.) If you are an experienced TCP/IP network administrator, consider moving on to chapters covering the tasks you want to perform.

Introducing the Internet Protocol Suite

This section presents an in-depth introduction to the protocols that compose TCP/IP. Although the information is conceptual, you should learn the names of the protocols and what each does. This is important because TCP/IP books explain tasks with the assumption that you understand the concepts introduced here.

TCP/IP is the commonly used nickname for the set of network protocols composing the *Internet Protocol suite*. Many texts use the term "Internet" to describe both the protocol suite and the global wide-area network. In this book, the "TCP/IP" refers specifically to the Internet protocol suite; "Internet" refers to the wide-area network and the bodies that govern it.

To interconnect your TCP/IP network with other networks, you must obtain a unique IP network number. At the time of this writing, IP network numbers are assigned by an organization known as the InterNIC.

If hosts on your network are going to participate in the Internet Domain Name system (DNS), you must obtain and register a unique domain name. The InterNIC also handles the registration of domain names under certain top-level domains such as .com (commercial), .edu (education), and .gov (government). Chapter 3 contains more information about the InterNIC. (For more information on DNS, refer to *Solaris Naming Administration Guide*.)

Protocol Layers and the OSI Model

Most network protocol suites are structured as a series of layers, sometimes referred to collectively as a *protocol stack*. Each layer is designed for a specific purpose and exists on both the sending and receiving hosts. Each is designed so that a specific layer on one machine sends or receives exactly the same object sent or received by its *peer process* on another machine. These activities take place independently from what is going on in layers above or below the layer under consideration. In other words, each layer on a host acts independently of other layers on the same machine, and in concert with the same layer on other hosts.

OSI Reference Model

Most network protocol suites are viewed as structured in layers. This is a result of the Open Systems Interconnect (OSI) Reference Model designed by the International Standards Organization (ISO). The OSI model describes network activities as having a structure of seven layers, each of which has one or more protocols associated with it. The layers represent data transfer operations common to all types of data transfers among cooperating networks.

The protocol layers of the OSI Reference Model are traditionally listed from the top (layer 7) to the bottom (layer 1) up, as shown in Table 2–1.

TABLE 2–1 The Open Systems Interconnect Reference Model

Layer No.	Layer Name	Description
7	Application	Consists of standard communication services and applications that everyone can use.
6	Presentation	Ensures that information is delivered to the receiving machine in a form that it can understand.
5	Session	Manages the connections and terminations between cooperating computers.
4	Transport	Manages the transfer of data and assures that received and transmitted data are identical.

TABLE 2–1 The Open Systems Interconnect Reference Model *(continued)*

Layer No.	Layer Name	Description
3	Network	Manages data addressing and delivery between networks.
2	Data Link	Handles the transfer of data across the network media.
1	Physical	Defines the characteristics of the network hardware.

The operations defined by the OSI model are conceptual and not unique to any particular network protocol suite. For example, the OSI network protocol suite implements all seven layers of the OSI Reference Model. TCP/IP uses some of OSI model layers and combines others. Other network protocols, such as SNA, add an eighth layer.

TCP/IP Protocol Architecture Model

The OSI model describes an idealized network communications protocol family. TCP/IP does not correspond to this model directly, as it either combines several OSI layers into a single layer, or does not use certain layers at all. Table 2–2 shows the layers of the Solaris implementation of TCP/IP, listed from topmost layer (application) to lowest (physical network).

TABLE 2–2 TCP/IP Protocol Stack

OSI Ref. Layer No.	OSI Layer Equivalent	TCP/IP Layer	TCP/IP Protocol Examples
5,6,7	Application, Session, Presentation	Application	NFS, NIS+, DNS, `telnet`, `ftp`, "r" commands[1], RIP, RDISC, SNMP, others
4	Transport	Transport	TCP, UDP
3	Network	Internet	IP, ARP, ICMP
2	Data Link	Data Link	PPP, IEEE 802.2
1	Physical	Physical Network	Ethernet (IEEE 802.3) Token Ring, RS-232, others

1. "r" commands include `rlogin`, `rsh`, and `rcp`.

The table shows the TCP/IP protocol layers, their OSI Model equivalents, and examples of the protocols available at each level of the TCP/IP protocol stack. Each host involved in a communication transaction runs its own implementation of the protocol stack.

Physical Network Layer

The physical network layer specifies the characteristics of the hardware to be used for the network. For example, it specifies the physical characteristics of the communications media. The physical layer of TCP/IP describes hardware standards such as IEEE 802.3, the specification for Ethernet network media, and RS-232, the specification for standard pin connectors.

Data-Link Layer

The data-link layer identifies the network protocol type of the packet, in this case TCP/IP. It also provides error control and "framing." Examples of data-link layer protocols are Ethernet IEEE 802.2 framing and Point-to-Point Protocol (PPP) framing.

Internet Layer

This layer, also known as the network layer, accepts and delivers packets for the network. It includes the powerful Internet protocol (IP), the ARP protocol, and the ICMP protocol.

IP Protocol

The IP protocol and its associated routing protocols are possibly the most significant of the entire TCP/IP suite. IP is responsible for:

- *IP addressing* - The IP addressing conventions are part of the IP protocol. (Chapter 3 describes IP addressing in complete detail.)
- *Host-to-host communications* - IP determines the path a packet must take, based on the receiving host's IP address.
- *Packet formatting* - IP assembles packets into units known as *IP datagrams*. Datagrams are fully described in "Internet Layer" on page 25.
- *Fragmentation* - If a packet is too large for transmission over the network media, IP on the sending host breaks the packet into smaller fragments. IP on the receiving host then reconstructs the fragments into the original packet.

ARP Protocol

The Address Resolution Protocol (ARP) conceptually exists between the data link and Internet layers. ARP assists IP in directing datagrams to the appropriate receiving host by mapping Ethernet addresses (48 bits long) to known IP addresses (32 bits long).

ICMP Protocol

Internet Control Message Protocol (ICMP) is the protocol responsible for detecting network error conditions and reporting on them. ICMP reports on:

- Dropped packets (when packets are arriving too fast to be processed)
- Connectivity failure (when a destination host can't be reached)
- Redirection (which tells a sending host to use another router)

Chapter 6 contains more information on the operating system commands that use ICMP for error detection.

Transport Layer

The TCP/IP transport layer protocols ensure that packets arrive in sequence and without error, by swapping acknowledgments of data reception, and retransmitting lost packets. This type of communication is known as "end-to-end." Transport layer protocols at this level are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).

TCP Protocol

TCP enables applications to communicate with each other as though connected by a physical circuit. TCP sends data in a form that appears to be transmitted in a character-by-character fashion, rather than as discreet packets. This transmission consists of a starting point, which opens the connection, the entire transmission in byte order, and an ending point, which closes the connection.

TCP attaches a header onto the transmitted data. This header contains a large number of parameters that help processes on the sending machine connect to peer processes on the receiving machine.

TCP confirms that a packet has reached its destination by establishing an end-to-end connection between sending and receiving hosts. TCP is therefore considered a "reliable, connection-oriented" protocol.

UDP Protocol

UDP, the other transport layer protocol, provides datagram delivery service. It does not provide any means of verifying that connection was ever achieved between receiving and sending hosts. Because UDP eliminates the processes of establishing and verifying connections, applications that send small amounts of data use it rather than TCP.

Application Layer

The application layer defines standard Internet services and network applications that anyone can use. These services work with the transport layer to send and receive data. There are many applications layers protocols, some of which you probably already use. Some of the protocols include:

- Standard TCP/IP services such as the `ftp`, `tftp`, and `telnet` commands
- UNIX "r" commands, such as `rlogin` and `rsh`
- Name services, such as NIS+ and Domain Name System (DNS)
- File services, such as NFS
- Simple Network Management Protocol (SNMP), which enables network management
- RIP and RDISC routing protocols

Standard TCP/IP Services

- *FTP and Anonymous FTP* - The File Transfer Protocol (FTP) transfers files to and from a remote network. The protocol includes the `ftp` command (local machine) and the `in.ftpd` daemon (remote machine). FTP enables a user to specify the name of the remote host and file transfer command options on the local host's command line. The `in.ftpd` daemon on the remote host then handles the requests from the local host. Unlike `rcp`, `ftp` works even when the remote computer does not run a UNIX-based operating system. A user must log in to the remote computer to make an `ftp` connection unless it has been set up to allow anonymous FTP.

  You can now obtain a wealth of materials from *anonymous FTP servers* connected to the Internet. These servers are set up by universities and other institutions to make certain software, research papers, and other information available to the public domain. When you log in to this type of server, you use the login name `anonymous`, hence the term "anonymous FTP servers."

  Using anonymous FTP and setting up anonymous FTP servers is outside the scope of this manual. However, many trade books, such as *The Whole Internet User's Guide & Catalog*, discuss anonymous FTP in detail. Instructions for using FTP to reach standard machines are in *System Administration Guide, Volume I*. The

ftp(1) man page describes all `ftp` command options, including those invoked through the command interpreter. The **ftpd**(1M) man page describes the services provided by the daemon `in.ftpd`.

- *Telnet* - The Telnet protocol enables terminals and terminal-oriented processes to communicate on a network running TCP/IP. It is implemented as the program `telnet` (on local machines) and the daemon `in.telnet` (on remote machines). Telnet provides a user interface through which two hosts can communicate on a character-by-character or line-by-line basis. The application includes a set of commands that are fully documented in the **telnet**(1) man page.
- *TFTP* - The trivial file transfer protocol (`tftp`) provides functions similar to `ftp`, but it does not establish `ftp`'s interactive connection. As a result, users cannot list the contents of a directory or change directories. This means that a user must know the full name of the file to be copied. The **tftp**(1) man page describes the `tftp` command set.

UNIX "r" Commands

The UNIX "r" commands enable users to issue commands on their local machines that are actually carried out on the remote host that they specify. These commands include

- `rcp`
- `rlogin`
- `rsh`

Instructions for using these commands are in **rcp**(1), **rlogin**(1), and **rsh**(1) man pages.

Name Services

Two name services are available from the Solaris implementation of TCP/IP: NIS+ and DNS.

- *NIS+* - NIS+ provides centralized control over network administration services, such as mapping host names to IP and Ethernet addresses, verifying passwords, and so on. See *Solaris Naming Administration Guide* for complete details.
- *Domain Name System* - The Domain Name System (DNS) provides host names to the IP address service. It also serves as a database for mail administration. For a complete description of this service, see *Solaris Naming Administration Guide*. See also the **in.named**(1M) man page.

File Services

The NFS application layer protocol provides file services for the Solaris operating environment. You can find complete information about the NFS service in *NFS Administration Guide.*

Network Administration

The Simple Network Management Protocol (SNMP) enables you to view the layout of your network, view status of key machines, and obtain complex network statistics from graphical user interface based software. Many companies offer network management packages that implement SNMP; SunNet Manager™ software is an example.

Routing Protocols

The Routing Information Protocol (RIP) and the Router Discovery Protocol (RDISC) are two routing protocols for TCP/IP networks. They are described in Chapter 5.

How the TCP/IP Protocols Handle Data Communications

When a user issues a command that uses a TCP/IP application layer protocol, a chain of events is set in motion. The user's command or message passes through the TCP/IP protocol stack on the local machine, and then across the network media to the protocols on the recipient. The protocols at each layer on the sending host add information to the original data.

As the user's command makes its way through the protocol stack, protocols on each layer of the sending host also interact with their peers on the receiving host. Figure 2–1 shows this interaction.

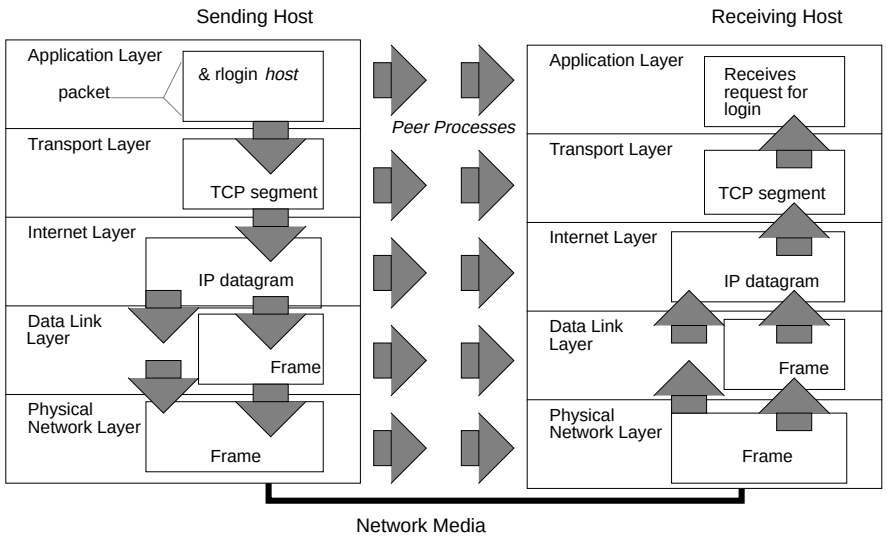


Figure 2–1 How a Packet Travels Through the TCP/IP Stack

Data Encapsulation and the TCP/IP Protocol Stack

The packet is the basic unit of information transferred across a network, consisting, at a minimum, of a header with the sending and receiving hosts' addresses, and a body with the data to be transferred. As the packet travels through the TCP/IP protocol stack, the protocols at each layer either add or remove fields from the basic header. When a protocol on the sending host adds data to the packet header, the process is called *data encapsulation*. Moreover, each layer has a different term for the altered packet, as shown in Figure 2–1.

This section summarizes the life cycle of a packet from the time the user issues a command or sends a message to the time it is received by the appropriate application on the receiving host.

Application Layer—User Initiates Communication

The packet's history begins when a user on one host sends a message or issues a command that must access a remote host. The application protocol associated with the command or message formats the packet so that it can be handled by the appropriate transport layer protocol, TCP or UDP.

Suppose the user issues an `rlogin` command to log in to the remote host, as shown in Figure 2–1. The `rlogin` command uses the TCP transport layer protocol. TCP expects to receive data in the form of a stream of bytes containing the information in the command. Therefore, `rlogin` sends this data as a TCP stream.

Not all application layer protocols use TCP, however. Suppose a user wants to mount a file system on a remote host, thus initiating the NIS+ application layer protocol. NIS+ uses the UDP transport layer protocol. Therefore, the packet containing the command must be formatted in a manner that UDP expects. This type of packet is referred to as a *message*.

Transport Layer—Data Encapsulation Begins

When the data arrives at the transport layer, the protocols at the layer start the process of data encapsulation. The end result depends on whether TCP or UDP has handled the information.

TCP Segmentation

TCP is often called a "connection-oriented" protocol because it ensures the successful delivery of data to the receiving host. Figure 2–1 shows how the TCP protocol receives the stream from the `rlogin` command. TCP divides the data received from the application layer into segments and attaches a header to each segment.

Segment headers contain sender and recipient ports, segment ordering information, and a data field known as a *checksum*. The TCP protocols on both hosts use the checksum data to determine whether data has transferred without error.

Establishing a TCP Connection

In addition, TCP uses segments to determine whether the receiving host is ready to receive the data. When the sending TCP wants to establish connections, it sends a segment called a SYN to the peer TCP protocol running on the receiving host. The receiving TCP returns a segment called an ACK to acknowledge the successful receipt of the segment. The sending TCP sends another ACK segment, then proceeds to send the data. This exchange of control information is referred to as a *three-way handshake*.

UDP Packets

UDP is a "connectionless" protocol. Unlike TCP, it does not check to make sure that data arrived at the receiving host. Instead, UDP takes the message received from the application layer and formats it into *UDP packets*. UDP attaches a header to each packet, which contains the sending and receiving host ports, a field with the length of the packet, and a checksum.

The sending UDP process attempts to send the packet to its peer UDP process on the receiving host. The application layer determines whether the receiving UDP process acknowledges that the packet was received. UDP requires no notification of receipt. UDP does not use the three-way handshake.

Internet Layer

As shown in Figure 2–1, both TCP and UDP pass their segments and packets down to the Internet layer, where they are handled by the IP protocol. IP prepares them for delivery by formatting them into units called IP datagrams. IP then determines the IP addresses for the datagrams, so they can be delivered effectively to the receiving host.

IP Datagrams

IP attaches an *IP header* to the segment or packet's header in addition to the information added by TCP or UDP. Information in the IP header includes the IP addresses of the sending and receiving hosts, datagram length, and datagram sequence order. This information is provided in case the datagram exceeds the allowable byte size for network packets and must be fragmented.

Data-Link Layer—Framing Takes Place

Data-link layer protocols such as PPP format the IP datagram into a *frame*. They attach a third header and a footer to "frame" the datagram. The frame header includes a *cyclical redundancy check* (CRC) field that checks for errors as the frame travels over the network media. Then the data-link layer passes the frame to the physical layer.

Physical Network Layer—Preparing the Frame for Transmission

The physical network layer on the sending host receives the frames and converts the IP addresses into the hardware addresses appropriate to the network media. The physical network layer then sends the frame out over the network media.

How the Receiving Host Handles the Packet

When the packet arrives on the receiving host, it travels through the TCP/IP protocol stack in the reverse order from that which it took on the sender. Figure 2–1 illustrates this path. Moreover, each protocol on the receiving host strips off header information attached to the packet by its peer on the sending host. Here is what happens.

1. Physical Network Layer receives the packet in its frame form. It computes the CRC of the packet, then sends the frame to the data link layer.
2. Data-Link Layer verifies that the CRC for the frame is correct and strips off the frame header and CRC. Finally, the data link protocol sends the frame to the Internet layer.

3. Internet Layer reads information in the header to identify the transmission and determine if it is a fragment. If the transmission was fragmented, IP reassembles the fragments into the original datagram. It then strips off the IP header and passes the datagram on to transport layer protocols.
4. Transport Layer (TCP and UDP) reads the header to determine which application layer protocol must receive the data. Then TCP or UDP strips off its related header and sends the message or stream up to the receiving application.
5. Application Layer receives the message and performs the operation requested by the sending host.

Finding Out More About TCP/IP and the Internet

A great deal of information about TCP/IP and the Internet has been published. If you require specific information that is not covered in this text, you probably can find what you need in the sources cited below.

Computer Trade Books

Many books about TCP/IP and the Internet are available from your local library or computer bookstore. Three highly recommended books are

- Craig Hunt. *TCP/IP Network Administration* - This book contains some theory and much practical information for managing a heterogeneous TCP/IP network.
- W. Richard Stevens. *TCP/IP Illustrated, Volume I* - This book is an in-depth explanation of the TCP/IP protocols. It is ideal for network administrators requiring a technical background in TCP/IP and for network programmers.
- Ed Krol. *The Whole Internet User's Guide & Catalog* - This book is ideal for anyone interested in using the many tools available for retrieving information over the Internet.

RFCs and FYIs

Since 1969, developers working on the Internet protocol suite have described their protocols and related subjects in documents known as Requests for Comments (RFCs). Many RFCs are specifications for particular TCP/IP protocols and describe standards with which software implementing the protocols must comply. Other RFCs discuss the Internet, its topology, and its governing bodies. Still other RFCs explain how to manage TCP/IP applications, such as DNS.

All RFCs must be approved by the Internet Architecture Board (IAB) before they are placed in the public domain. Typically, the information in RFCs is geared to developers and other highly technical readers, though this isn‘t always the case.

In recent years, For Your Information (FYI) documents have appeared as a subset of the RFCs. The FYIs contain information that does not deal with Internet standards; rather, they contain Internet information of a more general nature. For example, FYI documents include a bibliography listing introductory TCP/IP books and papers, an exhaustive compendium of Internet-related software tools, and a glossary of Internet and general networking terms.

You’ll find references to relevant RFCs throughout this guide and other books in the Solaris 2.6 System Administrator set.

How to Obtain RFCs

The InterNIC Directory and Database Service maintains the repository of RFCs. If you have a connection to the Internet, you can retrieve online RFCs as follows:

- Through `ftp`, by sending your requests to the InterNIC directory and database server `ds.internic.net`. Your request should have the format:

  `rfc/rfc.`*rfcnum*`.txt` or `rfc/rfc.`*rfcnum*`.ps`

  where *rfcnum* represents the number of the RFC you want. For example, if you wanted to retrieve RFC 1540 in PostScript® format, you would request `rfc/rfc.1540.ps`.

- Through electronic mail, by emailing `mailserv@ds.internic.net`. This is an automatic server that expects the body of your request message to have the format:

  `document-by-name rfc`*rfcnum* or `document-by-name rfc`*rfcnum*`.ps`

- Through a World Wide Web browser, by specifying the URL `http://ds.internic.net/ds/dspg1intdoc.html`. The home page is `http://ds.internic.net`

If you need an online index of RFCs, send electronic mail to ds.internic.net with a message containing the request `document-by-name rfc-index`.

Note - The InterNIC information above is current as of this writing. However, the Internet is expanding at a fast pace, and the addresses listed might no longer be current when you read this manual.

CHAPTER 3

Planning Your Network

This chapter describes the issues you must resolve in order to create your network in an organized, cost-effective manner. After you have resolved these issues, you can devise a plan for your network to follow as you set it up and administer it in the future.

If you are unfamiliar with TCP/IP fundamentals, refer to Chapter 2.

Designing the Network

The first phase in the life of a network—designing the network—involves making decisions about the type of network that best suits the needs of your organization. Some of the planning decisions you make will involve network hardware; for example:

- Number of host machines your network can support
- Type of network media to use: Ethernet, token ring, FDDI, and so on
- Network topology; that is, the physical layout and connections of the network hardware
- Types of hosts the network will support: standalone, diskless, and dataless

Based on these factors, you can determine the size of your local-area network.

Note - Planning the network hardware is outside the scope of this manual. Refer to the manuals that came with your hardware for assistance.

Factors Involved in Network Planning

After you have completed your hardware plan, you are ready to begin network planning, from the software perspective.

As part of the planning process you must:

1. Obtain a network number and, if applicable, register your network domain with the InterNIC.
2. Devise an IP addressing scheme for your hosts, after you receive your IP network number.
3. Create a list containing the IP addresses and host names of all machines that make up your network, which you can use as you build network databases.
4. Determine which name service to use on your network: NIS, NIS+, DNS, or the network databases in the local `/etc` directory.
5. Establish administrative subdivisions, if appropriate for your network.
6. Determine if your network is large enough to require routers, and, if appropriate, create a network topology that supports them.
7. Set up subnets, if appropriate for your network.

The remainder of Chapter 3 explains how to plan your network with these factors in mind.

Setting Up an IP Addressing Scheme

The number of machines you expect to support will affect several decisions you will need to make at this stage of setting up a network for your site. Your organization may require a small network of several dozen standalone machines located on one floor of a single building. Alternatively, you may need to set up a network with more than 1000 hosts in several buildings. This arrangement may require you to further divide your network into subdivisions called *subnets*. The size of your prospective network will affect the

- Network class you apply for
- Network number you receive
- IP addressing scheme you use for your network

Obtaining a network number and then establishing an IP addressing scheme is one of the most important tasks of the planning phase of network administration.

Parts of the IP Address

Each network running TCP/IP must have a unique network number, and every machine on it must have a unique IP address. It is important to understand how IP addresses are constructed before you register your network and obtain its network number.

The IP address is a 32-bit number that uniquely identifies a network interface on a machine. An IP address is typically written in decimal digits, formatted as four 8-bit fields separated by periods. Each 8-bit field represents a byte of the IP address. This form of representing the bytes of an IP address is often referred to as the *dotted-decimal format*.

The bytes of the IP address are further classified into two parts: the network part and the host part. Figure 3–1 shows the component parts of a typical IP address, 129.144.50.56.

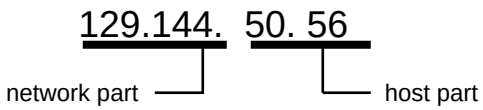


Figure 3–1 Parts of an IP Address

Network Part

This part specifies the unique number assigned to your network. It also identifies the class of network assigned. In Figure 3–1, the network part takes up two bytes of the IP address.

Host Part

This is the part of the IP address that you assign to each host. It uniquely identifies this machine on your network. Note that for each host on your network, the network part of the address will be the same, but the host part must be different.

Subnet Number (Optional)

Local networks with large numbers of hosts are sometimes divided into subnets. If you choose to divide your network into subnets, you need to assign a *subnet number*

for the subnet. You can maximize the efficiency of the IP address space by using some of the bits from the host number part of the IP address as a network identifier. When used as a network identifier, the specified part of the address becomes the subnet number. You create a subnet number by using a netmask, which is a bit mask that selects the network and subnet parts of an IP address. (Refer to “Creating the Network Mask” on page 53 for full details.)

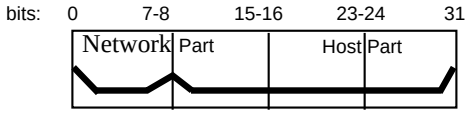
Network Classes

The first step in planning for IP addressing on your network is to determine which network class is appropriate for your network. After you have done this, you can take the crucial second step: obtain the network number from the InterNIC addressing authority.

Currently there are three classes of TCP/IP networks. Each class uses the 32-bit IP address space differently, providing more or fewer bits for the network part of the address. These classes are class A, class B, and class C.

Class A Network Numbers

A class A network number uses the first eight bits of the IP address as its “network part.” The remaining 24 bits comprise the host part of the IP address, as illustrated in Figure 3–2 below.



Class A Address

Figure 3–2 Byte Assignment in a Class A Address

The values assigned to the first byte of class A network numbers fall within the range 0–127. Consider the IP address 75.4.10.4. The value 75 in the first byte indicates that the host is on a class A network. The remaining bytes, 4.10.4, establish the host address. The InterNIC assigns only the first byte of a class A number. Use of the remaining three bytes is left to the discretion of the owner of the network number. Only 127 class A networks can exist. Each one of these numbers can accommodate up to 16,777,214 hosts.

Class B Network Numbers

A class B network number uses 16 bits for the network number and 16 bits for host numbers. The first byte of a class B network number is in the range 128–191. In the number 129.144.50.56, the first two bytes, 129.144, are assigned by the InterNIC, and

comprise the network address. The last two bytes, 50.56, make up the host address, and are assigned at the discretion of the owner of the network number. Figure 3–3 graphically illustrates a class B address.

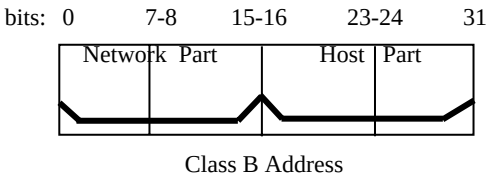


Figure 3–3 Byte Assignment in a Class B Address

Class B is typically assigned to organizations with many hosts on their networks.

Class C Network Numbers

Class C network numbers use 24 bits for the network number and 8 bits for host numbers. Class C network numbers are appropriate for networks with few hosts—the maximum being 254. A class C network number occupies the first three bytes of an IP address. Only the fourth byte is assigned at the discretion of the network owners. Figure 3–4 graphically represents the bytes in a class C address.

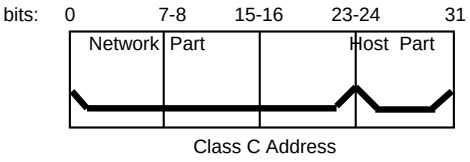


Figure 3–4 Byte Assignment in a Class C Address

The first byte of a class C network number covers the range 192–223. The second and third each cover the range 1– 255. A typical class C address might be 192.5.2.5. The first three bytes, 192.5.2, form the network number. The final byte in this example, 5, is the host number.

Administering Network Numbers

If your organization has been assigned more than one network number, or uses subnets, appoint a centralized authority within your organization to assign network numbers. That authority should maintain control of a pool of assigned network numbers, assigning network, subnet, and host numbers as required. To prevent problems, make sure that duplicate or random network numbers do not exist in your organization.

Designing Your IP Addressing Scheme

After you have received your network number, you can then plan how you will assign the host parts of the IP address.

Table 3–1 shows the division of the IP address space into network and host address spaces. For each class, "range" specifies the range of decimal values for the first byte of the network number. "Network address" indicates the number of bytes of the IP address that are dedicated to the network part of the address, with each byte represented by *xxx*. "Host address" indicates the number of bytes dedicated to the host part of the address. For example, in a class A network address, the first byte is dedicated to the network, and the last three are dedicated to the host. The opposite is true for a class C network.

TABLE 3–1 Division of IP Address Space

Class	Range	Network Address	Host Address
A	0–127	*xxx*	*xxx.xxx.xxx*
B	128–191	*xxx.xxx*	*xxx.xxx*
C	192–223	*xxx.xxx.xxx*	*xxx*

The numbers in the first byte of the IP address define whether the network is class A, B, or C and are always assigned by the InterNIC. The remaining three bytes have a range from 0–255. The numbers 0 and 255 are reserved; you can assign the numbers 1–254 to each byte *depending on the network number assigned to you*.

Table 3–2 shows which bytes of the IP address are assigned to you and the range of numbers within each byte that are available for you to assign to your hosts.

TABLE 3–2 Range of Available Numbers

Network Class	Byte 1 Range	Byte 2 Range	Byte 3 Range	Byte 4 Range
A	0–127	1–254	1–254	1–254
B	128–191	Preassigned by Internet	1–254	1–254
C	192–223	Preassigned by Internet	Preassigned by Internet	1–254

How IP Addresses Apply to Network Interfaces

In order to connect to the network, a computer must have at least one network interface, as explained in “Network Interfaces” on page 7. Each network interface must have its own unique IP address. The IP address that you give to a host is assigned to its network interface, sometimes referred to as the *primary network interface*. If you add a second network interface to a machine, it must have its own unique IP number. Adding a second network interface changes the function of a machine from a host to a router, as explained in Chapter 5. If you add a second network interface to a host and disable routing, the host is then considered a multihomed host.

Each network interface has a device name, device driver, and associated device file in the `/devices` directory. The network interface might have a device name such as `le0` or `smc0`, device names for two commonly used Ethernet interfaces.

Note - This book assumes that your machines have Ethernet network interfaces. If you plan to use different network media, refer to the manuals that came with the network interface for configuration information.

Naming Entities on Your Network

After you have received your assigned network number and given IP addresses to your hosts, the next task is to assign names to the hosts and determine how you will handle name services on your network. You will use these names when you initially set up your network and, later, for expanding your network through routers or PPP.

The TCP/IP protocols locate a machine on a network by using its IP address. However, humans find it much easier to identify a machine if it has an understandable name. Therefore, the TCP/IP protocols (and the Solaris operating environment) require both the IP address and the host name to uniquely identify a machine.

From a TCP/IP perspective, a network is a set of named entities. A host is an entity with a name. A router is an entity with a name. The network is an entity with a name. A group or department in which the network is installed can also be given a name, as can a division, a region, or a company. In theory, there is virtually no limit to the hierarchy of names that can be used to identify a network and its machines. The term for these named entities is *domain*.

Administering Host Names

Many sites let users pick host names for their machines. Servers also require at least one host name, which is associated with the IP address of its primary network interface.

As network administrator, you must ensure that each host name in your domain is unique. In other words, no two machines on your network could both have the name "fred," although the machine "fred" might have multiple IP addresses.

When planning your network, make a list of IP addresses and their associated host names for easy access during the setup process. The list can help you verify that all host names are unique.

Selecting a Name Service

The Solaris operating environment gives you the option of using four types of name services: local files, NIS, NIS+, and DNS. Name services maintain critical information about the machines on a network, such as the host names, IP addresses, Ethernet addresses, and the like.

Network Databases

When you install the operating system, you supply the host name and IP address of your server, clients, or standalone machine as part of the procedure. The Solaris installation program enters this information into a *network database* called the `hosts` database. The `hosts` database is one of a set of network databases that contain information necessary for TCP/IP operation on your network. These databases are read by the name service you select for your network.

Setting up the network databases is a critical part of network configuration. Therefore, you need to decide which name service to use as part of the network planning process. Moreover, the decision to use name services also affects whether or not you organize your network into an administrative domain. Chapter 4 has detailed information on the set of network databases.

Using NIS, NIS+, or DNS for Name Service

The NIS, NIS+, or DNS name services maintain network databases on several servers on the network. *Solaris Naming Setup and Configuration Guide* fully describes these name services and explains how to set them up. It also explains the "namespace" and "administrative domain" concepts in complete detail. If you are changing name services from NIS to NIS+, refer to *NIS+ Transition Guide*. You should refer to these manuals to help you decide whether to use these name services on your network.

Using Local Files for Name Service

If you do not implement NIS, NIS+, or DNS, the network will use *local files* to provide name service. The term “local files” refers to the series of files in the `/etc` directory that the network databases use. The procedures in this book assume you are using local files for your name service, unless otherwise indicated.

Note - If you decide to use local files as the name service for your network, you can set up another name service at a later date.

Domain Names

Many networks organize their hosts and routers into a hierarchy of administrative domains. If you are going to use NIS, NIS+, or the DNS name services, you must select a domain name for your organization that is unique worldwide. To ensure that your domain name is unique, you should register it with the InterNIC. This is especially important if you plan to use DNS.

The domain name structure is hierarchical. A new domain typically is located below an existing, related domain. For example, the domain name for a subsidiary company could be located below the domain of the parent company. If it has no other relationship, an organization can place its domain name directly under one of the existing top-level domains.

Examples of top-level domains include:

- `.com` – Commercial companies (international in scope)
- `.edu` – Educational institutions (international in scope)
- `.gov` – U.S. government agencies
- `.fr` – France

The name that identifies your organization is one that you select, with the provision that it is unique.

Administrative Subdivisions

The question of administrative subdivisions deals with matters of size and control. The more hosts and servers you have in a network, the more complex your management task. You may wish to handle such situations by setting up additional administrative divisions in the form of more additional networks of a particular class or by dividing existing networks into subnets. The decision as to whether to set up administrative subdivisions for your network hinges on the following factors:

- How large is the network?

  A single network of several hundred hosts, all in the same physical location and requiring the same administrative services, can be handled by a single

administrative division. On the other hand, a network of fewer machines, divided into a number of subnets and physically scattered over an extensive geographic area, would be likely to benefit from the establishment of several administrative subdivisions.

- Do users on the network have similar needs?

  For example, you may have a network that is confined to a single building and supports a relatively small number of machines. These machines are divided among a number of subnetworks, each supporting groups of users with different needs. Such a case could call for an administrative subdivision for each subnet.

  Solaris Naming Administration Guide discusses administrative subdivisions in detail.

Registering Your Network

Before you assign IP addresses to the machines on your Solaris network, you must obtain a network number from the InterNIC. Moreover, if you plan to use administrative domains, you should register them with the InterNIC.

InterNIC and InterNIC Registration Services

The InterNIC was created in 1993 to act as a central body where users of the Internet could go for information, such as

- What the Internet's policies are
- How to access the Internet, including training services
- What resources are available to Internet users, such as anonymous FTP servers, Usenet user groups, and so on.

The InterNIC also includes the InterNIC Registration Services, the organization with which you register your TCP/IP network. The InterNIC Registration Services provide templates for obtaining a network number and for registering your domain. Two points to remember about registration are:

- The InterNIC assigns network numbers.

Note - Do not arbitrarily assign network numbers to your network, even if you do not plan to attach it to other existing TCP/IP networks.

Subnet numbers are not assigned by the InterNIC. Rather, they are composed partly of the assigned network number and numbers that you define, as explained in "What is Subnetting" on page 52.

- You—not InterNIC—determine the domain name for your network and then register it with the InterNIC.

How to Contact the InterNIC

You can reach the InterNIC Registration Services by:

- Mail

  Write to:

  ```
  Network Solutions
  Attn: InterNIC Registration Services
  505 Huntmar Park Drive
  Herndon, Virginia 22070
  ```

- Telephone

  The phone number is 1-703-742-4777. Phone service is available from 7 a.m. to 7 p.m. Eastern Standard Time.

- Electronic mail

  Send email regarding network registration to: `Hostmaster@rs.internic.net`

- Anonymous FTP or Telnet inquiries, through the Gopher and WAIS interfaces. Connect to `rs.internic.net`. (Anonymous FTP and Telnet are outside the scope of this book; however, books on these subjects are available in computer bookstores.)

Adding Routers

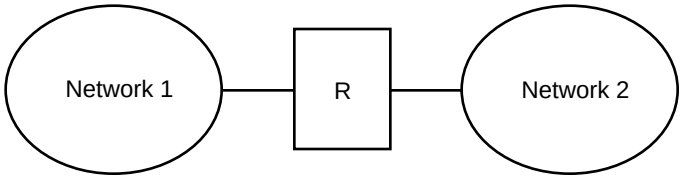
Recall that in TCP/IP, two types of entities exist on a network: hosts and routers. All networks must have hosts, while not all networks require routers. Whether you use routers should depend on the physical topology of the network. This section introduces the concepts of network topology and routing, important when you decide to add another network to your existing network environment.

Network Topology

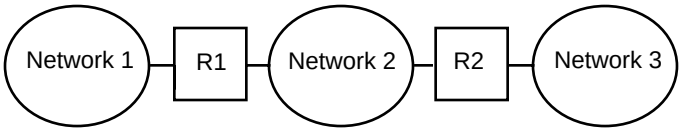
Network topology describes how networks fit together. Routers are the entities that connect networks to each other. From a TCP/IP perspective, a router is any machine that has two or more network interfaces. However, the machine cannot function as a router until properly configured, as described in Chapter 5.

Two or more networks can be connected together by routers to form larger internetworks. The routers must be configured to pass packets between two adjacent networks. They also should be able to pass packets to networks that lie beyond the adjacent networks.

Figure 3–5 shows the basic parts of a network topology. The first illustration shows a simple configuration of two networks connected by a single router. The second shows a configuration of three networks, interconnected by two routers. In the first case, network 1 and network 2 are joined into a larger internetwork by router R. In the second case, router R1 connects networks 1 and 2, and router R2 connects networks 2 and 3, thus forming a network made up of networks 1, 2, and 3.



T wo Networks Connected by a Router



Three Networks Connected by T wo Routers

Figure 3–5 Basic Network Topology

Routers join networks into internetworks and route packets between them based on the addresses of the destination network. As internetworks grow more complex, each router must make more and more decisions regarding where packets are to be sent.

A step up in complexity is the case shown in Figure 3–6. Networks 1 and 3 are directly connected by a router R3. The reason for such redundancy is reliability. If network 2 goes down, router R3 still provides a route between networks 1 and 3. Any number of networks can be interconnected and communicate as long as they all adhere to the same network protocols.

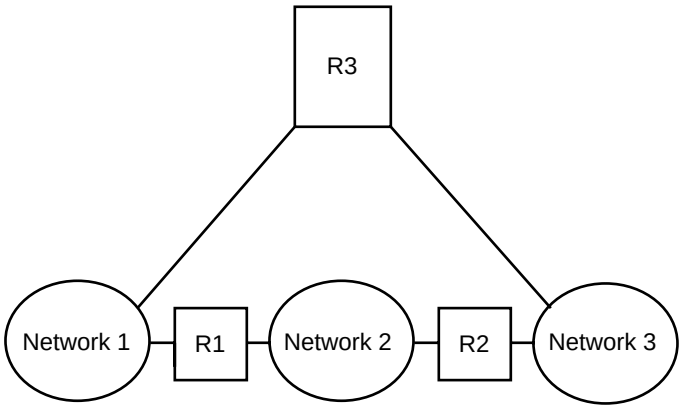


Figure 3–6 Providing an Additional Path Between Networks

How Routers Transfer Packets

Routing decisions on a network are based on the network portion of the IP address of the recipient that is contained in the packet header. If this address includes the network number of the local network, the packet goes directly to the host with that IP address. If the network number is not the local network, the packet goes to the router on the local network.

Routers maintain routing information in *routing tables*. These tables contain the IP address of the hosts and routers on the networks to which the router is connected. The tables also contain pointers to these networks. When a router gets a packet, it consults its routing table to see if it lists the destination address in the header. If the table does not contain the destination address, the router forwards the packet to another router listed in its routing table. Refer to Chapter 5 for detailed information on routers.

Figure 3–7 shows a network topology with three networks connected by two routers.

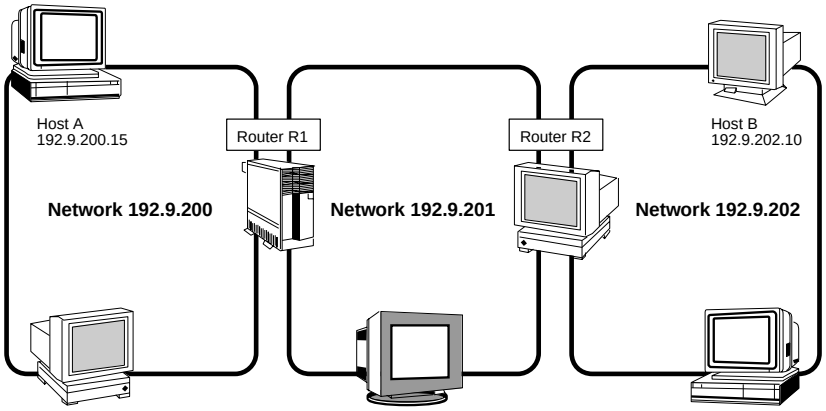


Figure 3–7 Three Interconnected Networks

Router R1 connects networks 192.9.200 and 192.9.201. Router R2 connects networks 192.9.201 and 192.9.202. If host A on network 192.9.200 sends a message to host B on network 192.9.202, this is what happens.

1. Host A sends a packet out over network 192.9.200. The packet header contains the IP address of the recipient host B, 192.9.202.10.
2. None of the machines on network 192.9.200 has the IP address 192.9.202.10. Therefore, router R1 accepts the packet.
3. Router R1 examines its routing tables. No machine on network 192.9.201 has the address 192.9.202.10. However, the routing tables do list router R2.
4. R1 then selects R2 as the “next hop” router and sends the packet to R2.
5. Because R2 connects network 192.9.201 to 192.9.202, it has routing information for host B. Router R2 then forwards the packet to network 192.9.202, where it is accepted by host B.

CHAPTER 4

Configuring TCP/IP on the Network

The second phase of network administration involves setting up the network. This consists of assembling the hardware which makes up the physical part of the network, and configuring TCP/IP. This chapter explains how to configure TCP/IP, including:

After reading thsi chapter, you should be able to::

- Determine the host configuration mode for each machine on your network
- Set up the subnet mask for your network
- Configure TCP/IP on the machines that run in local files mode
- Configure a network configuration server
- Configure TCP/IP on machines that run in network client mode
- Edit the network databases, based on the name service you have selected for your network
- Configure the name service switch file

Before You Configure TCP/IP

Before configuring the TCP/IP software, you should have:

1. Designed the network topology, if you are the network designer. (See "Network Topology" on page 39 for details.)
2. Obtained a network number from your Internet addressing authority. (See "Network Classes" on page 32.)
3. Assembled the network hardware according to the topology designed and assured that the hardware is functioning. (See the hardware manuals and "Network Topology" on page 39.)
4. Run any configuration software required by network interfaces and routers, if applicable. (See Chapter 3 and Chapter 5 for information on routers. If you have purchased network interfaces for your machines, refer to the manuals that came with them for software configuration requirements.)
5. Planned the IP addressing scheme for the network, including subnet addressing, if applicable. (See "Designing Your IP Addressing Scheme" on page 34.)
6. Assigned IP numbers and host names to all machines involved in the network. (See "Designing Your IP Addressing Scheme" on page 34.)
7. Determined which name service your network uses: NIS, NIS+, DNS, or local files. (See *Solaris Naming Administration Guide*.)
8. Selected domain names for your network, if applicable. (See *Solaris Naming Administration Guide*.)
9. Installed the operating system on at least one machine on the prospective network. (See *Solaris Advanced Installation Guide*.)

Determining Host Configuration Modes

One of your key functions as a network administrator is configuring TCP/IP to run on hosts and routers (if applicable). You can set up these machines to obtain configuration information from two sources: files on the local machine or files located on other machines on the network. Configuration information includes:

- Host name of a machine
- IP address of the machine
- Domain name to which the machine belongs
- Default router
- Netmask in use on the machine's network

A machine that obtains TCP/IP configuration information from local files is said to be operating in *local files mode*. A machine that obtains TCP/IP configuration information from a remote machine is said to be operating in *network client mode*.

Machines That Should Run in Local Files Mode

To run in local files mode, a machine must have local copies of the TCP/IP configuration files. These files are described in "TCP/IP Configuration Files" on page 47. The machine should have its own disk, though this is not strictly necessary.

Most servers should run in local file mode. This requirement includes:

- Network configuration servers
- NFS servers
- Name servers supplying NIS, NIS+, or DNS services
- Mail servers

Additionally, routers should run in local files mode.

Machines that exclusively function as print servers do not need to run in local files mode. Whether individual hosts should run in local files mode depends on the size of your network.

If you are running a very small network, the amount of work involved in maintaining these files on individual hosts is manageable. If your network serves hundreds of hosts, the task becomes difficult, even with the network divided into a number of administrative subdomains. Thus, for large networks, using local files mode is usually less efficient. On the other hand, because routers and servers must be self-sufficient, they should be configured in local files mode.

Network Configuration Servers

Network configuration servers are the machines that supply the TCP/IP configuration information to hosts configured in network client mode. These servers support three booting protocols:

- RARP – Reverse Address Resolution Protocol (RARP) maps known Ethernet addresses (48 bits) to IP addresses (32 bits), the reverse of ARP. When you run RARP on a network configuration server, this enables hosts running in network client mode to obtain their IP addresses and TCP/IP configuration files from the server. The `in.rarpd` daemon enables RARP services. Refer to the **`in.rarpd`**(1M) man page for complete details.
- TFTP – Trivial File Transfer Protocol (TFTP) is an application that transfers files between remote machines. The `in.tftpd` daemon carries out TFTP services, enabling file transfer between network configuration servers and their network clients.

- bootparams – The bootparams protocol supplies parameters for booting that are required by diskless clients. The `rpc.bootparamd` daemon carries out these services.

Network configuration servers can also can function as NFS file servers.

If you are going to configure any hosts as network clients, then you must also configure at least one machine on your network as a network configuration server. If your network is subnetted, then you must have at least one network configuration server for each subnet with network clients.

Machines That Are Network Clients

Any host that gets its configuration information from a network configuration server is said to be "operating" in network client mode. Machines configured as network clients do not require local copies of the TCP/IP configuration files.

Network client mode greatly simplifies administration of large networks. It minimizes the number of configuration tasks that must be performed on individual hosts and assures that all machines on the network adhere to the same configuration standards.

You can configure network client mode on all types of computers, from fully standalone systems to diskless and dataless machines. Although it is possible to configure routers and servers in network client mode, local files mode is a better choice for these machines. Routers and servers should be as self-sufficient as possible.

Diskless Booting

Setting up systems for diskless booting is described in the *System Administration Guide, Volume I*.

Mixed Configurations

Due to the flexibility of the system, configurations are not limited to either an all-local-hosts mode or an all-network-client mode. The configuration of routers and servers typifies this, in that routers and servers should always be configured in local mode. For hosts, you can use any combination of local and network client mode you want.

Sample Network

Figure 4–1 shows the hosts of a fictional network with the network number 192.9.200. The network includes one network configuration server, the machine

sahara. It serves the diskless client ahaggar. Machines tenere and nubian have their own disks and run in local files mode. Machine faiyum also has a disk but operates in network client mode.

Finally, the machine timbuktu is configured as a router. It includes two network interfaces, one named timbuktu on network 192.9.200 and one named timbuktu-201 on network 192.9.201. Both networks are in the organizational domain deserts.worldwide.com. The domain uses local files as its name service.

Most examples in this chapter use the network shown in Figure 4–1 as their basis.

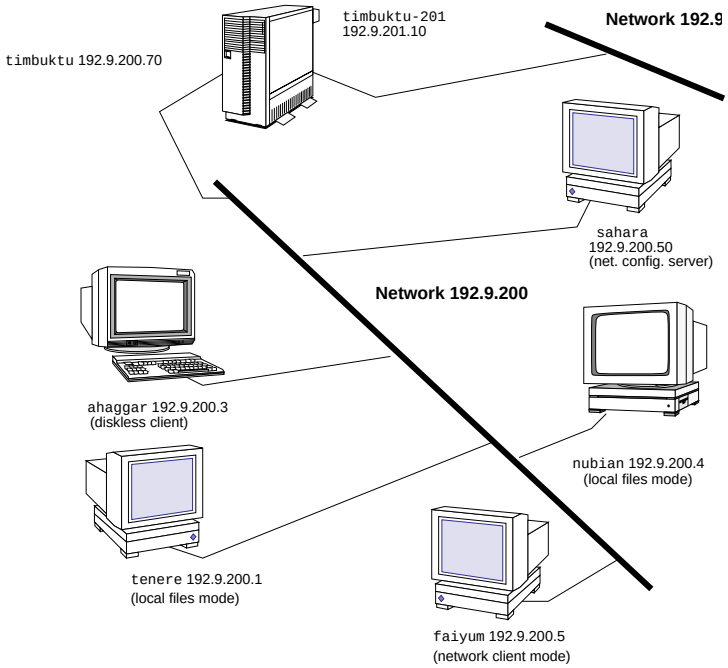


Figure 4–1 Hosts in a Sample Network

TCP/IP Configuration Files

Each machine on the network gets its TCP/IP configuration information from the following TCP/IP configuration files and network databases:

- /etc/hostname.*interface* file
- /etc/nodename file
- /etc/defaultdomain file

- `/etc/defaultrouter` file (optional)
- `hosts` database
- `netmasks` database (optional)

The Solaris installation program creates these files as part of the installation process. You can also edit the files manually, as explained in this section. The `hosts` and `netmasks` databases are two of the network databases read by the name services available on Solaris networks. “Network Databases and `nsswitch.conf` File” on page 56 describes the concept of network databases in detail.

`/etc/hostname.`*interface* File

This file defines the network interfaces on the local host. At least one `/etc/hostname.`*interface* file should exist on the local machine. The Solaris installation program creates this file for you. In the file name, *interface* is replaced by the device name of the primary network interface.

The file contains only one entry: the host name or IP address associated with the network interface. For example, suppose smc0 is the primary network interface for a machine called `ahaggar`. Its `/etc/hostname.`*interface* file would have the name `/etc/hostname.smc0`; the file would contain the entry `ahaggar`.

For Multiple Network Interfaces

If a machine contains more than one network interface, you must create additional `/etc/hostname.`*interface* files for the additional network interfaces. You must create these files with a text editor; the Solaris installation program does not create them for you.

For example, consider the machine `timbuktu` shown in Figure 4–1. It has two network interfaces and functions as a router. The primary network interface `le0` is connected to network 192.9.200. Its IP address is 192.9.200.70, and its host name is `timbuktu`. The Solaris installation program creates the file `/etc/hostname.le0` for the primary network interface and enters the host name `timbuktu` in the file.

The second network interface is `le1`; it is connected to network 192.9.201. Although this interface is physically installed on machine `timbuktu`, it must have a separate IP address. Therefore, you have to manually create the `/etc/hostname.le1` file for this interface; the entry in the file would be the router‘s name, `timbuktu-201`.

/etc/nodename File

This file should contain one entry: the host name of the local machine. For example, on machine `timbuktu`, the file `/etc/nodename` would contain the entry `timbuktu`.

/etc/defaultdomain File

This file should contain one entry, the fully qualified domain name of the administrative domain to which the local host's network belongs. You can supply this name to the Solaris installation program or edit the file at a later date.

In Figure 4–1, the networks are part of the domain `deserts.worldwide`, which was classified as a `.com` domain. Therefore, `/etc/defaultdomain` should contain the entry `deserts.worldwide.com`. For more information on network domains, refer to the *Solaris Naming Administration Guide*.

/etc/defaultrouter File

This file should contain an entry for each router directly connected to the network. The entry should be the name for the network interface that functions as a router between networks.

In Figure 4–1, the network interface `le1` connects machine `timbuktu` with network 192.9.201. This interface has the unique name `timbuktu-201`. Thus, the machines on network 192.9.200 that are configured in local files mode have the name `timbuktu-201` as the entry in `/etc/defaultrouter`.

hosts Database

The `hosts` database contains the IP addresses and host names of machines on your network. If you use the NIS, NIS+, or DNS name services, the `hosts` database is maintained in a database designated for host information. For example, on a network running NIS+, the `hosts` database is maintained in the host table.

If you use local files for name service, the `hosts` database is maintained in the `/etc/inet/hosts` file. This file contains the host names and IP addresses of the primary network interface, other network interfaces attached to the machine, and any other network addresses that the machine must know about.

Note - For compatibility with BSD-based operating systems, the file `/etc/hosts` is a symbolic link to `/etc/inet/hosts`.

/etc/inet/hosts File Format

The /etc/inet/hosts file uses this basic syntax: (Refer to the **hosts**(4) man page for complete syntax information.)

IP-address hostname [nicknames] [#comment]

IP-address contains the IP address for each interface that the local host must know about.

hostname contains the host name assigned to the machine at setup, plus the host names assigned to additional network interfaces that the local host must know about.

[nickname] is an optional field containing a nickname for the host.

[# comment] is an optional field where you can include a comment.

Initial /etc/inet/hosts File

When you run the Solaris installation program on a machine, it sets up the initial /etc/inet/hosts file. This file contains the minimum entries that the local host requires: its loopback address, its IP address, and its host name.

For example, the Solaris installation program might create the following /etc/inet/hosts file for machine ahaggar shown in Figure 4–1:

EXAMPLE 4–1 /etc/inet/hosts File for Machine ahaggar

```
127.0.0.1     localhost         loghost    #loopback address
192.9.200.3   ahaggar                      #host name
```

Loopback Address

In Example 4–1, the IP address 127.0.0.1 is the *loopback address*, the reserved network interface used by the local machine to allow interprocess communication so that it sends packets to itself. The ifconfig command uses the loopback address for configuration and testing, as explained in "ifconfig Command" on page 80. Every machine on a TCP/IP network must use the IP address 127.0.0.1 for the local host.

Host Name

The IP address 192.9.200.3 and the name ahaggar are the address and host name of the local machine. They are assigned to the machine's primary network interface.

Multiple Network Interfaces

Some machines have more than one network interface, either because they are routers or multihomed hosts. Each additional network interface attached to the machine requires its own IP address and associated name. When you configure a router or multihomed host, you must manually add this information to the router's `/etc/inet/hosts` file. (See Chapter 5 for more information on setting up routers and multihomed hosts.)

Example 4–2 is the `/etc/inet/hosts` file for machine `timbuktu` shown in Figure 4–1.

EXAMPLE 4–2 `/etc/inet/hosts` File for Machine `timbuktu`

```
127.0.0.1      localhost     loghost
192.9.200.70   timbuktu      #This is the local host name
192.9.201.10   timbuktu-201  #Interface to network 192.9.201
```

With these two interfaces, `timbuktu` connects networks 192.9.200 and 192.9.201 as a router.

How Name Services Affect the `hosts` Database

The NIS, NIS+, and DNS name services maintain host names and addresses on one or more servers. These servers maintain `hosts` databases containing information for every host and router (if applicable) on the servers' network. Refer to the *Solaris Naming Administration Guide* for more information about these services.

When Local Files Provide Name Service

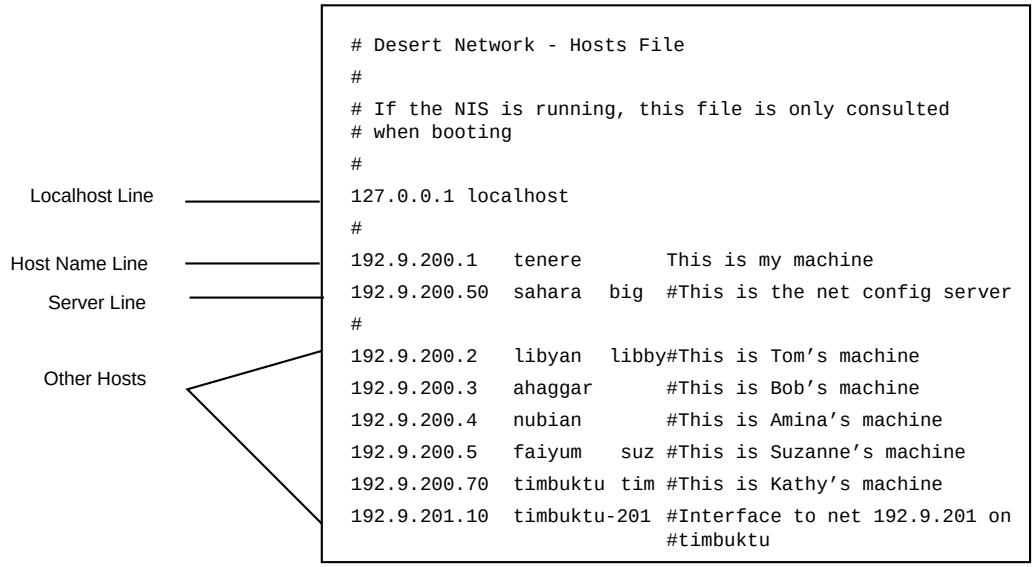
On a network using local files for name service, machines running in local files mode consult their individual `/etc/inet/hosts` files for IP addresses and host names of other machines on the network. Therefore, their `/etc/inet/hosts` files must contain the:

- Loopback address
- IP address and host name of the local machine (primary network interface)
- IP address and host name of additional network interfaces attached to this machine, if applicable
- IP addresses and host names of all hosts on the local network
- IP addresses and host names of any routers this machine must know about, if applicable
- IP address of any machine your machine wants to refer to by its host name

Example 4–3 shows the `/etc/inet/hosts` file for machine `tenere`, a machine that runs in local files mode. Notice that the file contains the IP addresses and host names for every machine on the 192.9.200 network. It also contains the IP address and interface name `timbuktu-201`, which connects the 192.9.200 network to the 192.9.201 network.

A machine configured as a network client uses the local `/etc/inet/hosts` file for its loopback address and IP address.

EXAMPLE 4–3 `/etc/inet/hosts` File for Machine Running in Local Files Mode




```
# Desert Network - Hosts File
#
# If the NIS is running, this file is only consulted
# when booting
#
127.0.0.1 localhost
#
192.9.200.1   tenere        This is my machine
192.9.200.50  sahara  big  #This is the net config server
#
192.9.200.2   libyan   libby#This is Tom's machine
192.9.200.3   ahaggar       #This is Bob's machine
192.9.200.4   nubian        #This is Amina's machine
192.9.200.5   faiyum   suz #This is Suzanne's machine
192.9.200.70  timbuktu tim #This is Kathy's machine
192.9.201.10  timbuktu-201 #Interface to net 192.9.201 on
                           #timbuktu
```

`netmasks` Database

You need to edit the `netmasks` database as part of network configuration *only* if you have set up subnetting on your network. The `netmasks` database consists of a list of networks and their associated subnet masks.

Note - When you create subnets, each new network must be a separate physical network. You cannot apply subnetting to a single physical network.

What is Subnetting

Subnetting is a method for getting the most out of the limited 32-bit IP addressing space and reducing the size of the routing tables in a large internetwork. With any address class, subnetting provides a means of allocating a part of the host address space to network addresses, which lets you have more networks. The part of the host address space allocated to new network addresses is known as the *subnet* number.

In addition to making more efficient use of the IP address space, subnetting has several administrative benefits. Routing can become very complicated as the number of networks grows. A small organization, for example, might give each local network a class C number. As the organization grows, administering a number of different network numbers could become complicated. A better idea is to allocate a few class B network numbers to each major division in an organization. For instance, you could allocate one to Engineering, one to Operations, and so on. Then, you could divide each class B network into additional networks, using the additional network numbers gained by subnetting. This can also reduce the amount of routing information that must be communicated among routers.

Creating the Network Mask

As part of the subnetting process, you need to select a network-wide netmask. The netmask determines how many and which bits in the host address space represent the subnet number and how many and which represent the host number. Recall that the complete IP address consists of 32 bits. Depending on the address class, as many as 24 bits and as few as 8 bits can be available for representing the host address space. The netmask is specified in the `netmasks` database.

If you plan to use subnets, you must determine your netmask before you configure TCP/IP. You then need to carry out the procedures in "How to Add a Subnet to a Network" on page 55. If you plan to install the operating system as part of network configuration, the Solaris installation program requests the netmask for your network.

As described in "Parts of the IP Address" on page 31, 32-bit IP addresses consist of a network part and a host part. The 32 bits are divided into 4 bytes. Each byte is assigned either to the network number or the host number, depending on the network class.

For example, in a class B IP address, the 2 left–hand bytes are assigned to the network number, and the 2 right–hand bytes are assigned to the host number. In the class B IP address 129.144.41.10, you can assign the 2 right–hand bytes to hosts.

If you are going to implement subnetting, you need to use some of the bits in the bytes assigned to the host number to apply to subnet addresses. For example, a 16-bit host address space provides addressing for 65,534 hosts. If you apply the third byte to subnet addresses and the fourth to host addresses, you can address up to 254 networks, with up to 254 hosts on each.

The bits in the host address bytes that will be applied to subnet addresses and those applied to host addresses is determined by a subnet mask. Subnet masks are used to select bits from either byte for use as subnet addresses. Although netmask bits must be contiguous, they need not align on byte boundaries.

The netmask can be applied to an IP address using the bitwise logical AND operator. This operation selects out the network number and subnet number positions of the address.

It is easiest to explain netmasks in terms of their binary representation. You can use a calculator for binary-to-decimal conversion. The following examples show both the decimal and binary forms of the netmask.

If a netmask 255.255.255.0 is applied to the IP address 129.144.41.101, the result is the IP address of 129.144.41.0.

129.144.41.101 & 255.255.255.0 = 129.144.41.0

In binary form, the operation is:

10000001.10010000.00101001.01100101 (IP address)

ANDed with

11111111.11111111.11111111.00000000 (netmask)

Now the system looks for a network number of 129.144.41 instead of a network number of 129.144. If you have a network with the number 129.144.41, that is what the system looks for and finds. Since you can assign up to 254 values to the third byte of the IP address space, subnetting lets you create address space for 254 networks, where previously there was room for only one.

If you want to provide address space for only two additional networks, you could use a subnet mask of:

255.255.192.0

This netmask provides a result of:

11111111.11111111.1100000.00000000

This still leaves 14 bits available for host addresses. Since all 0s and 1s are reserved, at least two bits must be reserved for the host number.

Editing the `/etc/inet/netmasks` File

If your network runs NIS or NIS+, the servers for these name services maintain `netmasks` databases. For networks that use local files for name service, this information is maintained in the `/etc/inet/netmasks` file.

Note - For compatibility with BSD-based operating systems, the file `/etc/netmasks` is a symbolic link to `/etc/inet/netmasks`.

Example 4–4 shows the `/etc/inet/netmasks` file for a class B network.

EXAMPLE 4–4 `/etc/inet/netmasks` File for a Class B Network

```
## The netmasks file associates Internet Protocol (IP) address
 # masks with IP network numbers.
```

(continued)

(Continuation)

```
#
#  network-number netmask
#
# Both the network-number and the netmasks are specified in
# ‘‘decimal dot’’ notation, e.g:
#
#        128.32.0.0   255.255.255.0
         129.144.0.0  255.255.255.0
```

If the file does not exist, create it. Use the following syntax:

network-number netmask-number

Refer to the **netmasks**(4) man page for complete details.

When creating netmask numbers, type the network number assigned by the InterNIC (not the subnet number) and netmask number in `/etc/inet/netmasks`. Each subnet mask should be on a separate line.

For example:

```
128.78.0.0     255.255.248.0
```

You can also type symbolic names for network numbers in the `/etc/inet/hosts` file. You can then use these network names instead of the network numbers as parameters to commands.

▼ How to Add a Subnet to a Network

If you are changing from a network that does not use subnets to one that is subnetted, perform the following steps:

1. **Decide on the new subnet topology, including considerations for routers and locations of hosts on the subnets.**
2. **Assign all subnet and host addresses.**
3. **Modify the `/etc/inet/netmasks` file, if you are manually configuring TCP/IP, or supply the netmask to the Solaris installation program.**
4. **Modify the `/etc/inet/hosts` files on all hosts to reflect the new host addresses.**
5. **Reboot all machines.**

Network Databases and `nsswitch.conf` File

The network databases are files that provide information needed to configure the network. The network databases are:

- `hosts`
- `netmasks`
- `ethers`
- `bootparams`
- `protocols`
- `services`
- `networks`

As part of the configuration process, you edit the `hosts` database and the `netmasks` database, if your network is subnetted. Two network databases, `bootparams` and `ethers`, are used to configure machines as network clients. The remaining databases are used by the operating system and seldom require editing.

Although it is not a network database, the `nsswitch.conf` file needs to be configured along with the relevant network databases. `nsswitch.conf` specifies which name service to use for a particular machine: NIS, NIS+, DNS, or local files.

How Name Services Affect Network Databases

Your network database takes a form that depends on the type of name service you select for your network. For example, the `hosts` database contains, at minimum, the host name and IP address of the local machine and any network interfaces directly connected to the local machine. However, the `hosts` database could contain other IP addresses and host names, depending on the type of name service on your network.

The network databases are used as follows:

- Networks that use local files for their name service rely on files in the `/etc/inet` and `/etc` directories
- NIS+ uses databases called NIS+ tables
- NIS uses databases called NIS maps
- DNS uses records with host information

Note - DNS boot and data files do not correspond directly to the network databases.

Figure 4–2 shows the forms of the `hosts` database used by these name services:

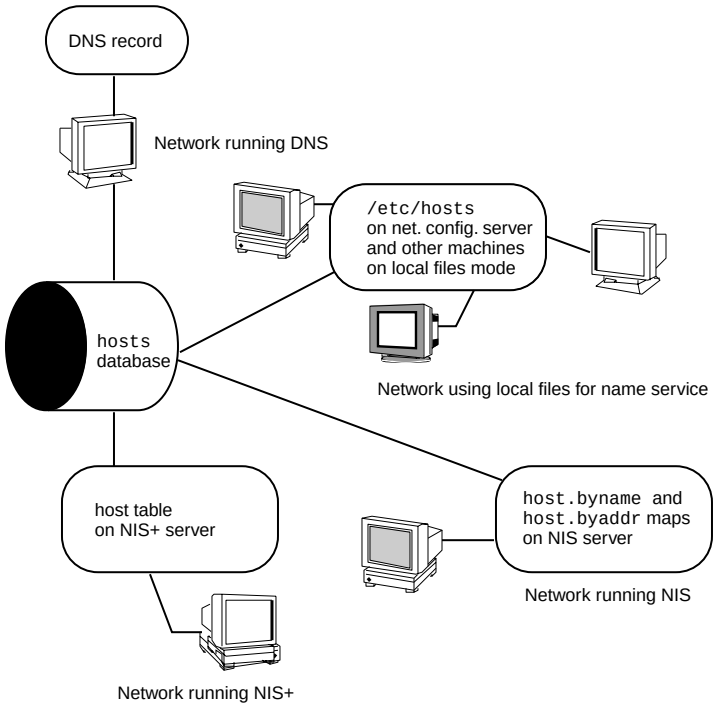


Figure 4–2 Forms of the `hosts` Database Used by Name Services

Table 4–1 lists the network databases and how they are used by local files, NIS+, and NIS.

TABLE 4–1 Network Databases and Corresponding Name Service Files

Network Database	Local Files	NIS+ Tables	NIS Maps
`hosts`	`/etc/inet/hosts`	`hosts.ord_dir`	`hosts.byaddr` `hosts.byname`
`netmasks`	`/etc/inet/netmasks`	`netmasks.ord_dir`	`netmasks.byaddr`
`ethers`	`/etc/ethers`	`ethers.ord_dir`	`ethers.byname` `ethers.byaddr`
`bootparams`	`/etc/bootparams`	`bootparams.ord_dir`	`bootparams`
`protocols`	`/etc/inet/protocols`	`protocols.ord_dir`	`protocols.byname` `protocols.bynumber`

TABLE 4–1 Network Databases and Corresponding Name Service Files *(continued)*

Network Database	Local Files	NIS+ Tables	NIS Maps
services	/etc/inet/services	services.ord_dir	services.byname
networks	/etc/inet/networks	networks.ord_dir	networks.byaddr networks.byname

This book discusses network databases as viewed by networks using local files for name services. Information regarding the `hosts` database is in “`hosts` Database” on page 49; information regarding the `netmasks` database is in “`netmasks` Database” on page 52. Refer to *Solaris Naming Administration Guide* for information on network databases correspondences in NIS, DNS, and NIS+.

`nsswitch.conf` File — Specifying Which Name Service to Use

The `/etc/nsswitch.conf` file defines the search order of the network databases. The Solaris installation program creates a default `/etc/nsswitch.conf` file for the local machine, based on the name service you indicate during the installation process. If you selected the “None” option, indicating local files for name service, the resulting `nsswitch.conf` file resembles Example 4–5.

EXAMPLE 4–5 `nsswitch.conf` for Networks Using Files for Name Service

```
# /etc/nsswitch.files:
#
# An example file that could be copied over to /etc/nsswitch.conf;
# it does not use any naming service.
#
# "hosts:" and "services:" in this file are used only if the
# /etc/netconfig file contains "switch.so" as a
# nametoaddr library for "inet" transports.

passwd:          files
group:           files
hosts:           files
networks:        files
protocols:       files
rpc:             files
ethers:          files
netmasks:        files
```

(continued)

(Continuation)

```
bootparams:      files
publickey:       files
# At present there isn't a 'files' backend for netgroup; the
# system will figure it out pretty quickly,
# and won't use netgroups at all.
netgroup:        files
automount:       files
aliases:         files
services:        files
sendmailvars:    files
```

The **`nsswitch.conf`**(4) man page describes the file in detail. Its basic syntax is:

database name-service-to-search

The *database* field can list one of many types of databases searched by the operating system. For example, it could indicate a database affecting users, such as `passwd` or `aliases`, or a network database. The parameter *name-service-to-search* can have the values `files`, `nis`, or `nis+` for the network databases. (The `hosts` database can also have `dns` as a name service to search.) You can also list more than one name service, such as `nis+` and `files`.

In Example 4–5, the only search option indicated is `files`. Therefore, the local machine gets security and automounting information, in addition to network database information, from files located in its `/etc` and `/etc/inet` directories.

Changing `nsswitch.conf`

The `/etc` directory contains the `nsswitch.conf` file created by the Solaris installation program. It also contains template files for the following name services:

- `nsswitch.files`
- `nsswitch.nis`
- `nsswitch.nis+`

If you want to change from one name service to another, you can copy the appropriate template to `nsswitch.conf`. You can also selectively edit the `nsswitch.conf` file, and change the default name service to search for individual databases.

For example, on a network running NIS, you might have to change the `nsswitch.conf` file on diskless clients. The search path for the `bootparams` and `ethers` databases must list `files` as the first option, and `nis`. Example 4–6 shows the correct search paths.

EXAMPLE 4–6 `nsswitch.conf` for a Diskless Client on a Network Running NIS

```
## /etc/nsswitch.conf:#
.
.
passwd:        files nis
group:         file nis

# consult /etc "files" only if nis is down.
hosts:         nis    [NOTFOUND=return] files
networks:      nis    [NOTFOUND=return] files
protocols:     nis    [NOTFOUND=return] files
rpc:           nis    [NOTFOUND=return] files
ethers:        files  [NOTFOUND=return] nis
netmasks:      nis    [NOTFOUND=return] files
bootparams:    files  [NOTFOUND=return] nis
publickey:     nis
netgroup:      nis

automount:     files nis
aliases:       files nis

# for efficient getservbyname() avoid nis
services:      files nis
sendmailvars:  files
```

For complete details on the name service switch, refer to *Solaris Naming Administration Guide*.

`bootparams` Database

The `bootparams` database contains information used by diskless clients and machines configured to boot in the network client mode. You need to edit it if your network will have network clients. (See “Configuring Network Clients” on page 67 for procedures.) The database is built from information entered into the `/etc/bootparams` file.

The **`bootparams`**(4) man page contains complete syntax for this database. Its basic syntax is

machine-name file-key-server-name:pathname

For each diskless or network client machine, the entry might contain the following information: the name of the client, a list of keys, the names of servers, and path names.

The first item of each entry is the name of the client machine. Next is a list of keys, names of servers, and path names, separated by tab characters. All items but the first are optional. The database can contain a wildcard entry that will be matched by all clients. Here is an example:

EXAMPLE 4–7 `bootparams` Database

```
myclient   root=myserver : /nfsroot/myclient  \
swap=myserver : /nfsswap//myclient \
dump=myserver : /nfsdump/myclient
```

In this example the term `dump=:` tells diskless hosts not to look for a dump file.

Wildcard Entry for `bootparams`

In most cases, you will want to use the wildcard entry when editing the `bootparams` database to support diskless clients. This entry is:

```
*  root=server:/path dump=:
```

The asterisk (*) wildcard indicates that this entry applies to all clients not specifically named within the `bootparams` database.

`ethers` Database

The `ethers` database is built from information entered into the `/etc/ethers` file. It associates host names to their Ethernet addresses. You need to create an `ethers` database only if you are running the RARP daemon; that is, if you are configuring network clients or diskless machines.

RARP uses the file to map Ethernet addresses to IP addresses. If you are running the RARP daemon `in.rarpd`, you need to set up the `ethers` file and maintain it on all hosts running the daemon to reflect changes to the network.

The **`ethers`**(4) man page contains complete syntax information for this database. Its basic format is:

Ethernet-address hostname #comment

Ethernet-address is the Ethernet address of the host.

hostname is the official name of the host.

#comment is any kind of note you want to append to an entry in the file.

The equipment manufacturer provides the Ethernet address. If a machine does not display the Ethernet address when you power up, see your hardware manuals for assistance.

When adding entries to the `ethers` database, make sure that host names correspond to the primary names in the `hosts` database, not to the nicknames, as shown in Example 4–8.

EXAMPLE 4–8 Entries in the `ethers` Database

```
8:0:20:1:40:16  fayoum
8:0:20:1:40:15  nubian
8:0:20:1:40:7   sahara    # This is a comment
8:0:20:1:40:14  tenere
```

Other Network Databases

The remaining network databases seldom need to be edited.

`networks` database

The `networks` database associates network names with network numbers, enabling some applications to use and display names rather than numbers. The `networks` database is based on information in the `/etc/inet/networks` file. It contains the names of all networks to which your network connects via routers.

The Solaris installation program sets up the initial `networks` database. The only time you need to update it is when you add a new network to your existing network topology.

The **`networks`**(4) man page contains full syntax information for `/etc/inet/networks`. Here is its basic format

network-name network-number nickname(s) # comment

network-name is the official name for the network.

network-number is the number assigned by the InterNIC.

nickname is any other name by which the network is known.

#comment is any kind of note you want to append to an entry in the file.

It is particularly important that you maintain the `networks` file. The `netstat` program uses the information in this database to produce status tables.

Example 4–9 shows a sample `/etc/networks` file:

EXAMPLE 4–9 `/etc/networks` File

```
#ident "@(#)networks 1.4 92/07/14 SMI" /* SVr4.0 1.1 */
#
# The networks file associates Internet Protocol (IP) network
numbers with network names. The format of this file is:
#
#  network-name     network-number     nicnames . . .
```

(continued)

(Continuation)

```
# The loopback network is used only for intra-machine
communication
#loopback     127

# Internet networks
#
arpanet     10    arpa  # Historical
ucb-ether   46    ucbether
#
# local networks

eng   193.9.0  #engineering
acc   193.9.1  #accounting
prog  193.9.2  #programming
```

`protocols` Database

The `protocols` database lists the TCP/IP protocols installed on your system and their numbers; the Solaris installation program automatically creates it. It is rare when this file requires administrative handling.

The `protocols` database contains the names of the TCP/IP protocols installed on the system. Its syntax is completely described in the **`protocols`**(4) man page. Example 4–10 shows an example of the `/etc/inet/protocols` file:

EXAMPLE 4–10 `/etc/inet/protocols` File

```
#
# Internet (IP) 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
```

`services` Database

The `services` database lists the names of TCP and UDP services and their well known port numbers; it is used by programs that call network services. The Solaris installation automatically creates the `services` database; it generally requires no administrative handling.

The **`services`**(4) man page contains complete syntax information. Example 4–11 shows an excerpt from a typical `/etc/inet/services` file:

EXAMPLE 4–11 `/etc/inet/services` File

```
#
# Network services
#
echo      7/udp
echo      7/tcp
discard   9/udp     sink null
discard   11/tcp
daytime   13/udp
daytime   13/tcp
netstat   15/tcp
ftp-data  20/tcp
ftp       21/tcp
telnet    23/tcp
time      37/tcp    timeserver
time      37/udp    timeserver
name      42/udp    nameserver
whois     43/tcp    nickname
```

Network Configuration Procedures

Network software installation takes place along with the installation of the operating system software. At that time, certain IP configuration parameters must be stored in appropriate files so they can be read at boot time.

The procedure is simply a matter of creating or editing the network- configuration files. How configuration information is made available to a machine's kernel depends on whether these files are stored locally (local files mode) or acquired from the network configuration server (network client mode).

Parameters supplied during network configuration are:

- IP address of each network interface on every machine
- Host names of each machine on the network. You can type the host name in a local file or a name service database.
- NIS, NIS+, or DNS domain name in which the machine resides, if applicable
- Default router addresses. You supply this only if you have a simple network topology with only one router attached to each network, or your routers don't run routing protocols such as the Router Discovery Server Protocol (RDISC) or the Router Information Protocol (RIP). (See Chapter 5 for more information about these protocols.)
- Subnet mask (required only for networks with subnets)

This chapter contains complete information on creating and editing local configuration files. See the *Solaris Naming Administration Guide* for information on working with name service databases.

▼ How to Configure a Host for Local Files Mode

Use this procedure for configuring TCP/IP on a machine that run in local files mode.

1. **Become superuser and change to the `/etc` directory.**

2. **Type the host name of the machine in the file `/etc/nodename`.**
   For example, if the name of the host is `tenere`, type `tenere` in the file.

3. **Create a file named `/etc/hostname.`*interface* for each network interface.**
   (The Solaris installation program automatically creates this file for the primary network interface.)
   Refer to "`/etc/hostname.`*interface* File" on page 48 for complete details.

4. **Type either the interface IP address or the interface name in each `/etc/hostname.`*interface* file.**
   For example, create a file named `hostname.ie1`, and type either the IP address of the host's interface or the host's name.

5. **Edit the `/etc/inet/hosts` file to add**:
   a. **IP addresses that you have assigned to any additional network interfaces in the local machine, along with the corresponding host name for each interface.**
      The Solaris installation program will already have created entries for the primary network interface and loopback address.

   b. **IP address or addresses of the file server, if the `/usr` file system is NFS mounted.**

   Note - The Solaris installation program creates the default `/etc/inet/hosts` for the local machine. If the file does not exist, create it as shown in "`hosts` Database" on page 49.

   ---

6. **Type the host's fully qualified domain name in the `/etc/defaultdomain` file.**
   For example, suppose host `tenere` was part of the domain deserts.worldwide.com. Therefore, you would type: `deserts.worldwide.com` in `/etc/defaultdomain`. See "`/etc/defaultdomain` File" on page 49 for more information.

7. **Type the router's name in** `/etc/defaultrouter`**.**

   See "`/etc/defaultrouter` File" on page 49 for information about this file.

8. **Type the name of the default router and its IP addresses in** `/etc/inet/hosts`**.**

   Additional routing options are available. Refer to the discussion on routing options in "How to Configure Hosts for Network Client Mode" on page 67. You can apply these options to a local files mode configuration.

9. **If your network is subnetted, type the network number and the netmask in the file** `/etc/inet/netmasks`**.**

   If you have set up a NIS or NIS+ server, you can type `netmask` information in the appropriate database on the server as long as server and clients are on the same network.

10. **Reboot each machine on the network.**

▼ Setting Up a Network Configuration Server

If you plan to configure certain hosts as network clients, you must configure at least one machine on your network as a network configuration server. (Refer to "Network Configuration Servers" on page 45 for an introduction.)

Setting up a network configuration server involves:

1. Turning on the network configuration daemons:
   - `in.tftpd`
   - `in.rarpd`
   - `rpc.bootparamd`
2. Editing and maintaining the network configuration files on the configuration server.

   "How to Set Up a Network Configuration Server" on page 66 assumes that you have already set up the network configuration server for local files mode.

▼ How to Set Up a Network Configuration Server

1. **Become superuser and change to the root directory of the prospective network configuration server.**

2. **Turn on the** `in.tftpd` **daemon by creating the directory** `/tftpboot`:

   # **`mkdir /tftpboot`**

   This configures the machine as a TFTP, bootparams, and RARP server.

3. **Create a symbolic link to the directory.**

   # **ln -s /tftpboot/. /tftpboot/tftpboot**

4. **Enable the** `tftp` **line in** `intetd.conf`**.**

   Check that the `/etc/inetd.conf` entry reads:

```
tftp dgram udp wait root /usr/sbin/in.tftpd in.tftpd -s /tftpboot
```

   This prevents `inettftpd( )` from retrieving any file other than one located in `/tftpboot`.

5. **Edit the** `hosts` **database, and add the host names and IP addresses for every client on the network.**

6. **Edit the** `ethers` **database, and create entries for every host on the network to run in network client mode.**

7. **Edit the** `bootparams` **database.**

   See “`bootparams` Database” on page 60. Use the wildcard entry or create an entry for every host that run in network client mode.

8. **Reboot the server.**

Information for setting up diskless clients, install servers, and boot servers can be found in *Solaris Advanced Installation Guide.*

Configuring Network Clients

Network clients receive their configuration information from network configuration servers. Therefore, before you configure a host as a network client you must ensure that at least one network configuration server is set up for the network.

▼ How to Configure Hosts for Network Client Mode

Do the following on each host to be configured in network client mode:

1. **Become superuser.**

2. **Check the directory for the existence of an** `/etc/nodename` **file. If one exists, delete it.**

   Eliminating `/etc/nodename` causes the system to use the `hostconfig` program to obtain the host name, domain name, and router addresses from the network configuration server. See “Network Configuration Procedures” on page 64.

3. **Create the file** `/etc/hostname.`***interface*****, if it does not exist.**

   Make sure that the file is empty. An empty `/etc/hostname.`*interface* file causes the system to acquire the IP address from the network configuration server.

4. **Ensure that the** `/etc/inet/hosts` **file contains only the host name and IP address of the loopback network interface.**

   (See "Loopback Address" on page 50.) The file should not contain the IP address and host name for the local machine (primary network interface).

   EXCEPTION: For a diskless client (a machine with an NFS-mounted root file system), type the name and IP address of the server that provides the client's root file system (usually, but not always, the network configuration server).

5. **Check for the existence of an** `/etc/defaultdomain` **file. If one exists, delete it.**

   The `hostconfig` program sets the domain name automatically. If you want to override the domain name set by `hostconfig`, type the substitute domain name in the file `/etc/defaultdomain`.

6. **Ensure that the search paths in the client's** `/etc/nsswitch.conf` **reflects the name service requirements for your network.**

▼ How to Specify a Router for the Network Client

1. **If you have only one router on the network and you want the network configuration server to specify its name automatically, ensure that the network client does not have a** `/etc/defaultrouter` **file.**

2. **To override the name of the default router provided by the network configuration server:**

   a. **Create** `/etc/defaultrouter` **on the network client.**

   b. **Type the host name and IP address of the machine you have designated as the default router.**

   c. **Add the host name and IP address of the designated default router to the network client's** `/etc/inet/hosts`**.**

3. **If you have multiple routers on the network, create** `/etc/defaultrouter` **on the network client, but leave it empty.**

Creating `/etc/defaultrouter` and leaving it empty causes one of the two dynamic routing protocols to run: ICMP Router Discovery protocol (RDISC), or Routing Information Protocol (RIP). The system first runs the program `in.rdisc`, which looks for routers that are running the router discovery protocol. If it finds one such router, `in.rdisc` continues to run and keeps track of the routers that are running the RDISC protocol.

If the system discovers that routers are not responding to the RDISC protocol, it uses RIP and runs the daemon `in.routed` to keep track of them.

After Installing a Network Client

After you have finished editing the files on each network client machine, do the following on the network configuration server.

1. **Add entries for the hosts in the `ethers` and `hosts` databases.**

2. **Add entries for the hosts to the `bootparams` database.**

   To simplify matters, you can type a wild card in the `bootparams` database in place of individual entries for each host. For an example, see "`bootparams` Database" on page 60.

3. **Reboot the server.**

Configuring Standard TCP/IP Services

Services such as `telnet`, `ftp`, and `rlogin` are started by the `inetd` daemon, which runs automatically at boot time. Like the name service ordering specified in `nsswitch.conf`, you can configure TCP/IP services in the file `/etc/inetd.conf` by using the `inetd` –`t` flag.

For example, you can use `inetd` to log the IP addresses of all incoming TCP connections (remote logins and `telnet`). To turn the logging on, kill the running `inetd` and type:

```
# /usr/sbin/inetd -t -s
```

The `t` switch turns on TCP connection-tracing in `inetd`.

Refer to the **`inetd`**(1M) and **`inetd.conf`**(4) man pages.

See *Solaris Naming Administration Guide* and *Solaris Naming Setup and Configuration Guide* for further information on name services.

Overview of the Booting Processes

The following information is provided for your reference. It is a brief overview of the network booting processes to help you better visualize what is happening during configuration.

Note - The names of startup scripts might change from one release to another.

---

1. You start the operating system on a host.
2. The kernel runs `/sbin/init`, as part of the booting process.
3. `/sbin/init` runs the `/etc/rcS.d/S30rootusr.sh`. startup script.
4. The script runs a number of system startup tasks, including establishing the minimum host and network configurations for diskless and dataless operations. `/etc/rcS.d/S30rootusr.sh` also mounts the `/usr` file system.
   a. If the local database files contain the required configuration information (host name and IP address), the script uses it.
   b. If the information is not available in local host configuration files, `/etc/rcS.d/S30rootusr.sh` uses RARP to acquire the host's IP address.
5. If the local files contain domain name, host name, and default router address, the machine uses them. If the configuration information is not in local files, then the system uses the Bootparams protocol to acquire the host name, domain name, and default router address. Note that the required information must be available on a network configuration server that is located on the same network as the host. This is necessary because no internetwork communications exist at this point.
6. After `/etc/rcS/S30rootusr.sh` completes its tasks and several other boot procedures have executed, `/etc/rc2.d/S69inet` runs. This script executes startup tasks that must be completed before the name services (NIS, NIS+, or DNS) can start. These tasks include configuring the IP routing and setting the domain name.
7. At completion of the `S69inet` tasks, `/etc/rc2.d/S71rpc` runs. This script starts the NIS, NIS+, or DNS name service.
8. After `/etc/rc2.d/S71` runs, `/etc/rc2.d/S72inetsvc` runs. This script starts up services that depend on the presence of the name services. `S72inetsvc` also starts the daemon `inetd`, which manages user services such as `telnet`.

See *System Administration Guide, Volume I* for a complete description of the booting process.

CHAPTER 5

Configuring Routers

This chapter describes routing protocols and contains procedures specifically for configuring routers on TCP/IP networks. A router is any machine that has two or more network interfaces and forwards packets from one network to another. Two common types of routers are computers with additional network interfaces in their card slots and dedicated routers sold by various manufacturers.

This chapter does not explain the theory of routing. You can find that information in "Network Topology" on page 39; "How Routers Transfer Packets" on page 41 explains basic topics regarding routing. Tasks for creating subnets are found in "`netmasks` Database" on page 52.

Routing Protocols

Solaris system software supports two routing protocols: Routing Information Protocol (RIP) and ICMP Router Discovery (RDISC). RIP and RDISC are both standard TCP/IP protocols.

Routing Information Protocol (RIP)

RIP is implemented by `in.routed`, the routing daemon, which automatically starts when the machine boots. When run on a router with the `s` option specified,

`in.routed` fills the kernel routing table with a route to every reachable network and advertises "reachability" through all network interfaces.

When run on a host with the `q` option specified, `in.routed` extracts routing information but does not advertise reachability. On hosts, routing information can be extracted in two ways:

- Do *not* specify the `S` flag (capital "S": "Space-saving mode") and `in.routed` builds a full routing table exactly as it does on a router.
- Specify the `S` flag and `in.routed` creates a minimal kernel table, containing a single default route for each available router.

ICMP Router Discovery (RDISC) Protocol

Hosts used RDISC to obtain routing information from routers. Thus, when hosts are running RDISC, routers must also run another protocol, such as RIP, in order to exchange router information among themselves.

RDISC is implemented by `in.rdisc`, which should run on both routers and hosts. Normally, when `in.rdisc` runs on a host, it enters a default route for each router that is also running `in.rdisc`. A host that is running `in.rdisc` can not discover routers that are running only RIP. Furthermore, when routers are running `in.rdisc` (rather than `in.routed`), they can be configured to have a different preference, which causes hosts to select a better router. See the **`rdisc`**(1M) man page.

Configuring Routers

TCP/IP's first requirement for a router is that the machine must have at least two network interfaces installed, as introduced in "Network Interfaces" on page 7. As long as one of the network interfaces is not disabled, the router automatically "talks" to the RDISC and RIP protocols. These protocols keep track of routers on the network and advertise the router to the hosts on the network.

After the router is physically installed on the network, configure it to operate in local files mode, as described in "How to Configure a Host for Local Files Mode" on page 65. This ensures that routers will boot in case the network configuration server is down. Remember that,unlike a host, a router has at least two interfaces to configure.

Configuring Both Router Network Interfaces

Because a router provides the interface between two or more networks, you must assign a unique name and IP address to each of the router's network interface cards.

Thus, each router has a host name and IP address associated with its primary network interface, plus at least one more unique name and IP address for each additional network interface.

▼ How to Configure a Machine as a Router

Become superuser on the machine to be configured as a router and do the following:

1. **Create an** `/etc/hostname.`***interface*** **file or each network interface installed.**

   For example, create `hostname.ie0` and `hostname.ie1`. (See "`/etc/hostname.`*interface* File" on page 48 for more information.)

2. **Type in each file the host name you have selected for that interface.**

   For example, you could type the name `timbuktu` in the file `hostname.ie0`, then type the name `timbuktu-201` in the file `hostname.ie1`. Both interfaces would be located on the same machine.

3. **Type the host name and IP address of each interface into** `/etc/inet/hosts`**.**

   For example:

```
192.9.200.20     timbuktu       #interface for network 192.9.200
192.9.201.20     timbuktu-201   #interface for network 192.9.201
192.9.200.9      gobi
192.9.200.10     mojave
192.9.200.110    saltlake
192.9.200.12     chilean
```

   The interfaces `timbuktu` and `timbuktu-201` are on the same machine. Notice that the network address for `timbuktu-201` is different from that of `timbuktu`. That is because the medium for network 192.9.201 is connected to the `timbuktu-201` network interface while the media for network 192.9.200 is connected to the `timbuktu` interface.

4. **If the router is connected to any subnetted network, edit** `/etc/inet/netmasks` **and type the local network number (129.9.0.0, for example) and associated netmask number (255.255.255.0, for example).**

How a Machine Determinesif it is a Router

The `/etc/rc2.d/S69inet` startup script, which runs when the machine boots, determines whether a machine is a router or a host. This decision also determines whether the routing protocols (RIP and RDISC) should run in router mode or host mode.

The `/etc/rc2.d/S69inet` script concludes that a machine is a router if the following two conditions exist:

- More than one `/etc/hostname.`*interface* file exists.
- More than one interface was configured "up" by the `ifconfig` command. (See the **`ifconfig`**(1M) man page.)

If only one interface is found, the script concludes that the machine is a host. See "Configuring Both Router Network Interfaces" on page 72. An interface that is configured by any means other than an `/etc/hostname.`*interface* file is not taken into account.

Automatic Routing Protocol Selection

The startup script then must determine whether to start up a routing protocol (RIP or RDISC) on the machine or use static routing.

To Select Static Routing on a Host

If the host is a diskless client or network client, add an entry for a router on the network into `/etc/defaultrouter`. (See "`/etc/defaultrouter` File" on page 49.) A single static default route is then installed in the routing table. Under this condition, the host does not run any dynamic routing protocol (such as RIP and RDISC).

To Select Dynamic Routing on a Host

To force a diskless client or network client to select a dynamic routing protocol, its `/etc/defaultrouter` file should be empty. The type of dynamic routing used is selected according to the following criteria:

- If the `/usr/sbin/in.rdisc` program exists, the startup script starts `in.rdisc`. Any router on the network that is running RDISC then responds to any RDISC queries from the host. If at least one router responds, the host selects RDISC as its routing protocol.
- If the network router is not running RDISC or fails to respond to the RDISC queries, then `in.rdisc` on the host exits. The host then starts `in.routed`, which runs RIP.

Forcing a Machine to Be a Router

You can force a machine that has only one `/etc/hostname.`*interface* file (by default a host) to be a router. To do so, create a file named `/etc/gateways` and leave it

empty. This is important if you decide to configure PPP links, as explained in “Routing Considerations” on page 113.

Creating a Multihomed Host

By default, TCP/IP considers any machine with multiple network interfaces to be a router. However, you can change a router into a *multihomed host*—a machine with more than one network interface that does not run routing protocols or forward IP packets. You typically configure the following types of machines as multihomed hosts:

- NFS servers, particularly large data centers, can be attached to more than one network in order to share files among a large pool of users. These servers don’t need to maintain routing tables.
- Database servers can have multiple network interfaces for the same reason as NFS servers—to provide resources to a large pool of users.
- Firewall gateways are machines that provide the connection between a company’s network and public networks such as the Internet. Administrators set up firewalls as a security measure. When configured as a firewall, the host will not pass packets between the networks attached to it. On the other hand, it can still provide standard TCP/IP services, such as `ftp` or `rlogin`, to authorized users.

Since TCP/IP considers any machine with multiple network interfaces to be a router, you need to perform a few operations to turn it into a multihomed host.

▼ How to Create a Multihomed Host

Become superuser on the prospective multihomed host and do the following:

1. **Create an `/etc/hostname.`*interface* file for each additional network interface installed in the machine.**

2. **Type:**

   % **`touch /etc/notrouter`**

   This creates an empty file called `/etc/notrouter`.

3. **Reboot the machine.**

When the machine reboots, the startup script looks for the presence of the `/etc/notrouter` file. If the file exists, the startup script does not run `in.routed -s` or `in.rdisc -r`, and does not turn on IP forwarding on all interfaces configured “up” by `ifconfig`. This happens regardless of whether an `/etc/gateways` file exists. Thus the machine is now a multihomed host.

Turning On Space-Saving Mode

Space-saving mode provides the host with a table that contains only the default routes. On a host, `in.routed` runs with space saving mode turned off by default.

If you do not want the host to have a full routing table (which provides increased protection against misconfigured routers), turn space saving mode on. To do so, edit the `/etc/rc2.d/S69inet` startup script by changing the line:

```
/usr/sbin/in.routed -q
```

to

```
/usr/sbin/in.routed -q -S
```

Turning Off ICMP Router Discovery on the Host

For reasons involving router reliability, you might not want your hosts to use RDISC. To turn RDISC off, change the name of the host's `/usr/sbin/in.rdisc` to some other name, such as `/usr/sbin/in.rdisc.saved`, and then reboot the host.

Turning Off ICMP Router Discovery on the Router

If the automatic selection of RIP rather than RDISC by a host is to work reliably, the routers in the network (particularly those running RDISC) must also work reliably.

If your routers are not running RDISC and you install a single Solaris router, by default all hosts connected to that router rely on it alone. To have the hosts on that network use the other routers as well, turn off RDISC on the new router. To do this, change the name of the router's `/usr/bin/in.rdisc` file to some other file name and reboot the router.

CHAPTER 6

Troubleshooting TCP/IP

This chapter describes general methods for troubleshooting TCP/IP networks and some of the tools available for doing so. These tools include `ping`, `ifconfig`, `netstat`, and `route`.

General Troubleshooting Methods

One of the first signs of trouble on the network is a loss of communications by one or more hosts. If a host refuses to come up at all the first time it is added to the network, the problem might lie in one of the configuration files, or in the network interface. If a single host suddenly develops a problem, the network interface might be the cause. If the hosts on a network can communicate with each other but not with other networks, the problem could lie with the router, or it could lie in another network.

You can use the `ifconfig` program to obtain information on network interfaces and `netstat` to display routing tables and protocol statistics. Third-party network diagnostic programs provide a number of troubleshooting utilities. Refer to third-party documentation for information.

Less obvious are the causes of problems that degrade performance on the network. For example, you can use tools like `ping` to quantify problems like the loss of packets by a host.

Running Software Checks

If there is trouble on the network, some actions that you can take to diagnose and fix software-related problems include:

1. Using the `netstat` command to display network information.
2. Checking the `hosts` database to make sure that the entries are correct and up to date.
3. If you are running RARP, checking the Ethernet addresses in the `ethers` database to make sure that the entries are correct and up to date.
4. Trying to connect by `telnet` to the local host.
5. Ensuring that the network daemon `inetd` is running. To do this, log in as superuser and type:

   # **`ps -ef | grep inetd`**

Here is an example of output displayed if the `inetd` daemon is running:

```
root 57 1 0 Apr 04 ? 3:19 /usr/sbin/inetd -s
root 4218 4198 0 17:57:23 pts/3 0:00 grep inetd
```

`ping` Command

Use the `ping` command to find out whether there is IP connectivity to a particular host. The basic syntax is:

`/usr/sbin/ping` *host [timeout]*

where *host* is the host name of the machine in question. The optional *timeout* argument indicates the time in seconds for `ping` to keep trying to reach the machine—20 seconds by default. The **`ping`**(1M) man page describes additional syntaxes and options.

When you run `ping`, the ICMP protocol sends a datagram to the host you specify, asking for a response. (ICMP is the protocol responsible for error handling on a TCP/IP network. See "ICMP Protocol" on page 19 for details.)

Suppose you type:

```
$ ping elvis
```

If host `elvis` is up, this message is displayed:

```
elvis is alive
```

indicating that `elvis` responded to the ICMP request. However, if `elvis` is down or cannot receive the ICMP packets, you receive the following response from `ping`:

```
no answer from elvis
```

If you suspect that a machine might be losing packets even though it is up, you can use the `s` option of `ping` to try to detect the problem. For example, type:

```
$ ping -s elvis
```

`ping` continually sends packets to `elvis` until you send an interrupt character or a timeout occurs. The responses on your screen will resemble:

```
PING elvis: 56 data bytes
64 bytes from 129.144.50.21: icmp_seq=0. time=80. ms
64 bytes from 129.144.50.21: icmp_seq=1. time=0. ms
64 bytes from 129.144.50.21: icmp_seq=2. time=0. ms
64 bytes from 129.144.50.21: icmp_seq=3. time=0. ms
.
.
.
----elvis PING Statistics----
4 packets transmitted, 4 packets received, 0% packet loss
round-trip (ms) min/avg/max = 0/20/80
```

The packet-loss statistic indicates whether the host has dropped packets.

If `ping` fails, check the status of the network reported by `ifconfig` and `netstat`, as described in "`ifconfig` Command" on page 80 and "`netstat` Command" on page 81.

ifconfig Command

The `ifconfig` command displays information about the configuration of an interface that you specify. (Refer to the **`ifconfig`**(1M) man page for complete details.) The syntax of `ifconfig` is:

`ifconfig` *interface-name [protocol_family]*

If you want information about a specific interface, for example `le0`, type:

```
$ ifconfig le0
```

For an `le0` interface, your output resembles the following:

```
le0: flags=863<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
  inet 129.144.44.140 netmask ffffff00 broadcast 129.144.44.255
ether 8:0:20:8:el:fd
```

The flags section just given shows that the interface is configured "up," capable of broadcasting, and not using "trailer" link level encapsulation. The `mtu` field tells you that this interface has a maximum transfer rate of 1500. Information on the second line includes the IP address of the host you are using, the netmask being currently used, and the IP broadcast address of the interface. The third line gives the machine address (Ethernet, in this case) of the host.

A useful `ifconfig` option is –`a`, which provides information on all interfaces on your network. For example, typing **`ifconfig -a`**produces:

```
le0:  flags=49<UP,LOOPBACK,RUNNING> mtu 8232
     inet 127.144.44.140 netmask ff000000
le0:flags=863<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
     inet 129.144.44.140 netmask ffffff00 broadcast 129.144.44.255
ether 8:0:20:8:el:fd
```

Note - If a user is privileged (root), and issues an `ifconfig` command, machine addresses are displayed in the output as shown above.

Output that indicates an interface is not running might mean a problem with that interface. In this case, see the **`ifconfig`**(1M) man page.

netstat Command

The `netstat` command generates displays that show network status and protocol statistics. You can display the status of TCP and UDP endpoints in table format, routing table information, and interface information.

`netstat` displays various types of network data depending on the command line option selected. These displays are the most useful for system administration. The syntax for this form is:

`netstat [-m] [-n] [-s] [-i | -r] [-f` *address_family*`]`

The most frequently used options for determining network status are: `s`, `r`, and `i`. See the **`netstat`**(1M) man page for a description of the options.

Displaying Per Protocol Statistics

The `netstat -s` option displays per protocol statistics for the UDP, TCP, ICMP, and IP protocols. The result resembles the display shown in the example below. (Parts of the output have been truncated.) The information can indicate areas where a protocol is having problems. For example, statistical information from ICMP can indicate where this protocol has found errors.

```
UDP

      udpInDatagrams      =  39228     udpOutDatagrams     =  2455
      udpInErrors         =     0

TCP

      tcpRtoAlgorithm     =     4      tcpMaxConn          =    -1
      tcpRtoMax           = 60000      tcpPassiveOpens     =     2
      tcpActiveOpens      =     4      tcpEstabResets      =     1
      tcpAttemptFails     =     3      tcpOutSegs          =   315
      tcpCurrEstab        =     1      tcpOutDataBytes     = 10547
      tcpOutDataSegs      =   288      tcpRetransBytes     =  8376
      tcpRetransSegs      =    29      tcpOutAckDelayed    =    23
      tcpOutAck           =    27      tcpOutWinUpdate     =     2
      tcpOutUrg           =     2      tcpOutControl       =     8
      tcpOutWinProbe      =     0      tcpOutFastRetrans   =     1
      tcpOutRsts          =     0
      tcpInSegs           =   563      tcpInAckBytes       = 10549
      tcpInAckSegs        =   289      tcpInAckUnsent      =     0
      tcpInDupAck         =    27      tcpInInorderBytes   =   673
      tcpInInorderSegs    =   254      tcpInInorderBytes   =   673
      tcpInUnorderSegs    =     0      tcpInUnorderBytes   =     0
      tcpInDupSegs        =     0      tcpInDupBytes       =     0
      tcpInPartDupSegs    =     0      tcpInPartDupBytes   =     0
```

(continued)

(Continuation)

```
      tcpInPastWinSegs    =     0      tcpInPastWinBytes   =     0
      tcpInWinProbe       =     0      tcpInWinUpdate      =   237
      tcpInClosed         =     0      tcpRttNoUpdate      =    21
      tcpRttUpdate        =   266      tcpTimRetrans       =    26
      tcpTimRetransDrop   =     0      tcpTimKeepalive     =     0
      tcpTimKeepaliveProbe=     0      tcpTimKeepaliveDrop =     0

IP

      ipForwarding        =     2      ipDefaultTTL        =   255
      ipInReceives        =  4518      ipInHdrErrors       =     0
      ipInAddrErrors      =     0      ipInCksumErrs       =     0
      ipForwDatagrams     =     0      ipForwProhibits     =     0
      ipInUnknownProtos   =     0      ipInDiscards        =     0
      ipInDelivers        =  4486      ipOutRequests       =  2805
      ipOutDiscards       =     5      ipOutNoRoutes       =     0
      ipReasmTimeout      =    60      ipReasmReqds        =     2
      ipReasmOKs          =     2      ipReasmReqds        =     2
      ipReasmDuplicates   =     0      ipReasmFails        =     0
      ipFragOKs           =    20      ipReasmPartDups     =     0
      ipFragCreates       =   116      ipFragFails         =     0
      tcpInErrs           =     0      ipRoutingDiscards   =     0
      udpInCksumErrs      =     0      udpNoPorts          =    33
      rawipInOverflows    =     0      udpInOverflows      =     6

ICMP

      icmpInMsgs          =     0      icmpInErrors        =     0
      icmpInCksumErrs     =     0      icmpInUnknowns      =     0
      icmpInDestUnreachs  =     0      icmpInTimeExcds     =     0
      icmpInParmProbs     =     0      icmpInSrcQuenchs    =     0
      icmpInRedirects     =     0      icmpInBadRedirects  =     0
      icmpInEchos         =     0      icmpInEchoReps      =     0
      icmpInTimestamps    =     0      icmpInTimestampReps =     0
      icmpInAddrMasks     =     0      icmpInAddrMaskReps  =     0
      icmpInFragNeeded    =     0      icmpOutMsgs         =     7
      icmpOutDestUnreachs =     1      icmpOutErrors       =     0
      icmpOutDrops        =     5      icmpOutTimeExcds    =     0
      icmpOutParmProbs    =     0      icmpOutSrcQuenchs   =     6
      icmpOutRedirects    =     0      icmpOutEchos        =     0
      icmpOutEchoReps     =     0      icmpOutTimestamps   =     0
      icmpOutTimestampReps=     0      icmpOutAddrMasks    =     0
      icmpOutAddrMaskReps =     0      icmpOutFragNeeded   =     0
      icmpInOverflows     =     0


IGMP:

0 messages received
0 messages received with too few bytes
0 messages received with bad checksum
0 membership queries received
0 membership queries received with invalid field(s)
```

(continued)

(Continuation)

```
0 membership reports received
0 membership reports received with invalid field(s)
0 membership reports received for groups to which we belong
0 membership reports sent
```

Displaying Network Interface Status

The `i` option of `netstat` shows the state of the network interfaces that are configured with the machine where you ran the command. Here is a sample display produced by `netstat -i`.

```
Name Mtu  Net/Dest     Address   Ipkts    Ierrs Opkts    Oerrs  Collis  Queue
le0  1500 b5-spd-2f-cm tatra     14093893 8492  10174659 1119   2314178   0
lo0  8232 loopback     localhost 92997622 5442  12451748 0      775125    0
```

Using this display, you can find out how many packets a machine thinks it has transmitted and received on each network. For example, the input packet count (`Ipkts`) displayed for a server can increase each time a client tries to boot, while the output packet count (`Opkts`) remains steady. This suggests that the server is seeing the boot request packets from the client, but does not realize it is supposed to respond to them. This might be caused by an incorrect address in the `hosts` or `ethers` database.

On the other hand, if the input packet count is steady over time, it means that the machine does not see the packets at all. This suggests a different type of failure, possibly a hardware problem.

Displaying Routing Table Status

The –`r` option of `netstat` displays the IP routing table. Here is a sample display produced by `netstat -r` run on machine `tenere`.

```
Routing tables
Destination   Gateway Flags Refcnt Use   Interface
temp8milptp   elvis   UGH   0      0
irmcpeb1-ptp0 elvis   UGH   0      0
route93-ptp0  speed   UGH   0      0
mtvb9-ptp0    speed   UGH   0      0
                .
mtnside       speed   UG    1      567
ray-net       speed   UG    0      0
```

(Continuation)

```
mtnside-eng   speed   UG    0      36
mtnside-eng   speed   UG    0      558
mtnside-eng   tenere  U     33     190248  le0
```

The first column shows the destination network, the second the router through which packets are forwarded. The `U` flag indicates that the route is up; the `G` flag indicates that the route is to a gateway. The `H` flag indicates that the destination is a fully qualified host address, rather than a network.

The `Refcnt` column shows the number of active uses per route, and the `Use` column shows the number of packets sent per route. Finally, the `Interface` column shows the network interface that the route uses.

Logging Network Problems

If you suspect a routing daemon malfunction, you can log its actions, including all packet transfers. To create a log file of routing daemon actions, supply a file name when you start up the `routed` daemon. For example:

```
# /usr/sbin/in.routed /var/routerlog
```

Caution - On a busy network, this can generate almost continuous output.

Displaying Packet Contents

You can use `snoop` to capture network packets and display their contents. Packets can be displayed as soon as they are received, or saved to a file. When `snoop` writes to an intermediate file, packet loss under busy trace conditions is unlikely. `snoop` itself is then used to interpret the file. For information about using the `snoop` command, refer to the **snoop**(1M) man page.

The snoop command must be run by root (#) to capture packets to and from the default interface in promiscuous mode. In summary form, only the data pertaining to the highest-level protocol is displayed. For example, an NFS packet will have only NFS information displayed. The underlying RPC, UDP, IP, and Ethernet frame information is suppressed but can be displayed if either of the verbose options is chosen.

The snoop capture file format is described in RFC 1761. To access, use your favorite web browser with the URL: http://ds.internic.net/rfc/rfc1761.txt.

snoop server client rpc rstatd collects all RPC traffic between a client and server, and filters it for rstatd.

▼ How to check all packets from your system

1. **Type** netstat -i **to find the interfaces attached to the system.**

   Snoop normally uses the first non-loopback device (le0).

2. **Become root and type** snoop

   Use Ctl C to halt the process.

```
# snoop
Using device /dev/le (promiscuous mode)
     maupiti -> atlantic-82  NFS C GETATTR FH=0343
 atlantic-82 -> maupiti      NFS R GETATTR OK
     maupiti -> atlantic-82  NFS C GETATTR FH=D360
 atlantic-82 -> maupiti      NFS R GETATTR OK
     maupiti -> atlantic-82  NFS C GETATTR FH=1A18
 atlantic-82 -> maupiti      NFS R GETATTR OK
     maupiti -> (broadcast)  ARP C Who is 129.146.82.36, npmpk17a-82 ?
```

3. **Interpret results**

   In the example, client maupiti transmits to server atlantic-82 using NFS file handle 0343. atlantic-82 acknowledges with OK. The conversation continues until maupiti broadcasts an ARP request asking who is 129.146.82.36?

   This example demonstrates the format of snoop. The next step is to filter snoop to capture packets to a file.

   Interpret the capture file using details described in RFC 1761. To access, use your favorite web browser with the URL: http://ds.internic.net/rfc/rfc1761.txt

▼ How to capture snoop results to a file

1. **As root, type** `snoop -o` ***filename*****. Example:**

```
# snoop -o /tmp/cap
Using device /dev/le (promiscuous mode)
30 snoop: 30 packets captured
```

This has captured 30 packets in a file `/tmp/cap`. The file can be anywhere there is enough disk space. The number of packets captured is displayed on the command line, enabling you to press Ctl-C to abort at any time.

`snoop` creates a noticeable networking load on the host machine, which can skew the results. To see reality at work, run `snoop` from a third system, (see the next section).

2. **Type** `snoop -i` ***filename*** **to inspect the file:**

```
# snoop -i /tmp/cap

1   0.00000 frmpk17b-082 -> 224.0.0.2    IP  D=224.0.0.2 S=129.146.82.1 LEN=32, ID=0
2   0.56104        scout -> (broadcast)  ARP C Who is 129.146.82.63, grail ?
3   0.16742  atlantic-82 -> (broadcast)  ARP C Who is 129.146.82.76, honeybea ?
4   0.77247        scout -> (broadcast)  ARP C Who is 129.146.82.63, grail ?
5   0.80532 frmpk17b-082 -> (broadcast)  ARP C Who is 129.146.82.92, holmes ?
6   0.13462        scout -> (broadcast)  ARP C Who is 129.146.82.63, grail ?
7   0.94003        scout -> (broadcast)  ARP C Who is 129.146.82.63, grail ?
8   0.93992        scout -> (broadcast)  ARP C Who is 129.146.82.63, grail ?
9   0.60887        towel -> (broadcast)  ARP C Who is 129.146.82.35, udmpk17b-82 ?
10  0.86691  nimpk17a-82 -> 129.146.82.255 RIP R (1 destinations)
```

Refer to specific protocol documentation for detailed analysis and recommended parameters for ARP, IP, RIP and so forth. Searching the web is a good place to look at RFCs.

▼ How to check packets between server and client

1. **Establish a snoop system off a hub connected to either the client or server.**

   The third system (the snoop system) sees all the intervening traffic, so the snoop trace reflects reality on the wire.

2. **As root, type** `snoop` **with options and save to a file.**

3. **Inspect and interpret results.**

   Look at RFC 1761 for details of the snoop capture file. To access, use your favorite web browser with the URL: `http://ds.internic.net/rfc/rfc1761.txt`

Use `snoop` frequently and consistently to get a feel for normal system behavior. For assistance in analyzing packets, look for recent white papers and RFCs, and seek the advice of an expert in a particular area, such as NFS or YP. For complete details on using `snoop` and its options, refer to the **snoop**(1M) man page.

Displaying Routing Information

The `traceroute` utility is used to trace the route an IP packet follows to some internet host. The `traceroute` Utility utilizes the IP protocol `ttl` (time to live) field and attempts to elicit an ICMP `TIME_EXCEEDED` response from each gateway along the path, and the response `PORT_UNREACHABLE` (or `ECHO_REPLY`) from the destination host. The `traceroute` utility starts sending probes with a `ttl` of one and increases by one until it gets to the intended host or has passed through a maximum number of intermediate hosts.

The `traceroute` utility is especially useful for determining routing misconfiguration and routing path failures. If a particular host is unreachable, you can use the `traceroute` utility to see what path the packet follows to the intended host and where possible failures might occur.

The `traceroute` utility also displays the round trip time for each gateway along the path to the target host. This information can be useful for analyzing where traffic is slow between the two hosts.

How to Run the Traceroute Utility

The simplest method of running the traceroute utility is to type:

```
traceroute hostname
```

where *hostname* is the destination host name.

The following sample `traceroute` command shows the 7–hop path a packet follows from the host istanbul to the host sanfrancisco along with the times for a packet to traverse each hop.

```
istanbul% traceroute sanfrancisco
 traceroute: Warning: Multiple interfaces found; using 172.31.86.247 @ le0
 traceroute to sanfrancisco (172.29.64.39), 30 hops max, 40 byte packets
  1  frbldg7c-86 (172.31.86.1)  1.516 ms  1.283 ms  1.362 ms
  2  bldg1a-001 (172.31.1.211)  2.277 ms  1.773 ms  2.186 ms
  3  bldg4-bldg1 (172.30.4.42)  1.978 ms  1.986 ms  13.996 ms
  4  bldg6-bldg4 (172.30.4.49)  2.655 ms  3.042 ms  2.344 ms
  5  ferbldg11a-001 (172.29.1.236)  2.636 ms  3.432 ms  3.830 ms
  6  frbldg12b-153 (172.29.153.72)  3.452 ms  3.146 ms  2.962 ms
  7  sanfrancisco (172.29.64.39)  3.430 ms  3.312 ms  3.451 ms
```

For complete deatils of the `traceroute` utility see the **`traceroute`**(1M) man page.

PART II Expanding Your Network With PPP

Part 2 explains how to set up and administer asynchronous PPP communications links on the network. The text assumes that you are an experienced network administrator who is familiar with TCP/IP.

CHAPTER 7

Understanding PPP

This chapter presents an overview of Solaris PPP, a data-link protocol included in the TCP/IP protocol suite. The text includes product specifications, introductions to the most typical PPP configurations, and definitions of the terms related to PPP.

Overview of Solaris PPP

PPP enables you to connect computers and networks at separate physical locations by using modems and telephone lines. With PPP, users with computers at home or in remote offices can connect to your site's network. You can also use the combination of PPP software, a modem, and telephone lines as a router connecting networks in different places. PPP offers strategies for configuring these machines and networks, which are introduced in this chapter.

Solaris PPP Specifications

Solaris PPP is an asynchronous implementation of the standard data-link level Point-to-Point Protocol (PPP) included in the TCP/IP protocol suite and provided by

a number of router system vendors and terminal concentrators. It includes a standard encapsulation protocol, making datagram transmission transparent to network layer protocols.

The major characteristics of the Solaris PPP protocol are:

- Implements the Internet Point-to-Point Protocol, as defined in RFC 1331
- Provides error detection through CRC
- Supports full duplex transmission

The major functions of the protocol are:

- Interface for IP to forward packets over asynchronous serial lines
- Connection establishment on demand
- Configurable options negotiation
- Connection termination (automatic hang-up)

Transmission Facilities Used by PPP

PPP supports interfaces to RS-232-C (V.24) facilities through the CPU serial ports included on most machines running the Solaris software. In addition, PPP runs over optional asynchronous serial ports supplied or supported by many manufacturers of machines that run the Solaris software. PPP supports the maximum data rates that your machine's serial ports can achieve. Consult the manufacturer of your computer system for more details on the speeds supported by your machine's serial hardware.

Note - Machines of the x86 architecture require UARTs that run above a certain speed. See the for details.

Standards Conformance

PPP, and the routing functions in the Solaris software, use industry-standard conventions for performing their tasks. These conventions support:

- Forwarding of IP datagrams
- Reception of packets for forwarding from any IP-compatible networked system
- Delivery of packets to any IP-compatible networked system on local-area network media, such as Ethernet, Token Ring, and FDDI
- Use of standard routing protocols, enabling users to exchange packets with equipment that supports the PPP protocol from many manufacturers

PPP Network Interfaces

PPP enables asynchronous devices, such as modems, to become network interfaces. Solaris PPP enables you to configure two types of *virtual network interfaces*, `ipdptp`*n* and `ipd`*n*. (The letter *n* represents the device number you assign to the interface.)

PPP network interfaces are considered virtual network interfaces because they do not involve network hardware, as does, for example, an Ethernet interface. Moreover, they are not associated with any particular serial port. The PPP network interfaces reside in the `/devices` directories along with the physical network interfaces. (For information on physical network interfaces, see “Network Interfaces” on page 7.)

The type of network interface you use depends on the PPP communications link you want to set up. The `ipdptp` interface supports point-to-point PPP links; the `ipd` interface supports point-to-multipoint links (called “multipoint links”).

Extending Your Network With PPP

This section introduces PPP-related communications concepts used. It also explains the most typical PPP configurations that you are likely to set up.

Point-to-Point Communications Links

The most common use of Solaris PPP is to set up a point-to-point communications link. A generic point-to-point communications configuration consists of two endpoints connected by a communications link. In a generic configuration, an *endpoint* system could be a computer or terminal, either in an isolated location or physically connected to a network. The term *communications link* refers to the hardware and software connecting these endpoint systems. Figure 7–1 illustrates these concepts.

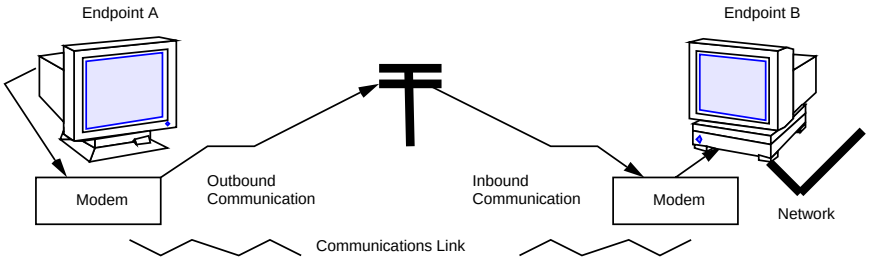


Figure 7–1 Basic Point-to-Point Link

Dial-out Operations and Outbound Communications

When an endpoint system wants to communicate with the end point on the other side of the communications link, it begins a *dial-out operation*. For example, to communicate with endpoint B, a user at its peer host, endpoint A, types `rlogin` *end-point-B*. This causes endpoint A to dial out over the communications link. In this instance, endpoint A functions as a *dial-out* machine. The `rlogin` command causes its modem to dial the phone number of endpoint B. The action it starts and information it passes are considered *outbound communications.*

Dial-ins and Inbound Communications

When the data travels over the link to endpoint B, this system receives incoming data and sends an acknowledgment signal to endpoint A to establish communications. In this instance, endpoint B functions as a *dial-in* machine, since it permits other systems to dial in to it. The information passed to the communications recipient and the actions the recipient takes are considered *inbound communications.*

Point-to-Point Configurations Supported by Solaris PPP

Solaris PPP supports four types of point-to-point configurations:

- Host in one location connected to a host at another physical location, as shown in Figure 7–1
- Dial-in servers with dynamic point-to-point links to remote hosts, as shown in Figure 7–2
- Network connected to another physically distant network, as shown in Figure 7–3
- Computers connected to a multipoint dial-in server physically attached to a distant network, as shown in Figure 7–4

These PPP links provide essentially the same type of connectivity provided by a local area network but without broadcast capability. The sections below summarize the

configuration types; Chapter 8 gives information for setting up each configuration type.

Two Isolated Hosts Connected by a Point-to-Point Link

PPP enables you to set up a point-to-point link to connect two standalone machines in separate locations, effectively creating a network consisting solely of these two machines. This is the simplest point-to-point configuration because it involves only the two endpoints. The generic configuration shown in Figure 7–1 also uses the host-to-host configuration.

Nomadic Machines Connected to a Dial-in Server

In the past, standard dial-up or temporary connections permitted only ASCII terminals to connect to a network. With Solaris PPP, an individual machine can become part of a physically distant network by configuring it as one endpoint of the PPP link. The advantage of this *nomadic* connection is particularly apparent if your network includes users who travel frequently or work from home.

Figure 7–2 shows nomadic computers, each with a point-to-point link to an endpoint system on the network. The endpoint on the network is a dial-in server.

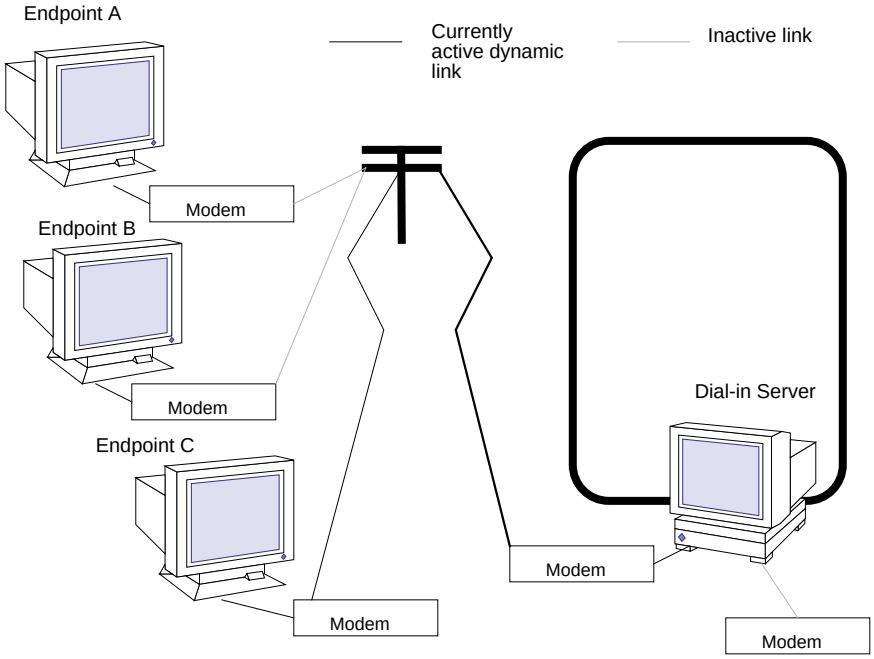


Figure 7–2 Nomadic Computers and Dynamic Link Dial-in Server

Dial-in Server With Dynamic Point-to-Point Link

The endpoint machine on the network shown in Figure 7–2 functions as a dial-in server with dynamic point-to-point links. It is called a *dial-in server* because remote machines can dial in to it to reach the network. When the server receives a request to dial in from a machine, the server allocates the PPP link to the machine on an as-needed basis.

A dial-in server can communicate with the remote hosts through a dynamic point-to-point link or through a multipoint link, as explained in “Multipoint Communications Links” on page 97. The dynamic point-to-point link has the advantages of point-to-point communications: RIP can run over the link, and broadcasting is enabled. Perhaps most importantly, more than one machine on the physical network can function as the dial-in server. This allows you to configure backup servers, thus enabling redundancy and easier administration. Although the machines in Figure 7–2 can directly communicate with the network endpoint, they cannot directly communicate with each other. They must pass information to each other through the dial-in server endpoint.

Two Networks Connected by Point-to-Point Link

You can use PPP to connect two separate networks through a point-to-point link, with one system on each network serving as an endpoint. These endpoints communicate through modems and phone lines, essentially in the same fashion as shown in Figure 7–1. But in this setup, the endpoints, modems, and PPP software become routers for their physical networks. Using this type of configuration scheme, you can create an internetwork with wide geographic reach.

Figure 7–3 shows two networks in different locations connected by a point-to-point link.

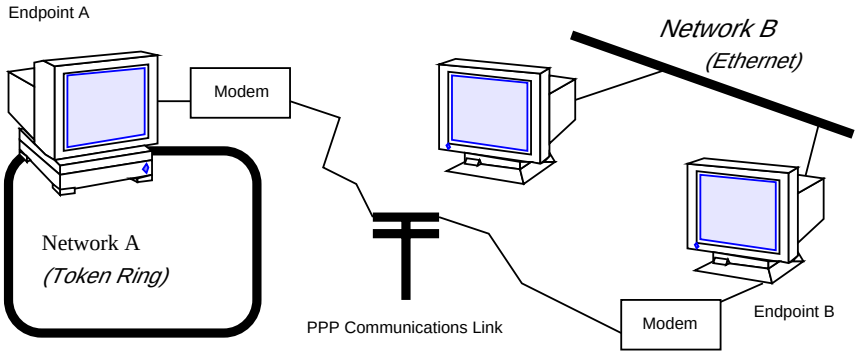


Figure 7–3 Two Networks Connected by a PPP Link

In this example, endpoints A and B, their modems, public telephone lines, and the PPP software act as a router between the networks. These networks may have other hosts serving as routers between physical networks. Sometimes, the host functioning

as the PPP router may have an additional network interface board, thus also serving as a router for a physical network.

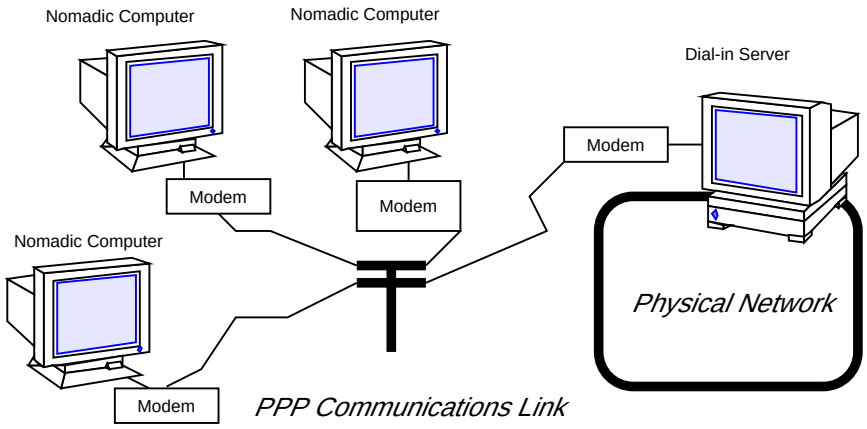


Figure 7–4 Nomadic Computers and Multipoint Dial-in Server

Multipoint Communications Links

You can use Solaris PPP to set up a multipoint communications link. In this type of configuration, an individual machine functions as one endpoint on the communications link. At the other end of the link may be several endpoint machines. This differs from point-to-point configurations, with a single endpoint system at either side of the communications link.

Multipoint Configurations Supported by PPP

Two types of multipoint links you can configure with PPP are:

- Dial-in server with multipoint connections to remote machines, as shown in Figure 7–4
- Logical, or *virtual*, network consisting of three or more nomadic computers, as shown in Figure 7–5

The sections below summarize these configurations; Chapter 8 explains how to set up the configuration.

Multipoint Dial-in Servers

Figure 7–4 shows three geographically isolated computers communicating through a point-to-point link to an endpoint machine on a network. However, the network

endpoint machine can communicate with the nomadic computers through a *multipoint* link, thus making it a multipoint dial-in server. (You can also set up a dial-in server with dynamic point-to-point connections, as explained in “Dial-in Server With Dynamic Point-to-Point Link” on page 96.)

The dial-in server can communicate with all the machines on the other end of its multipoint PPP link. Though the machines in Figure 7–4 can directly communicate with the multipoint dial-in server, they cannot communicate directly with each other. They must pass information to each other through the dial-in server.

Virtual Networks

You can use PPP to set up a *virtual network* wherein the modems, PPP software, and telephone wires become the “virtual” network media. In a physical network, such as Ethernet or Token Ring, computers are directly cabled to the network media. In a virtual network, no true network media exist.

Machines become peer hosts on the virtual network when you configure each with a multipoint communications link. Then each host can dial out through its modem over phone lines to reach another endpoint machine. Each computer also functions as a dial-in machine, permitting its peer hosts on the virtual network to dial in to it.

Figure 7–5 depicts a virtual network consisting of nomadic computers connected to each other through modems and telephone lines.

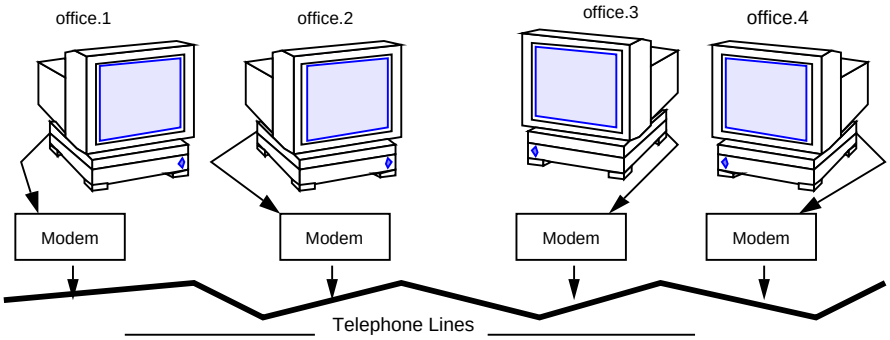


Figure 7–5 Virtual Network of Nomadic Computers

Each machine exists in a different office, perhaps in a different town from other members of the virtual network. However, each machine can establish communications with its peer hosts over its multipoint communications links.

Introducing the PPP Software

The PPP component software includes:

- Link manager (`/usr/sbin/aspppd`)
- Log in service (`/usr/sbin/aspppls`)
- Configuration file (`/etc/asppp.cf`)
- Log file (`/var/adm/log/asppp.log`)
- FIFO file (`/tmp/.asppp.fifo`)

After you install the PPP software, you will find the `/etc/init.d/asppp` file, which is the run-control script for PPP. It is linked to several other files in the run-control directories.

Figure 7–6 shows the software components of PPP and how they interact.

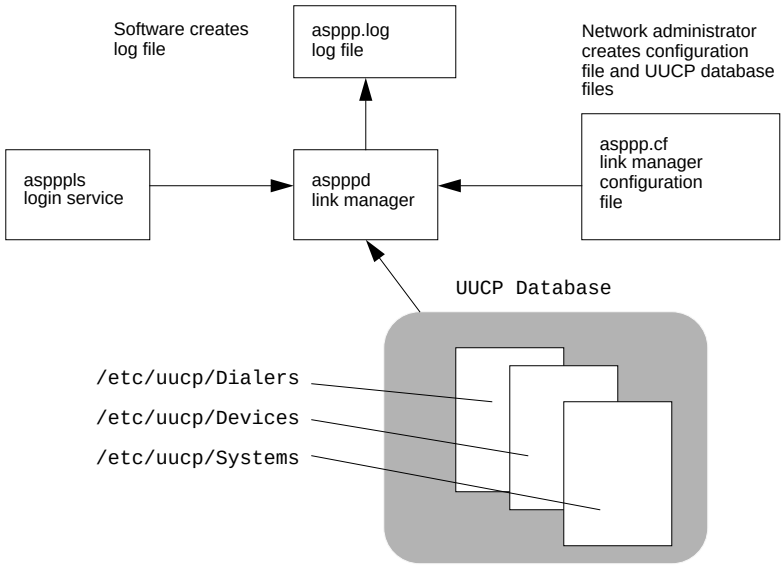


Figure 7–6 PPP Component Software

Link Manager

The `/usr/sbin/aspppd` link manager is a user-level daemon that automates the process of connecting to a remote host when PPP service is required. This automated process starts whenever any activity that generates IP traffic takes place (for example, a user logs in to a remote machine, accesses an NFS-mounted file, and so on). If a

remote host tries to establish a connection, the link manager on the local host will complete the connection.

Refer to the **aspppd**(1M) man page for specific information about the link manager.

Login Service

The `/usr/sbin/aspppls` login service is invoked as a login shell that starts PPP after you dial up and log in. Its function is similar to the `/usr/lib/uucp/uucico` command described in “UUCP Software” on page 168. When configuring a machine as a dial-in server, you must specify `aspppls` as the login shell in the `/etc/passwd` file in the entries for every nomadic computer allowed to dial in to the local host.

Configuration File

The `asppp.cf` file provides the link manager with information about each remote endpoint with which the local host will communicate. You define this information in a section of the configuration file called a *path*. The path section also defines the PPP interface to be used and, optionally, other attributes determining how communications will take place, including security issues. “Parts of Basic Configuration File” on page 125 explains the sections of the `asppp.cf` file in detail. Example 7–1 shows an unmodified `asppp.cf` file.

EXAMPLE 7–1 An Unmodified `asppp.cf` File

```
#ident "@(#)asppp.cf 10 93/07/07 SMI"
#
# Copyright (c) 1993 by Sun Microsystems, Inc.
#
# Sample asynchronous PPP /etc/asppp.cf file
#
#

ifconfig ipdptp0 plumb mojave gobi private up

path
   inactivity_timeout 120    # Approx. 2 minutes
   interface ipdptp0
   peer_system_name Pgobi    # The name this system logs in with when
                             # it dials this server
                             # *OR* the entry we look up in
                             # /etc/uucp/Systems when we dial out.
```

Log File

The link manager produces messages and logs them in the log file `/var/adm/log/asppp.log`. The level of detail reported into the file is controlled by the `-d` option of `aspppd` or the `debug_level` keyword in the configuration file. See “Configuration Keywords” on page 161 and the **`aspppd`**(1M) man page for more information.

FIFO File

The PPP FIFO file `/tmp/.asppp.fifo` is a named pipe used to communicate between `aspppd` and `asppls`. This file must be present in `/tmp` for the PPP login service to connect to the link manager. The `/tmp/.asppp.fifo` file is created, managed, and deleted by the link manager.

UUCP Databases

Besides its component software, Solaris PPP uses information in three UUCP files, `/etc/uucp/Systems`, `/etc/uucp/Dialers`, and `/etc/uucp/Devices`, to help it establish the communications link. You must modify these files to enable a host to dial out over the PPP link. Alternatively, you can use the file `/etc/uucp/Sysfiles` to specify different names for the `Systems`, `Devices`, and `Dialers` files.

Refer to Chapter 12 for full descriptions of these UUCP files.

How the Components Work Together

This section describes how the components of PPP function for outbound and inbound connections.

Outbound Connections Scenario

Outbound communications begin when a user on one endpoint host initiates an activity involving the peer host on the other end of the PPP link. The following activities take place when a user types an `rcp` command to copy a file from a host on the other side of the link

1. `rcp` sends the data through the levels of the TCP/IP protocol stack.
2. A virtual network interface (`ipd`*n* or `ipdptp`*n*) receives the data in the form of IP packets.

3. The interface sends the `aspppd` link manager a connection request that initiates an outbound connection.
4. The link manager then:
   a. Verifies that the connection request corresponds to a configured path in the `/etc/asppp.cf` configuration file.
   b. Consults the UUCP database files (`/etc/uucp/Systems`, `/etc/uucp/Devices`, and `/etc/uucp/Dialers`) for specific information about the modem and destination system.
   c. Places a phone call to the destination host or attaches to the appropriate hardwired serial line.
5. The physical link to the peer host is established.
6. The link manager configures and initiates PPP.
7. The data-link layer is established, and the PPP modules on the peer hosts start communicating.
8. The link manager enables IP over the link.

The link manager then monitors the connection until an even, such as an idle time out, line disconnect, or error condition, occurs. When any of these events occur, the link manager disconnects from the peer host and returns to the idle state.

Inbound Connections Scenario

The host initiating the inbound communication logs in, which invokes the `/usr/sbin/aspppls` login service. Then the following events occur:

1. The login service connects to the link manager through the `/tmp/.asppp.fifo` file.
2. The login service provides the link manager with information such as the login name used by the endpoint at the other end of the link.
3. The link manager uses this login name to find a corresponding configured path in the configuration file.
4. The link manager then configures and initiates PPP.
5. The data-link layer is established, and the PPP modules on the peer hosts start communicating.
6. The link manager enables IP over the link.

The link manager then monitors the connection until an event occurs such as an idle time out, line disconnect, or error condition. When any of these events occur, the link manager disconnects from the peer and returns to the idle state.

PPP Security

After you have completed installing PPP on every machine involved in your configuration, you can add either one or two levels of security for the PPP link.

The first level, Password Authentication Protocol (PAP), is the least secure. A password is sent over the circuit “in the clear” until authentication is acknowledged or the connection terminated.

The second level of security, Challenge-Handshake Authentication Protocol (CHAP), periodically verifies the identity of the peer—the other end of the point-to-point link. A challenge message is sent to the peer by the authenticator—the system starting the link or challenge. The response is checked against a “secret” not sent over the link, and if the values match, authentication is acknowledged. Otherwise, the link is terminated. The process of adding PPP security is described in “Editing `asppp.cf` for PAP/CHAP Security” on page 156.

CHAPTER 8

Preparing Your PPP Configuration

Before configuring the PPP software, you need to prepare the hardware and software involved and gather some information that is needed during the configuration process. This chapter explains the tasks you have to perform prior to configuration, such as:

- Determining your network addressing scheme
- Ensuring that your hardware meets the requirements for PPP
- Preparing your software to meet the requirements for PPP

The chapter concludes with a checklist to help you organize this information before you configure your PPP link.

Determining Requirements for Your Configuration Type

Solaris PPP supports many configuration options, including:

- Remote computer-to-network over a point-to-point link
- Remote computer-to-remote computer over a point-to-point link
- Network-to-network over a point-to-point link
- Dial-in server-to-multiple remote computers through one or more dynamic point-to-point links
- Dial-in server-to-multiple remote computers through a multipoint link
- Multiple remote computers comprising a virtual network, all communicating through multipoint links

These configurations are introduced in "Extending Your Network With PPP" on page 93 in Chapter 7.

This section describes the information you need to gather and tasks you have to perform for each configuration type before beginning the configuration process. Read the section that describes the configuration you want to set up.

Areas you need to consider are:

- Network interface
- Addressing method
- Name service used, if any
- Dial-in as well as dial-out support
- Routing requirements

Remote Computer-to-Network Configuration

The remote computer-to-network is the most common asynchronous PPP configuration. Use it to configure machines in remote offices or user's homes that dial out over a point-to-point PPP link to a dial-in server on a network.

- *Network interface* – This point-to-point link uses the `ipdptp`*n* virtual network interface. You need to specify it in the configuration files of all remote machines that dial out to a network.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that communicates over the link. For remote hosts, you should use existing host names and IP addresses. Refer to "Determining IP Addressing for Your PPP Link" on page 110 for complete details.

- *Name service* – NIS and NIS+ name services are not recommended for remote hosts. These services generate a great deal of network traffic, often at unexpected times. The DNS name service is more efficient for this type of configuration. You might want to set up DNS, as described in *Solaris Naming Administration Guide*, on each remote host. If you don't use DNS, PPP accesses `/etc/inet/hosts` file on the remote machine.
- *Dial-in and dial-out support* – Remote hosts usually implement dial-out communications only. They do not allow other machines to dial in to them directly. Therefore, you must update the UUCP files on each to support dial-out communications, as explained in "Editing UUCP Databases" on page 122.
- *Routing requirements* – Because RIP is part of the Solaris TCP/IP protocol stack, it runs by default on remote hosts. Turn off RIP to improve performance, if necessary, and instead use static routing. See "To Select Static Routing on a Host" on page 74 and "Turning Off RIP" on page 113 for details.

Remote Host-to-Remote Host Configuration

Use the host-to-host configuration to establish point-to-point communications between two remote hosts in different physical locations. This configuration is useful for two standalone machines in remote offices that need to exchange information. No physical network is involved.

- *Network interface* – This basic point-to-point link uses the `ipdptp`*n* virtual network interface. You must specify the interface in the configuration files of both endpoints.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that can communicate over the link. Use the existing host names and the IP addresses assigned to the primary network interface, if they already exist. Otherwise, create IP addresses for the endpoints. Refer to "Determining IP Addressing for Your PPP Link" on page 110 for complete details.
- *Name service* – Because only two peer hosts are involved, you don't need a true name service. The `/etc/inet/hosts` files on both peer hosts are used for address resolution.
- *Dial-in and Dial-out support* – Both machines need to perform dial-in and dial-out operations. You must modify the UUCP databases and `/etc/passwd` on both endpoints.
- *Routing requirements* – Because RIP is part of the Solaris TCP/IP protocol stack, it runs by default on remote hosts. Turn off RIP to improve performance, if necessary, and instead use static routing. See "To Select Static Routing on a Host" on page 74 and "Turning Off RIP" on page 113 for details.

Network-to-Network Configuration

Use the network-to-network PPP configuration to create an internetwork joining two networks in physically separate locations. In this case, modems and PPP software function as the router connecting the networks.

- *Network interface* – The point-to-point link uses the `ipdptp`*n* virtual network interface. You must specify `ipdptp`*n* in the configuration files for both endpoint machines joining the two networks.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that communicate over the link. Two possible addressing scenarios exist for this type of configuration; they are explained in "Determining IP Addressing for Your PPP Link" on page 110.
- *Name service* – NIS and NIS+ name services can function over this type of PPP link; however, each network should be a separate domain. If you use DNS, both networks can be part of a single domain. Refer to *Solaris Naming Administration Guide* for details. If you use local files for name service, the `/etc/inet/hosts` files on both endpoint machines are used for address resolution. They must contain the host names and IP addresses of every host on each network that can communicate over the link.
- *Dial-in and Dial-out support* – Both network endpoint machines need to perform dial-in and dial-out operations, so you should update their UUCP and `/etc/passwd` files.
- *Routing requirements* – The endpoints in a network-to-network link usually run RIP in order to exchange routing information. Do not disable RIP for this configuration.

Dial-in Server With Dynamic Point-to-Point Links

A dynamic point-to-point link is one of two types of configurations that you can use for a dial-in server functioning as the network endpoint that remote hosts access. In this configuration scheme, the server connects to its remote hosts over a dynamically allocated point-to-point link. The dial-in server uses its dynamic links on an as-needed basis to establish communications with the remote hosts it serves.

- *Network interface* – The dynamic point-to-point link uses the `ipdptp*` virtual network interface with an asterisk wildcard character. The asterisk enables the link to be allocated dynamically. You must specify this interface in the configuration file.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that communicate over the link. Refer to "Determining IP Addressing for Your PPP Link" on page 110 for complete details.
- *Name service* – Although NIS and NIS+ are not recommended for remote hosts, the dial-in server in a remote host-to-network configuration can be an NIS client on the network to which it is physically connected. If NIS is on the server's physical

network, make sure that the NIS maps are updated with the host names and IP addresses of the remote hosts. You can use DNS on the dial-in server and its remote hosts. For more information regarding DNS and name services in general, refer to *Solaris Naming Administration Guide*. If you use local files for name service, PPP access the `/etc/inet/hosts` file on the dial-in server for address resolution.

- *Dial-in support* – You must update the `/etc/passwd` file on the dynamic point-to-point dial-in server. The dynamic link server does not directly dial out to the remote hosts.
- *Routing requirements* – Because RIP is part of the Solaris TCP/IP protocol stack, it runs by default on remote hosts. Turn off RIP to improve performance, if necessary, and instead use static routing. See "To Select Static Routing on a Host" on page 74 and "Turning Off RIP" on page 113 for details.

Multipoint Dial-in Server

A multipoint link is one of two types of configurations that you can use for a dial-in server functioning as the network endpoint that remote machines can access. In this configuration scheme, the dial-in server connects to multiple remote hosts over the same multipoint link. The remote hosts always connect to the dial-in server over a point-to-point link, as explained in "Remote Computer-to-Network Configuration" on page 106.

Use this configuration when you want to define a separate network of remote hosts and their dial-in server.

- *Network interface* – The multipoint link uses the `ipd`*n* virtual network interface. You must specify this interface in the configuration file for the dial-in server.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that communicate over the link. Refer to "Determining IP Addressing for Your PPP Link" on page 110 for complete details. You must create a separate network for the machines on the multipoint link. See "Assigning a Network Number to the PPP Link" on page 112 for more information.
- *Name service* – Although NIS and NIS+ are not recommended for remote hosts, the dial-in server in a remote host-to-network configuration can be an NIS client on the physical network to which it is connected. If NIS is on the server's physical network, make sure that the NIS maps are updated with the host names and IP addresses of the remote hosts. You can use DNS on the dial-in server and its remote hosts. For more information regarding DNS and name services in general, refer to *Solaris Naming Administration Guide*. If you use local files for name service, PPP uses the `/etc/inet/hosts` file on the dial-in server for address resolution.
- *Dial-in and dial-out support* – The multipoint dial-in server functions as a network router between its PPP virtual network and the physical network to which it is connected. It dials out to its remote hosts whenever it receives IP traffic from the

physical network destined for its PPP network. Therefore, you must configure the multipoint dial-in server for both dial-in and dial-out support, and update its UUCP and `/etc/passwd` files.

- *Routing requirements* – The `ipd`*n* interface does not support RIP; there is no need to disable it.

Hosts on a Virtual Network

Use a virtual network configuration to connect three or more physically separated computers into a virtual network of phone lines, modems, and PPP software.

- *Network interface* – This type of configuration requires a multipoint link, which uses the `ipd`*n* virtual network interface. This interface connects each endpoint system with the other endpoints on the virtual network.
- *Addressing method* – The configuration file must include the host names or IP addresses of the machines that communicate over the link. Refer to "Determining IP Addressing for Your PPP Link" on page 110 for more information. You must assign a network number to the virtual network. Refer to "Creating a Unique IP Address and Host Name" on page 112 for complete details.
- *Name Service* – You can run NIS and NIS+ for the virtual network; however, this can affect the performance of the link. DNS is a better alternative. Refer to *Solaris Naming Administration Guide* for instructions on setting up these name services. If you use files for name service, be sure to update `/etc/inet/hosts` on each machine with the host names and IP addresses of all machines on the virtual network.
- *Dial-in and dial-out support* – All machines in the virtual network must be configured for both dial-in and dial-out operations, so you should update their UUCP and `/etc/passwd` files.
- *Routing requirements* – The `ipd`*n* interface does not support RIP; you do not need to disable it.

Determining IP Addressing for Your PPP Link

To enable communications over the PPP link, the machine at one end of the link must know the host name and IP address of the peer host on the other end of the link. The PPP configurations often require a particular addressing scheme. This section explains the addressing schemes and where each should be used.

Specifying IP Addresses

On each endpoint machine, you specify addressing information in these places:

- `/etc/asppp.cf` configuration file
- `/etc/inet/hosts` file
- NIS+, NIS, or DNS databases, if applicable

When you edit the local machine's `asppp.cf` file, you must provide the host names and, in certain cases, the IP addresses for each endpoint machine to be on the link. For example, you must type either the IP addresses or host names for each endpoint as arguments in the `ifconfig` section in the configuration file:

```
ifconfig ipdptp0 plumb 192.99.44.01 192.99.44.02 up
```

See Chapter 9 for information regarding the format of `/etc/asppp.cf`.

Additionally, to enable communications, you must add the IP address and host name of the remote endpoints to the `hosts` database on the local end point by editing `/etc/inet/hosts`. This process is explained in "Configuring Network Clients" on page 67.

Types of Addressing Schemes

You have a choice of several addressing schemes for PPP, depending on your configuration type. Before you edit the `asppp.cf` file and `hosts` database, you must decide on the appropriate addressing scheme for your configuration. These schemes include:

- Using the same IP addresses for the PPP endpoints as is assigned to their primary network interface in their local `/etc/inet/hosts` files
- Assigning a unique IP address for each PPP endpoint
- Assigning a new network number for the network created by the PPP link

Using the Same IP Address as the Primary Network Interface

This addressing scheme is appropriate for point-to-point links only. In this scheme, you specify the addresses of the primary network interface for each endpoint. (See Chapter 1 for more information about the primary network interface.) These endpoints might be:

- Two standalone machines communicating over the PPP link (if they have existing IP addresses)
- Two network endpoints communicating over the PPP link
- Remote host connecting to a network dial-in server through a point-to-point link

- Dial-in server connecting to remote hosts through a dynamically allocated point-to-point link

When you edit the `/etc/inet/hosts` file on a local endpoint, supply the IP address of its primary network interface and host name and the IP address of the peer host on the other end of the link.

Creating a Unique IP Address and Host Name

In this method, you assign a unique host name and IP address to the PPP network interface. (You might want to call the interface `hostname-ppp`.) Use this addressing scheme fo:

- Endpoint machines on a network used as a multipoint dial-in server
- Machines on a virtual network
- Remote host that uses a dedicated IP address for communicating with a dial-in server over a dynamically allocated PPP link. (Note that this is not a requirement for the dynamic link configuration.)
- Machine that is also configured as a router for a physical network, such as Ethernet or Token Ring
- Machine in a standalone-to-standalone configuration that does not have an existing IP address. (The PPP interface becomes the primary network interface.)

You must specify the unique address and host name for the PPP network interface in the `asppp.cf` configuration file.

To create the new host name and IP address, add it to the `/etc/inet/hosts` file on the endpoint machines, as described in “`hosts` Database” on page 49.

Assigning a Network Number to the PPP Link

You create a new network number for the PPP configuration when it involves:

- Virtual networks of computers communicating through PPP multipoint links (required)
- A multipoint dial-in server and its remote hosts (required)
- The PPP link between two networks, particularly when one or both of the network endpoint machines are also routers for a physical network (optional)

(See Chapter 3 for information on network numbers.)

The PPP link becomes a *virtual network*, since it does not involve any physical network media. You need to type its network number in the `networks` database on all endpoint machines, along with the network numbers of the networks being linked.

Example 8–1 shows a sample `/etc/inet/networks` file for an internetwork with PPP:

EXAMPLE 8–1 `/etc/inet/networks` File for an Internetwork With PPP

```
kalahari      192.9.253
negev         192.9.201
nubian-ppp    192.29.15
```

In the sample file, `kalahari` and `negev` are two local area networks, and `nubian-ppp` is the name of the PPP link.

Routing Considerations

The RIP routing protocol runs on Solaris TCP/IP networks by default. In most cases, you should leave RIP running on point-to-point links. However, if you are having performance problems with the link, you might want to disable RIP on the point-to-point link.

Note - RIP is not started on multipoint links. Therefore, you must set up static routing for the multipoint link. Refer to “To Select Static Routing on a Host” on page 74 for instructions.

Turning Off RIP

You can disable RIP on a point-to-point link through the file `/etc/gateways`. This file does not come with your operating system: you must create it with a text editor.

To turn off RIP, `/etc/gateways` must have the following entry:

```
norip ipdptpn
```

where `ipdptp`*n* represents the device name of the point-to-point PPP interface used.

For more information, refer to the **`in.routed`**(1M) man page.

PPP Hardware Requirements

The basic PPP configuration involves a computer, a modem, and RS-232 telephone lines. However, before you configure, you need to verify whether the hardware you selected can support PPP. This section describes the hardware requirements for PPP.

- *Modem requirements* – To run PPP, each endpoint machine must have a modem that supports at least 9600 bps or faster bidirectional connections. Such a modem implements the V.32 or V.32bis specification.
- *Serial port selection (for dial-in servers only)* – You can configure either serial port A or serial port B on most CPUs for PPP usage. Use the Solaris Serial Port Manager to initialize the ports on the dial-in server. *System Administration Guide, Volume I* contains instructions for selecting the appropriate port. If you have additional serial cards installed, you can also use their serial ports for PPP connections.
- *Disk space* – You must have 300 Kbytes of free space in `/usr` to install PPP. You need an additional 300 Kbytes of free space in `/usr` to install 64-bit PPP.

File Space Requirements

You need sufficient space in the following directories for the PPP software:

- `/usr`
- `/usr/kernel/drv`
- `/usr/kernel/strmod`
- `/usr/sbin`

You need sufficient space in the following directories for the 64–bit PPP software:

- `/usr/kernel/drv/sparcv9`
- `/usr/kernel/strmod/sparcv9`

PPP occupies approximately 243 Kbytes in `/usr` and 4 Kbytes in `/` (root).

The 64-bit PPP occupies a similar amount of disk space as the 32-bit PPP. The 64-bit drivers reside in `/usr/kernel/drv/sparcv9` and the 64–bit modules reside in `/usr/kernel/strmod/sparcv9`.

Checklist for Configuring PPP

Use this checklist to prepare for configuring PPP. It lists the information you need to gather and the tasks you need to do before starting the configuration process.

TABLE 8–1 Checklist for Configuring PPP

Do you have 300 Kbytes of free space available in `/usr` (add an additional 300 Kbytes if you are installing 64-bit PPP)?	Yes / No
Do you have 4 Kbytes of free space available in `/` (root)?	Yes / No
Do the modems for each endpoint support V.32 or V.32bis or higher?	Yes / No
Have you used the Serial Port Manager on the dial-in server to designate the serial port for the modem?	Yes / No
Have you ensured that Solaris PPP is installed on each endpoint machine? (If PPP hasn't been installed, you can use the `pkgadd` program or `admintool` software manager to install it. Refer to *Solaris Advanced Installation Guide* for instructions.)	Yes / No
Have you ensured that there are no other versions of PPP running on each endpoint. (If there are, disable them, as explained in their documentation.)	Yes / No
Have you determined which IP addresses to use for all computers involved in the PPP link?	Yes / No
List the host names and IP addresses of these machines here.	_____ _____ _____ _____
Write the name and IP address of the dial-in server (if applicable).	_____
Write the name of the network interface that you need to use.	_____

CHAPTER 9

Configuring PPP

This chapter contains procedures and information for configuring PPP. The example used in the text is for the configuration with both types of PPP links— remote hosts and their multipoint dial-in server. Chapter 11 contains information for setting up other PPP configuration types.

Overview of the Configuration Process

You have completed the preinstallation activities noted in Chapter 8. Now you can begin PPP configuration.

PPP requires that you:

1. Install the PPP software, if it isn't already installed.
2. Edit the `/etc/inet/hosts` files on all machines involved.
3. Edit the UUCP database files for all dial-out machines.
4. Edit the `/etc/passwd` and `/etc/shadow` files for the dial-in machine.
5. Edit the `/etc/asppp.cf` file on each machine on the link.

6. Start the link manager `aspppd` on each machine on a link.
7. Verify that PPP is running successfully.

Although you don't have to perform Tasks 1–4 in order, you must complete them before you can edit the PPP-configuration file.

The sections in this chapter explain the procedures for configuring PPP.

Installing the PPP Software

The PPP software is automatically included when you run the Solaris installation program and select the entire distribution. If you did not select the entire distribution, you need to install PPP as a separate package.

Verifying Installation

Before proceeding further, you must check that the Solaris version of PPP is installed on all machines to be involved in the PPP link. On each endpoint involved in the link, type:

```
# pkginfo | grep ppp
```

If 32–bit PPP is installed, the following package names are displayed:

```
SUNWpppk       # Contains kernel modules
SUNWapppu      # Contains the link manager and login service
SUNWappp       # Contains configuration files
```

If 64–bit PPP is installed, the following package names are displayed:

```
SUNWpppk       # Contains the 32-bit kernel modules
SUNWpppkx      # Contains the 64-bit kernel modules
SUNWapppu      # Contains the link manager and login service
SUNWappp       # Contains configuration files
```

If PPP is not installed on an endpoint system, install it using either the `pkgadd` program or `admintool` software manager.

Note - When using `pkgadd` to install PPP, you must install the packages in the order listed in the preceding screen box.

Refer to *System Administration Guide, Volume I* for more information about `pkgadd` and `admintool` software manager.

Sample PPP Configuration

This and the following sections show you how to edit the appropriate files to support the most common PPP configuration: remote hosts and their dial-in server. Figure 9–1 illustrates the configuration used as the example for this chapter. It depicts three remote machines (`nomada`, `nomadb`, `nomadc`) and their dial-in server `nubian`, which compose the network 192.41.43. This is a separate network from the local area network 192.41.40, to which dial-in server `nubian` is directly attached. Network 192.41.40 runs NIS as its name service.

The IP number shown for each remote host is the address of its PPP network interface. However, the dial-in server has a specially created IP address for the PPP interface, 192.41.43.10, in addition to the IP address for its primary network interface, 192.41.40.45.

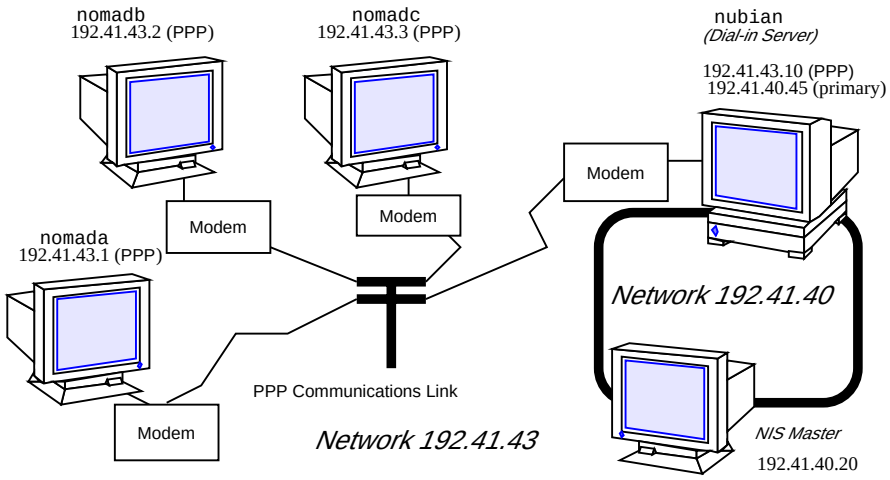


Figure 9–1 Sample Network of Remote Hosts and Multipoint Dial-in Server

Editing the /etc/inet/hosts File

After ensuring that PPP is installed on every machine involved in your configuration, your next task is to edit the /etc/inet/hosts files on each machine. You must add host information to the hosts database for every machine on the other end of the PPP link that the local machine needs to communicate with.

Note - You must update /etc/inet/hosts regardless of the name service in use on the physical network. This is necessary because PPP starts before the name service daemons during the booting process.

▼ How to Configure the Remote Machine's hosts Database

1. **Become superuser and prepare to edit the /etc/inet/hosts file.**

2. **Add an entry with the IP address and host name of the PPP network interface for the dial-in server on the other end of the link.**

   In Figure 9–1, nomada must have in its /etc/inet/hosts file an entry with the IP address for dial-in server nubian's PPP network interface. This is true also for the /etc/inet/hosts files for nomadb and nomadc.

3. **Add entries with the IP addresses of any machines on the dial-in server's physical network that the remote host can remotely log in to.**

   The /etc/inet/hosts file on nomadc would look like:

```
# Internet host table
#
127.0.0.1         localhost      loghost
192.41.43.3       nomadc
192.41.43.10      nubian-ppp
192.41.40.20      nismaster
```

4. **Update the databases on the name server (if the network has one) with the host names and IP addresses of the remote hosts.**

Multipoint Dial-in Server hosts Database

Multipoint dial-in servers must have a unique IP address for the PPP interface, besides the local IP address for the primary network interface. When configuring the hosts database for the dial-in server, you need to perform the following procedure.

▼ How to Configure the Dial-In Server's hosts Database

1. **Add an entry with the IP address for the PPP interface to the /etc/inet/hosts file for the dial-in server.**

   For example, the /etc/hosts file on dial-in server nubian in Figure 9–1 would have the following entries.

```
# Internet host table

#
127.0.0.1           localhost       loghost
192.41.43.10        nubian-ppp
192.41.40.45        nubian
```

2. **For configurations where the server's physical network does not use a name service:**

   a. **Add entries to the server's /etc/inet/hosts files for each remote host served.**

   b. **Add entries for the remote hosts to the /etc/inet/hosts files of every machine on the physical network permitted to communicate with the remote machines.**

3. **Add a new network number to the dial-in server's /etc/inet/networks file for the network that consists of the server and its remote hosts.**

   Refer to "Assigning a Network Number to the PPP Link" on page 112 for more information.

Editing UUCP Databases

Before a machine can dial out over the PPP link, you must edit these files in its UUCP database:

- `/etc/uucp/Devices`
- `/etc/uucp/Dialers`
- `/etc/uucp/Systems`

You must edit these files for remote hosts serving as PPP dial-out machines. Additionally, you must edit these files on the dial-in server if it is to dial out to the remote hosts (a requirement for multipoint dial-in servers). Chapter 12 describes these files in detail.

Updating `/etc/uucp/Devices` for PPP

The `/etc/uucp/Devices` file must contain entries for every communications device that a particular host uses or must know about. For example, if a machine uses a US Robotics V.32bis modem as part of the PPP link, you should ensure that `/etc/uucp/Devices` has an entry similar to the following:

```
# Use these if you have a USrobotics V.32bis modem on Port B.
ACUEC   cua/b - 9600 usrv32bis-ec
ACUEC   cua/b - 19200 usrv32bis-ec
ACUEC   cua/b - 38400 usrv32bis-ec
```

Be sure that the `Devices` file on each PPP endpoint machine has an entry describing its modem. For more information about `/etc/uucp/Devices`, refer to "`/etc/uucp/Devices` File" on page 178.

Updating `/etc/uucp/Dialers` for PPP

The `/etc/uucp/Dialers` file must have an entry describing the conversation with the modem attached to your PPP endpoint machine. Here is a sample entry for a US Robotics V.32bis modem that is part of a PPP link:

```
usrv32bis-ec =,-,  "" \dA\pT&FE1V1X1Q0S2=255S12=255&A1&H1&M5&B2\r\c OK\r
\EATDT\T\r\c CONNECT\s14400/ARQ STTY=crtscts
```

The first parameter in the entry, `usrv32bis`, corresponds to the last parameter in the `/etc/uucp/Devices` file, linking them together. The remainder of the entry describes the characters that the modem sends, those that it expects to receive, and so on. Table 12–6 defines the control codes used in the `Dialers` file.

Be sure that an entry is in the `Dialers` file for the modem attached to each dial-out endpoint on your link. If you are unsure of the correct conversation for a particular modem, refer to the *System Administration Guide, Volume I* and the operating manual for the modem.

Updating `/etc/uucp/Systems` for PPP

The `/etc/uucp/Systems` file contains entries for every machine to which the local host can dial out. Information in an entry might include the remote host's phone number, the line speed, and so on. Here is an example that host `nomadb` in Figure 9–1 might have for its dial-in server:.

```
nubian-ppp  Any ACUEC 38400 5551212 "" P_ZERO ""
\r\n\c login:-\r\n\c-login:-\r\n\c-login:-
EOT-login: bnomad password: Secret-Password
```

The first field gives the server's host name, `nubian-ppp`, a value used by the `asppp.cf` file keyword `peer_system_name`. `ACUEC` and `38400` refer to the device and speed, and are used to select an entry from the `/etc/uucp/Devices` file. The remaining information includes the phone number of the machine that `nomadb` wants to dial in to, the login name that `nomadb` is using to log in, and so on. "`/etc/uucp/Systems` File" on page 172 fully defines the parameters you need to supply to the `Systems` file.

On each remote host in your configuration, you must add an entry for its dial-in server. You can have additional entries in the `/etc/uucp/Systems` file for other machines to which the host can dial out for UUCP communications and for other PPP dial-in servers.

If the dial-in server also directly dials out to remote hosts, you must add entries to its `Systems` file describing each of these remote hosts.

Modifying the /etc/passwd File

To configure a dial-in server, you must also edit the /etc/passwd and /etc/shadow files.

You must add entries to the /etc/passwd file on the dial-in server for each user on a remote host authorized to log in to the server. When a remote host calls the dial-in server, it reads its UUCP databases and passes the server a user name or user ID for the host initiating the call. The server then verifies this user information in its /etc/passwd file.

If the user's password is authenticated, the server then logs the user in to a special shell for PPP hosts, /usr/sbin/aspppls. The server gets this information from the login shell entry in its /etc/passwd file. Using the example in Figure 9–1, dial-in server nubian might have the following entries in its /etc/passwd file:

```
bin:x:2:2::/bin:
sys:x:3:3::/bin:
uucp:x:5:5::/usr/lib/uucp:
nuucp:x:9:9::/var/spool/uucppublic:/usr/lib/uucp/uucico
news:x:6:6::/var/spool/news:/bin/csh
sundiag:x:0:1:System Diagnostic:/usr/diag/sundiag:/usr/diag/sundiag/sundiag
lily:x:20:99:Dial-in Operator:/home/nubian/lily:/bin/csh
nomada:x:21:99:R. Burton:/:/usr/sbin/aspppls
nomadb:x:22:99:T. Sherpa:/:/usr/sbin/aspppls
nomadc:x:23:99:S. Scarlett:/:/usr/sbin/aspppls
```

Refer to *System Administration Guide, Volume I* for information about the /etc/passwd file.

Note - In addition to the information in the /etc/passwd file, you update the /etc/shadow file with the passwords for the login names used by each endpoint machine permitted to dial in to the server. For more information, refer to *System Administration Guide, Volume I.*

Editing the /etc/asppp.cf Configuration File

The /etc/asppp.cf configuration file provides the PPP link manager on one endpoint machine with information about the machine on the other end of the link—or the machines on the other end of a multipoint (or dynamic point-to-point)

link. When the machine boots, the link manager uses this information to establish and maintain communication with a remote endpoint.

Parts of Basic Configuration File

The basic `asppp.cf` configuration file must contain at least two main sections: an `ifconfig` line and at least one `path` section. It can also contain a `defaults` section, which you use when you want to set the default values for an endpoint. (Refer to Chapter 11 for a description of keywords used in the `defaults` section.)

Example 9–1 shows a basic configuration file such as you would create for a remote host to establish a point-to-point link with a dial-in server.

EXAMPLE 9–1 Basic Configuration File

```
ifconfig ipdptp0 plumb nomada nubian-ppp up
   path
      interface ipdptp0
      peer_system_name nubian-ppp      # The name in the /etc/uucp/Systems file
      inactivity_timeout 300           # Allow five minutes before timing out
```

`ifconfig` Section of the `asppp.cf` File

The `asppp.cf` file must contain an `ifconfig` section with this syntax:

`ifconfig` *interface-number* `plumb` *local-machine remote-machine* `up`

Here is a description of the fields:

- `ifconfig` – Tells the link manager to run the `ifconfig` command and begin configuring the PPP interface.
- *interface-number* – Identifies the PPP interface `ipdptp`*n* for a point-to-point link or `ipd`*n* for a multipoint link. (Replace the *n* with the number of the interface.)
- `plumb` – Option of `ifconfig` that enables IP to recognize the interface.
- *local-machine* – Gives the name of the local endpoint, which can be the local host name or IP address.
- *remote-machine* – Gives the name of the remote endpoint, which can be the remote host name or IP address.
- `up` – Option of `ifconfig` that marks the interface just described as “up”.

The link manager first runs the `ifconfig` command on the local machine to configure the `ipdptp0` point-to-point interface. The zero in `ipdptp0` gives the device number of the interface. The `plumb` option performs various activities necessary for IP to recognize the `ipdptp0` interface. `nomada` is the name of the local host. `nubian-ppp` is the name of the dial-in server to which `nomada` connects through the point-to-point link. The `ifconfig` option `up` marks the `ipdptp0` interface as up.

Note - For more information about `ifconfig`, see Chapter 10 and the **`ifconfig`**(1M) man page.

`path` Section of the `asppp.cf` File

The `path` section of the configuration file tells the link manager the name of the remote endpoint and the name of the interface linking the endpoint machines. At a minimum the `path` section should contain the following lines:

```
path
   interface interface-number
   peer_system_name endpoint-name
```

`interface` *Keyword*

This keyword defines the PPP interface (either `ipdptp`*n* or `ipd`*n*). In Example 9–1, the following information appears in the `path` section:

```
interface ipdptp0
peer_system_name nubian-ppp
```

The `interface` keyword identifies `ipdptp0` as the point-to-point interface that local endpoint `nomada` uses to communicate with the remote endpoint in the manner described in this `path` section. It associates the `peer_system_name` with the interface.

`peer_system_name` *Keyword*

On a dial-out machine such as a remote host, the `peer_system_name` keyword takes the host name of the remote endpoint as its argument. This is the name of the remote endpoint given in `/etc/uucp/Systems`. The name need not be the same as the host name on the corresponding `ifconfig` line.

Note - The argument to the `peer_system_name` keyword for a dial-in server has a different value. See “Configuration File for Multipoint Dial-in Server” on page 127 for details.

In Example 9–1, `peer_system_name` identifies dial-in server `nubian-ppp` as the remote endpoint at the other end of this link. When the link manager reads the `asppp.cf` file, it then looks for the entry for `nubian-ppp` in the `/etc/uucp/Systems` file. (Recall that the `Systems` file contains information about

how to set up communications with the remote endpoint, including that machine's telephone number. Refer to "Updating /etc/uucp/Systems for PPP" on page 123.)

inactivity_timeout *Keyword*

The inactivity_timeout keyword is optional. It tells the link manager that the link can remain inactive for the interval designated. When that interval is passed, the link manager knows to automatically disconnect the link. The default interval is two minutes; you do not have to use inactivity_timeout unless you require a different inactivity interval.

Additional Keywords

You can supply other keywords in the asppp.cf file to define how endpoint machines should communicate. Chapter 11 has complete information about these keywords.

Configuration File for Multipoint Dial-in Server

The asppp.cf configuration file for a multipoint dial-in server contains the same basic sections as that for a point-to-point link: an ifconfig section, at least one path section, and, if desired, a defaults section.

Example 9–2 shows a configuration file for the dial-in server nubian introduced in Figure 9–1.

EXAMPLE 9–2 Configuration File for a Multipoint Dial-in Server

```
ifconfig ipd0 plumb nubian-ppp up

path
   interface ipd0
   peer_system_name tamerlane  # The user name this remote
                               # machine logs in with when it
                               # dials this server
    peer_ip_address nomada
                               # nomada is a remote machine that
                               # dials in to this server

# nomadb is another remote machine that dials in to nubian

path
   interface ipd0
   peer_system_name lawrence
   peer_ip_address nomadb
```

(continued)

(Continuation)

```
# nomadc is another remote machine that dials in to nubian

path
   interface ipd0
   peer_system_name azziz
   peer_ip_address nomadc
```

`ifconfig` Section for Multipoint Dial-in Server

The `ifconfig` section for a multipoint dial-in server has a slightly different syntax than that for a point-to-point link. This syntax is:

`ifconfig ipd`*n* `plumb` *server-name* `up`

The major difference is that no destination end points are listed as arguments to `ifconfig`. Instead, the link manager picks up this information from the `path` section of the `asppp.cf` file.

In Example 9–2, the link manager first runs the `ifconfig` command on the dial-in server to configure multipoint interface `ipd0`. The zero in `ipd0` gives the device number of the interface. The option `plumb` performs various activities necessary for IP to recognize the `ipd0` interface. The `ifconfig` option `up` marks interface `ipd0` as `up`.

Note - You may have to supply a netmask `+` parameter on the `ifconfig` line if you use subnetting.

`path` Section for Multipoint Dial-in Server

The `path` section of the `asppp.cf` file tells the link manager the name of the remote endpoint and the name of the interface linking the endpoint machines. However, on a multipoint dial-in server, you can include more than one `path` section. Additionally, some of the arguments to the keywords are used differently with multipoint links.

```
path
    interface interface-number
    peer_system_name endpoint-username
    peer_ip_address endpoint-hostname
```

You need to define a `path` section for each nomadic endpoint with which the dial-in server can establish connections.

`interface` *Keyword*

For a multipoint dial-in server, the `interface` keyword defines the PPP interface `ipd`*n*. You must specify the same PPP interface in the `path` section for every endpoint that communicates with the server through this interface.

`peer_system_name` *Keyword*

The `peer_system_name` keyword takes a slightly different argument for a dial-in machine than a dial-out machine. For a dial-in server, this argument is the login name used by the remote host when it tries to establish communications with the server. This user name must already be present in the server's `/etc/passwd` file. When the login service reads this name, it verifies the user name in the `/etc/passwd` and `/etc/shadow` files enabling communications.

In this excerpt from Example 9–2:

```
path
    interface ipd0
    peer_system_name scarlett
    peer_ip_address nomadc
```

the argument to `peer_system_name` is `scarlett`, indicating that when `nomadc` logs in to `nubian-ppp`, it uses the login name `scarlett`.

`peer_ip_address` *Keyword*

The `peer_ip_address` keyword is required for multipoint links. It takes the host name or IP address of the remote endpoint as its argument. The example above uses the host name `nomads` as the argument to keyword `peer_ip_address`.

Additional Keywords

You can supply other keywords in the `asppp.cf` file to define how endpoint machines should communicate. Refer to Chapter 11 for a complete list of keywords.

Editing the Configuration File

When editing `asppp.cf`:

- Separate keywords in the configuration file by white space (blanks, tabs, and new lines).

- Use a # sign before all character strings meant as comments. All characters placed between a # sign and the next new line are considered comments and ignored.

There are no other format requirements for the placement of the keywords in the file.

▼ How to Edit the `asppp.cf` Configuration File

1. **Become superuser on one endpoint machine and change to the `/etc` directory.**
2. **Edit the generic `asppp.cf` file to add the information defining the PPP link for this machine.**
3. **Save the file, making sure the permissions are set to `600`.**
4. **Change to the `/etc` directories on the remaining endpoints and repeat Steps 2 and 3.**

Adding PPP Security

After you have completed installing PPP on every machine involved in your configuration, you can add either PAP or CHAP levels of security for the PPP link by modifying the `asppp.cf` file. Refer to “Editing `asppp.cf` for PAP/CHAP Security” on page 156.

Starting up and Stopping Your New PPP Link

You can start PPP either automatically, at boot time, or manually from the command line.

▼ How to Manually Start PPP

You can start PPP manually, although this is not normally required.

1. **Become superuser and type:**

```
# /etc/init.d/asppp start
```

▼ How to Verify That PPP Is Running

1. **Run the** `ps` **command**:

```
# ps -e | grep asppp
```

   The resulting output from `grep` should list the `aspppd` daemon, indicating that PPP is running.

2. **If you do get results, verify that you can reach the remote PPP link by typing**:

```
# ping remote-host 300
```

   This version of `ping` sets a timeout value of 5 minutes (300 seconds). You should receive output similar to *remote-host* `is alive`. If you receive a different notice, such as *remote-host* `unreachable`, route configuration has failed.

3. **Check for errors in the configuration process by examining the log file.**

```
# tail /var/adm/log/asppp.log
```

   The `asppp.log` contains error messages if any errors were encountered during configuration.

See Chapter 10 for information on troubleshooting and problem solving.

▼ How to Stop PPP

1. **To stop PPP operations on your network, type**:

```
# /etc/init.d/asppp stop
```

CHAPTER 10

Troubleshooting PPP

This chapter is organized as a series of checks to make after you have configured PPP on your network. Thereafter, whenever you have trouble communicating over the PPP link, you can use PPP diagnostics to help troubleshoot problems.

In summary, you should do these checks in the following order:

1. Hardware
2. Interface status
3. Connectivity
4. Network interface activity
5. Local routing tables
6. Permissions
7. Packet flow

If PPP passes all the tests, you should be able to use TCP and UDP services such as `rlogin`, `telnet`, and `ftp` over the link. If the link still fails, turn on PPP diagnostics for assistance in troubleshooting.

The next sections describe these checks in detail.

Checking Hardware

Make sure that all modem and power cables are tightly seated. If you are having problems with PPP, always check the modems, cables, serial card, and phone lines first.

Checking Interface Status

After PPP is started, you can use `ifconfig` to monitor the current state of the line, using only the PPP interface name as an argument. Example 10–1 shows sample output from `ifconfig` for PPP links that are running.

Note - If a user is privileged (root), and issues an `ifconfig` command, machine addresses are displayed in the output as shown below.

EXAMPLE 10–1 `ifconfig` Output for Point-to-Point Link

```
nomadb# ifconfig ipdptp0

ipdptp0: flags=28d1<UP,POINTOPOINT,RUNNING,NOARP,MULTICAST,UNNUMBERED> mtu 1500
        inet 129.144.111.26 --> 129.144.116.157 netmask ffff0000
        ether 0:0:0:0:0:0
```

You receive output similar to that in Example 10–1 for both standard and dynamic point-to-point links.

EXAMPLE 10–2 `ifconfig` Output for Multipoint Link

```
nubian# ifconfig ipd0

ipd0: flags=c1<UP,RUNNING,NOARP> mtu 1500
        inet 129.144.201.191 netmask ffffff00
        ether 0:0:0:0:0:0
```

If `ifconfig` does not display `UP` and `RUNNING`, you did not configure PPP correctly. For more information on `ifconfig`, see “`ifconfig` Command” on page 80 and the **`ifconfig`**(1M) man page.

Checking Connectivity

Use the `ping` command to verify that the connection is up or can be established. For example, consider the following simple round-trip test:

```
# ping elvis
```

where `elvis` is the name of the PPP interface on the remote host. If the resulting display is

```
elvis is alive
```

then packets can be sent to and received from `elvis`. If not, a routing problem exists at some point between the local and remote hosts. For more information on `ping`, refer to “`ping` Command” on page 78 and the **`ping`**(1M) man page.

Checking Interface Activity

Use the `netstat` command as follow, to check that packets are being sent and received correctly:

```
# netstat --i
```

Refer to “`netstat` Command” on page 81 and the **`netstat`**(1M) man page.

Checking the Local Routing Tables

Use the `netstat` command to display the local routing tables:

```
# netstat --r
```

The following is sample output:

```
Routing tables
Destination   Gateway    Flags  Refcnt  Use    Interface
sahara        deserted   UGH    0       0       ie1
karakum       labia      UGH    0       0       ie1
frodo         bilbo      UGH    1       12897   ipdptp0
route7        route7     UGH    0       0       ie0
eastgate      route71    UGH    0       158     ie0
backbone      pitstopbb  U      1       16087   ie1
dresdenpc     route1     UG     0       0       ie1
loopback      localhost  U      2       113436  lo0
swan-bb       pitstop    U      406     146044  ie0
dallas2       route7     UG     0       0       ie0
trainingpc    route62    UG     0       0       ie1
```

Make sure there is a routing table entry for each possible destination network. In particular, PPP devices, listed under `Interface`, should be matched with the appropriate host names listed under `Gateway`. The `Gateway` entry should, in turn, be matched with the correct entry under `Destination`.

Otherwise, if you are using *static routing*, add the appropriate static routes. If you are using *dynamic routing* with `in.routed`:

1. **Verify that `in.routed` is running by typing:**

   ```
   # ps -e | grep route
   ```

   If the routing tables still don't look correct, become superuser and continue with the next steps.

2. **Kill `in.routed` by typing the process ID you got from `ps -e` as the argument to `kill`. For example, if *1384* was the process ID, you would type:**

   ```
   # kill 1384
   ```

3. **Flush the routing tables as follows:**

   ```
   #  /usr/sbin/route -f
   ```

4. **Restart `in.routed`:**

   ```
   # /usr/sbin/in.routed
   ```

Checking Permissions

If you attempt to use `rsh` and receive the message `Permission denied`, the remote system's `/etc/hosts.equiv` or `/.rhosts` file does not contain the sending system's host name or does not contain the line `+`.

Checking Packet Flow

Check the packet flow next. Use the `snoop` command to observe packets from the network and observe their contents. Example 10–3 shows some sample output from `snoop`.

EXAMPLE 10–3 Sample Output from `snoop`

```
# snoop -d ipdptp0
Using device ipdptp0 (promiscuous mode)
corey -> pacifica7    RLOGIN C port=1019
       hugo -> ponc3          RPC R XID=22456455 Success
       ponc3 -> hugo          NFS C WRITE FH=1B29 at 32768

    commlab3 -> commlab4      TELNET R port=34148
    commlab4 -> commlab3      IP  D=129.144.88.3 S=129.144.88.4 LEN=46, ID=41925
    commlab3 -> commlab4      TELNET R port=34148
    commlab4 -> commlab3      ICMP Echo request
    commlab3 -> commlab4      ICMP Echo reply
    commlab4 -> commlab3      FTP C port=34149
    commlab4 -> commlab3      FTP C port=34149
    commlab3 -> commlab4      FTP R port=34149
    commlab4 -> commlab3      FTP C port=34149
```

The `ipdptp0` device name mentioned in the first line of the output `Using device ipdptp0` indicates a point-to-point connection.

Note - You need to have the link up and some traffic generated in order to use `snoop` to check the line status.

`snoop` captures packets from the network and displays their contents. It uses both the network packet filter and streams buffer modules to provide efficient capture of packets from the network. Captured packets can be displayed as they are received or saved to a file for later viewing.

snoop can display packets in a single-line summary form or in verbose multiline forms. In summary form, only the data pertaining to the highest-level protocol is displayed. For example, an NFS packet will have only NFS information displayed. The underlying RPC, UDP, IP, and Ethernet frame information is suppressed but can be displayed if either of the verbose options is chosen.

For more information about the snoop command, refer to the **snoop**(1M) man page.

Using PPP Diagnostics for Troubleshooting

If you have problems with a link after successfully establishing modem connections, you can use PPP-level diagnostics for troubleshooting. PPP-level diagnostics report detailed information about the activities of a link to help you determine where it is failing.

To obtain diagnostic information, add the line `debug_level 8` to the `path` section of the `asppp.cf` file. (If you are very knowledgeable about data communications, you might want to use debug level 9, which provides very detailed information.) Here is a sample configuration file that invokes PPP diagnostics.

```
ifconfig ipdptp0 plumb nomada nubian-ppp up
path
   interface ipdptp0
   peer_system_name nubian-ppp   #The name in the /etc/uucp/Systems file
   inactivity_timeout 300        #Allow five minutes before timing out
   debug_level 8                 #Start up PPP diagnostics for this link
```

For complete details about the `aspppd.conf` file, refer to “Editing the `/etc/asppp.cf` Configuration File” on page 124.

▼ How to Set Diagnostics for Your Machine

Set diagnostics on the host you want to monitor as follows:

1. **Become superuser and change to the `/etc` directory.**
2. **Edit the current `asppp.cf` file and add the following to the `path` section:**
   `debug_level 8`**.**
3. **Save the file, making sure the permissions are set to `600`.**
4. **Kill the current `aspppd` daemon and restart it.**

```
#kill PID
#aspppd
```

where *PID* is the process ID for `aspppd`.

PPP reports diagnostic information in `/var/adm/log/asppp.log`.

Analyzing Diagnostic Output

When a PPP link runs correctly, the `asppp.log` file includes diagnostic information in addition to its normal output. This section explains what the diagnostic messages mean. If your output is different, refer to RFC 1331.

Host and Modem Setup

This section contains messages that occur as the local host sends configuration information to the modem, and then as the modem tries to dial the remote host. These initial activities are actually handled by the UUCP daemon. You might think of them as the UUCP portion of asynchronous PPP communications. (Refer to Chapter 12 for complete details on UUCP.)

The two messages below should always appear at the beginning of the session. They indicate that the `aspppd` daemon has started successfully.

```
11:53:33 Link manager (1057) started 04/14/94
11:53:33 parse_config_file: Successful configuration
```

The next line indicates that a packet was routed to the `ipdptp0` interface on the local host. It helps you to determine if a dial-out is occurring correctly. For example, if you tried to `ping` the remote machine and this message isn't in `asppp.log`, the packet was lost, probably due to a routing problem.

Next, UUCP looks for an entry that matches `Ppac7` in a chat script in the `/etc/uucp/Systems` file. It then reports that it found an entry that had a device type ACUTEC. (For more information on the `Systems` file, refer to "`/etc/uucp/Systems` File" on page 172.)

```
11:53:46 process_ipd_msg: ipdptp0 needs connection
conn(Ppac7)
Trying entry from '/etc/uucp/Systems' - device type ACUTEC.
```

UUCP then finds the dialing information for an ACUTEC dialer in the `/etc/uucp/Devices` file. When it finds the information, it opens the appropriate serial port on the local host and sets it with a speed of 9600. (For more information on `/etc/uucp/Devices`, see "`/etc/uucp/Devices` File" on page 178.)

```
Device Type ACUTEC wanted
Trying device entry 'cua/a' from '/etc/uucp/Devices'.
processdev: calling setdevcfg(ppp, ACUTEC)
fd_mklock: ok
fixline(8, 9600)
gdial(tb9600-ec) calle
```

UUCP looks for the entry `tb9600` in the `/etc/uucp/Dialers` file and then sends out these messages.

```
Trying caller script 'tb9600-ec' from '/etc/uucp/Dialers'
expect: (''''')
```

The host waits a couple of seconds and then sets the registers on the modem. The information shown in the log below is modem-specific. It comes from the `/etc/uucp/Dialers` file.

```
got it
sendthem (DELAY)
APAUSE
APAUSE
APAUSE
T&D2E1V1X1Q0S2=255S12=255S50=6S58=2^M<NO CR>)
```

The next lines are the dialog between the modem and the host machine. `expect (OK^M)` means that the host expects the modem to send an "okay." The words `got it` at the end of the second line indicate that the host got the "okay" message from the modem.

```
expect: (OK^M)
AAAT&D2E1V1X1Q0S2=255S12=255S50=6S58=2^M^M^JOK^Mgot it
```

Next, the host sends the string below to the modem, which does the actual dialing. The phone number in the second line is retrieved from the entry for the remote host in the `/etc/uucp/Systems` file.

```
sendthem (ECHO CHECK ON
A^JATTDDTT99003300887744^M^M<NO CR>)
```

The line beginning with `expect` indicates that the local host expects to get a response from the modem at a speed of 9600 bps. The next line indicates that the modem responded.

```
expect: (CONNECT 9600)
^M^JCONNECT 9600got it
```

This line indicates that hardware flow control has started on the link. The host obtains flow control information from the `/etc/uucp/Dialers` file.

```
STTY crtscts
```

In the next series of messages, the local host waits for the remote host to send it a standard UNIX login prompt.

```
getty ret 8
expect: (‘‘‘‘)
got it
sandiest (^J^M)
expect: (login:)
```

The next messages indicate that the local host has received the login prompt from the remote. It then retrieves the appropriate login sequence from the chat script in the `/etc/uucp/Systems` entry for the remote host. This sequence is `Ppong^M`, which is required for login by the remote host.

```
^M^J^M^Jlogin:got it
sendthem (Ppong^M)
```

In these messages, the local host waits for the `ssword` prompt from the remote host. Upon receipt of the prompt, the local host sends the password retrieved from the chat script in the `/etc/uucp/Systems` entry for the remote host.

```
expect: (ssword:)
login: Ppong^M^JPassword:got it
```

The following messages indicate that dialing and modem connection completed successfully.

```
sendthem (ppptest1^M)
call cleanup(0)^M
```

Communications Between the Local and Remote Hosts

At this point, PPP communications start, as the link between local and remote hosts is now established.

The first lines in this part of the session constitute a *configuration request* (`Config-Req`). This is the first PPP packet sent to the remote host. The configuration request is one example of a Link Control Protocol (LCP) packet. It requests that configuration be set up and then sets up the PPP link between endpoint machines. Example 10–4 shows a sample configuration request.

EXAMPLE 10–4 Configuration Request

```
11:54:20 004298 ipdptp0 SEND PPP ASYNC 29 Octets LCP Config-Req
ID=4c LEN=24 MRU=1500 ACCM=00000000 MAG#=69f4f5b2 ProtFCOMP
AddrCCOMP
```

Here is a description of the configuration request shown in Example 10–4.

- `11:54:20` – Time stamp field, indicating the time when the packet was sent
- `004298` – Number of the packet
- `ipdptp0` – Network interface used
- `SEND PPP ASYNC` – Indicates that the modem is sending asynchronous PPP
- `29 Octets` – Amount of data the host sent
- `LCP` – Packet type to send
- `ID=4c` – Identifier associated with the packet; it is actually part of the packet
- `LEN=24` – Length of the LCP part of the packet

The remaining items are a list of options to be negotiated between hosts.

- `MRU=1500` – Maximum Receive Unit (MRU), the largest packet size the calling host can receive from the remote host
- `ACCM=00000000` – Asynchronous Character Map (ACCM), the mask sent to the remote host that tells what control characters to escape on transmission
- `MAG#=69f4f5b2` – Magic number field; used for loopback detection mechanism
- `ProtFCOMP AddrCCOMP` – Asks for the remote host to compress certain parts of the frame header (protocol field, address field).

The next lines are reporting invalid PPP packets. They come from the remote host, which is sending out UNIX text. This does not indicate a problem with PPP.

```
11:54:20 004299 ipdptp0 RECEIVE {Invalid ppp packet}PPP ASYNC 7
Octets [BAD FCS] {Unrecognized protocol:    1}

11:54:20 004299 ipdptp0 RECEIVE PPP ASYNC 73 Octets [BAD FCS]
{Unrecognized protocol:    880a}
```

In these packets, the local host receives the remote host's request for configuration, then sends out another configuration request. The packets are identical except for their ID fields. The ID field helps to distinguish between the two packets.

```
11:54:21 004301 ipdptp0 RECEIVE PPP ASYNC 29 Octets LCP Config-
Req  ID=35 LEN=24 MRU=1500 ACCM=00000000 MAG#=a8562e5f ProtFCOMP
AddrCCOMP

11:54:21 004302 ipdptp0 SEND PPP ASYNC 29 Octets LCP Config-Req
ID=4d LEN=24 MRU=1500 ACCM=00000000 MAG#=69f4f5b2 ProtFCOMP
AddrCCOMP
```

In this packet, the local host acknowledges the remote request by sending it a configuration acknowledgment (`Config-ACK`).

```
11:54:21 004303 ipdptp0 SEND PPP ASYNC 29 Octets LCP Config-ACK
ID=35 LEN=24 MRU=1500 ACCM=00000000 MAG#=a8562e5f ProtFCOMP
AddrCCOMP
```

The local host receives a configuration request (`Config-Req`) from the remote host.

```
11:54:21 004304 ipdptp0 RECEIVE PPP ASYNC 29 Octets LCP Config-
Req  ID=36 LEN=24 MRU=1500 ACCM=00000000 MAG#=a8562e5f ProtFCOMP
AddrCCOMP
```

In these packets, the local host acknowledges the second packet sent by the remote host and receives the remote host's acknowledgment.

```
11:54:21 004305 ipdptp0 SEND PPP ASYNC 29 Octets LCP Config-ACK
ID=36 LEN=24 MRU=1500 ACCM=00000000 MAG#=a8562e5f ProtFCOMP
AddrCCOMP

11:54:21 004306 ipdptp0 RECEIVE PPP ASYNC 29 Octets LCP Config-
ACK  ID=4d LEN=24 MRU=1500 ACCM=00000000 MAG#=69f4f5b2 ProtFCOMP
AddrCCOMP
```

Here the local host negotiates parameters about IP transmission. `LEN=16` gives the packet size. `VJCOMP` indicates Van Jacobsen header compression. `IPADDR` is followed by the calling host's IP address.

```
11:54:21 004307 ipdptp0 SEND PPP ASYNC 21 Octets IP_NCP Config-
Req  ID=4e LEN=16 VJCOMP MAXSID=15 Sid-comp-OK IPADDR=192.9.68.70
```

This packet indicates that the local host has received IP configuration from the remote host, including its IP address.

```
11:54:22 004308 ipdptp0 RECEIVE PPP ASYNC 21 Octets IP_NCP
Config-Req  ID=37 LEN=16 VJCOMP MAXSID=15 Sid-comp-OK
IPADDR=192.9.68.71
```

The local host sends this ACK to the remote host and receives an ACK from the remote host.

```
11:54:22 004309 ipdptp0 SEND PPP ASYNC 21 Octets IP_NCP Config-
ACK  ID=37 LEN=16 VJCOMP MAXSID=15 Sid-comp-OK IPADDR=192.9.68.71

11:54:22 004310 ipdptp0 RECEIVE PPP ASYNC 21 Octets IP_NCP
Config-ACK  ID=4e LEN=16 VJCOMP MAXSID=15 Sid-comp-OK
IPADDR=192.9.68.70
```

The first message below indicates that IP has started on the link. The next message indicates that the local host is sending IP traffic over the link.

```
11:54:22 start_ip: IP up on interface ipdptp0, timeout set for
120 seconds

11:54:24 004311 ipdptp0 SEND PPP ASYNC 89 Octets IP_PROTO
```

In the first message below the local host receives IP traffic from the remote host. The subsequent messages indicate that the interface was disconnected because of an idle time-out.

```
11:54:25 004312 ipdptp0 RECEIVE PPP ASYNC 89 Octets IP_PROTO
11:56:25 process_ipd_msg: interface ipdptp0 has disconnected
11:56:25 disconnect: disconnected connection from  ipdptp0
```

The next messages begin the termination sequence. The first message indicates that the remote host has sent a packet to terminate the IP layer. The second is the local host's acknowledgment of the request to terminate.

```
11:56:25 004313 ipdptp0 RECEIVE PPP ASYNC 9 Octets IP_NCP Term-
REQ  ID=38 LEN=4

11:56:25 004314 ipdptp0 SEND PPP ASYNC 9 Octets IP_NCP Term-ACK
ID=38 LEN=4
```

The local host receives a request to terminate the LCP layer. The second message is an acknowledgment of the request, causing a graceful shutdown.

```
11:56:25 004315 ipdptp0 RECEIVE PPP ASYNC 9 Octets LCP Term-REQ
ID=39 LEN=4

11:56:25 004316 ipdptp0 SEND PPP ASYNC 9 Octets LCP Term-ACK
ID=39 LEN=4
```

This message indicates that the link has closed.

```
11:56:29 004317 ipdptp0 PPP DIAG CLOSE
```

CHAPTER 11

Tailoring Your PPP Link

This chapter contains information you need to configure PPP links less commonly used than the basic links described in Chapter 9. The text includes instructions for configuring two types of PPP links: the dial-in server with dynamic point-to-point links and the virtual network, which uses multipoint links. The chapter concludes with tables listing all available keywords for the `asppp.cf` configuration file.

Configuring Dynamically Allocated PPP Links

A dial-in server with a dynamic point-to-point link gives your site all the advantages of point-to-point communications. Chapter 7 introduces this configuration type. It consists of remote hosts communicating with at least one dial-in server that dynamically allocates point-to-point links on an as-needed basis. The sample configuration shown in Figure 11–1 is used throughout this section.

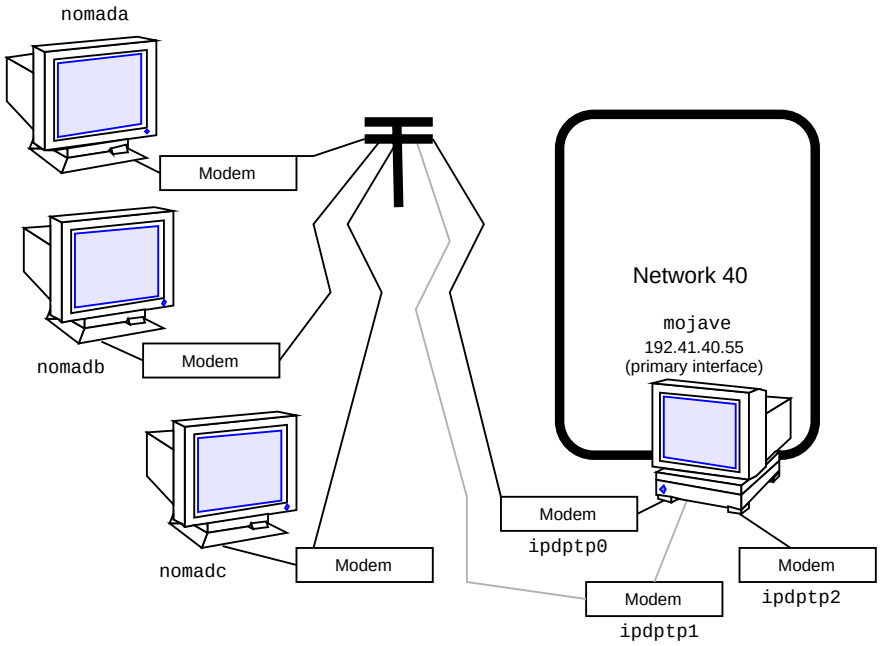


Figure 11–1 Network of Remote Hosts and Dynamic Link Dial-in Servers

Each remote host communicates with the dial-in server using a standard point-to-point link. However, unlike the multipoint dial-in server in Figure 9–1, dial-in server `mojave` connects to a calling host over a dynamic point-to-point link. The server allocates an available link whenever a remote host attempts to establish a connection.

The idea behind a dynamic link is that the server provides the client with an IP address each time a connection is established. When the connection is established, the server allocates an available IP interface to the client. The remote IP address of the interface then becomes the client's IP address for the duration of the connection. When the connection is terminated, the IP interface is returned to the pool of available interfaces, ready to be used for another connection.

You use the same generic procedures for configuring dynamic links as you do for the remote host–to–multipoint dial-in server link, as described in "Overview of the Configuration Process" on page 117. However, the dynamic point-to-point link has its own set of issues and requires slightly different modifications to the files involved in configuration.

Addressing Issues for Dynamically Allocated Links

You must add host information to the `/etc/inet/hosts` file for each machine that use the dynamically allocated PPP link. The IP addresses for the PPP endpoints should follow these conventions:

- For the dial-in server, you must use the IP address of the server's primary network interface (for example `le0` or `smc0`) as the address of the dynamic link.
- For a dynamic link, you don't need to assign an IP address to each remote host (as you would for a static link), but you do need to assign a remote IP address to each point-to-point IP interface on the server. The number of IP interfaces you can use is equal to the number of modems your server is connected to. For example, if you have three modems, you need three point-to-point IP interfaces and three IP addresses
- You must include a dummy IP address for the `ifconfig` command to work properly on the client. This address acts as a placeholder for the local IP address assigned to the client IP interface when PPP is started.

Note - There are no restrictions on the remote IP addresses that can be assigned to the IP interfaces, but, for clarity, it is probably best to include only IP addresses belonging to the same subnet.

Updating the `hosts` Database for Dynamic Links

You must update the `hosts` database on all machines involved in the dynamic-link configuration.

▼ How to Update a Remote Host

When configuring the `hosts` databases on the remote machines, do the following:

1. **Add to the `/etc/inet/hosts` file the IP address and host name of the primary network interface for each dial-in server on the other end of the link.**

   For example, in Figure 11–1, the `/etc/inet/hosts` file for `nomada`, `nomadb`, and `nomadc` should each include the IP address of the primary network interface of the dial-in server `mojave`.

2. **Add the dummy IP address.**

   This IP address is used only when PPP is started.

   The `/etc/inet/hosts` file on `nomadc` might look like:

```
# Internet host table
#
```

(Continuation)

```
127.0.0.1          localhost        loghost
192.41.40.55       mojave
1.2.3.4            dummy
```

3. **Add to the** `/etc/inet/hosts` **file the IP addresses of all machines on the dial-in server's physical network that the remote host can remotely log in to.**

4. **Update the databases on any name server on the physical network with the host names and IP addresses of the remote hosts.**

▼ How to Update the Dial-in Server

You do not have to add any PPP-specific address to the `hosts` database for the dial-in server. The dynamically allocated link must use the server's primary network interface. Therefore, when configuring the `hosts` database for the dial-in server, do the following:

1. **Add entries to the server's** `/etc/inet/hosts` **files for each remote host served.**

2. **Add to the** `/etc/inet/hosts` **files of every machine on the physical network entries for any remote hosts they are permitted to communicate with.**

Considerations for Other Files

The next steps in the configuration process involve editing the `/etc/passwd` file and the `/etc/shadow` file. Edit these files for the dynamic–link configurations just as you would for the remote host–to–multipoint dial-in server configuration. Refer to "Modifying the `/etc/passwd` File" on page 124 for information regarding the `/etc/passwd` and `/etc/shadow` files.

Editing `asppp.cf` for Dynamic Link

The `asppp.cf` configuration file for a dynamic–link configuration must contain information about remote hosts and the interfaces to use for the PPP link. After the dial-in server boots, its link manager uses this information to establish communications whenever the server is called by a remote endpoint.

Remote Host with Dynamic Link

The `asppp.cf` configuration file for a remote host is the same as the one described in “Parts of Basic Configuration File” on page 125, except for the addition of the parameter *negotiate_address*:

```
ifconfig ipdptp0 plumb dummy mojave up
path
    interface ipdptp0
    peer_system_name mojave-ppp
    connectivity_timeout 300
    negotiate_address on
```

The *negotiate_address* parameter indicates whether or not local IP address assignment is obtained through negotiation and assigned dynamically. If set to on, the IP address supplied by the server is used as the client’s local address for the duration of the connection.

Dial-in Server With Dynamic Link

When the dial-in server receives an incoming packet, the link manager reads the `path` sections of its configuration file to identify the remote endpoint and determine the interface to use. The configuration file shown in Example 11–1 does not contain an interface keyword. Instead, the link manager uses interface information established in the `defaults` section.

The `asppp.cf` configuration file for a dial-in server with dynamically allocated links might resemble Example 11–1:

EXAMPLE 11–1 Configuration File for Server With Dynamically Allocated Link

```
ifconfig ipdptp0 plumb mojave clienta down
ifconfig ipdptp1 plumb mojave clientb down
ifconfig ipdptp2 plumb mojave clientc down

# This means grab whatever interface is available (not in use)
defaults
     interface ipdptp*

# Each path specifies a machine that might dial up / log
# in to this server

path
    peer_system_name tamerlane   # nomada uses the login name
                                 # tamerlane
```

(continued)

(Continuation)

```
path
    peer_system_name lawrence    # nomadb uses the name lawrence
                                 # for login

path
    peer_system_name nomadc
```

`ifconfig` *Section for Server With Dynamic Links*

The `ifconfig` section for a dial-in server with a dynamically allocated link has the syntax:

`ifconfig ipdptp`*n* `plumb` *server-name client-address* `down`

Example 11–1 contains three `ifconfig` lines, each initializing a point-to-point interface.

```
ifconfig  ipdptp0  plumb  mojave  clienta  down
ifconfig  ipdptp1  plumb  mojave  clientb  down
ifconfig  ipdptp2  plumb  mojave  clientc  down
```

`defaults` *Section for Server With Dynamic Links*

When you configure a dynamically allocated link, you might want to include a `defaults` section in the `asppp.cf` file. This section sets the defaults for the value replacing *keyword*, wherever *keyword* subsequently appears in the `asppp.cf` file. The syntax for the `defaults` section is:

```
default
     keyword
```

Example 11–1 uses the keyword `interface` to define the interface as `ipdptp*`, indicating a dynamic link. The asterisk wildcard tells the link manager to use any available `ipdptp` interface defined in the `ifconfig` section. Thus the link manager on server `mojave` uses either `ipdptp0`, `ipdptp1`, or `ipdptp2`—whichever is the first interface configured “down” that it finds.

`path` *Section for Server With Dynamic Links*

The configuration file for the server with dynamic links must contain `path` sections for every remote host permitted to establish connections with the server. The path section has the following syntax: .

```
path
    peer_system_name endpoint-username
```

No `interface` keyword has been defined in the `path` section because this value is defined in the defaults section.The `peer_system_name` keyword has the same meaning here as it does in the configuration file for the multipoint server. See “`path` Section for Multipoint Dial-in Server” on page 128 for more information.

Additional Keywords

You can supply other keywords in the `asppp.cf` file to define how endpoint machines should communicate, including the use of security keywords as explained in “Configuration Keywords” on page 161.

Configuring a Virtual Network

Virtual networks consist of a group of standalone computers, each in an isolated location, that can connect to each other through PPP multipoint links. “Virtual Networks” on page 98 introduces virtual network concepts. This section explains how to configure a virtual network.

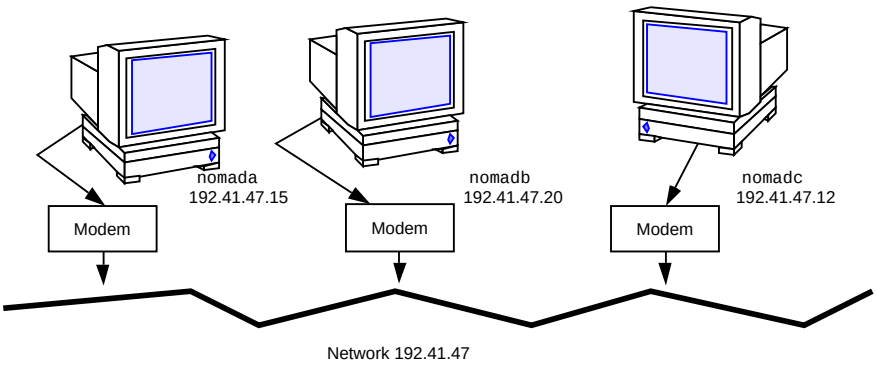


Figure 11–2 Sample Virtual Network

The network shown in Figure 11–2 consists of three isolated computers. Each member of the network connects to the other members of the network through a multipoint PPP link. Therefore, to create such a network, you (and perhaps other network administrators at the remote location) have to configure a multipoint PPP link on each participating host.

You use the same generic process for configuring multipoint links as you do for configuring a multipoint dial-in server link, as described in “Overview of the Configuration Process” on page 117. However, the virtual network has its own set of issues and requires you to configure each host in the network accordingly.

Addressing Issues for Virtual Networks

You must add host information to the `/etc/hosts` file for each machine in the virtual network. When typing the IP addresses used for the PPP endpoints:

- Designate a PPP-specific IP address for its point-to-point link. Note that if the machine was not previously configured in a physical network, you must create an IP address for the PPP link. This address becomes the host’s primary network interface.
- Create a network number for the virtual network. See “Assigning a Network Number to the PPP Link” on page 112 for more information.

Updating `hosts` and `networks` Databases

The first step in the configuration process involves updating the `hosts` and `networks` databases with information about your virtual network.

`/etc/inet/hosts` File for the Virtual Network

The `/etc/inet/hosts` file on each machine must contain the addressing information for every member of the network that this host has permission to access. For example, each host in the network in Figure 11–2 would have this information:

```
# Internet host table
#
127.0.0.1           localhost loghost
192.41.47.15        nomada
192.41.47.20        nomadb
192.41.47.12        nomadc
```

`/etc/inet/networks` File for the Virtual Network

Since the virtual network requires a unique IP address, you must type this address in the `networks` database. For example, the network shown in Figure 11–2 has the number 192.41.47. Moreover, if the hosts on the network need to communicate with other networks, you should register the network with the InterNIC addressing authority. See Chapter 4 for information on editing the `networks` database.

Each host on the virtual network must have an entry with the network's address in the /etc/inet/networks file. For example, each host on network 192.41.47 might have the following in /etc/inet/networks:

```
# Internet networks
#
# arpanet   10          arpa
# ucb-ether 46          ucbether
#
# local networks
loopback    127
ppp         192.41.47   #remote sales offices
```

Considerations for Other Files

The next steps in the configuration process involve editing the UUCP databases, the /etc/passwd file, and the /etc/shadow file. You edit these files for the machines in the virtual network just as you would for the multipoint dial-in server configuration. Refer to "Editing UUCP Databases" on page 122 for UUCP-related information and "Modifying the /etc/passwd File" on page 124 for information regarding the passwd file.

asppp.cf Configuration File for a Virtual Network

The configuration file for a local machine on a virtual network must contain information about all remote hosts on the network that the local host can access. Moreover, each machine on the virtual network must be configured for both dial-in and dial-out functions. After the local machine boots, its link manager reads the asppp.cf file to establish communications.

Example 11–2 shows a configuration file such as you would set up for nomada on a virtual network 192.41.47.

EXAMPLE 11–2 Configuration File for nomada

```
# /etc/asppp.cf for hosta

ifconfig ipd0 plumb nomada netmask + up
defaults
   interface ipd0
path
   peer_ip_address  nomadb
   peer_system_name lawrence     # name machine logs in with
```

(continued)

(Continuation)

```
path
   peer_ip_address nomadc
   peer_system_name azziz
```

Example 11–3 shows a configuration file such as you would set up for `nomadb` on virtual network 192.41.47.

EXAMPLE 11–3 Configuration File for `nomadb`

```
# /etc/asppp.cf for nomadb

ifconfig ipd0 plumb nomadb netmask + up
defaults
   interface ipd0
path
   peer_ip_address   nomada
   peer_system_name  tamerlane  # name the machine logs in with
path
   peer_ip_address   nomadc
   peer_system_name  azziz
```

Editing `asppp.cf` for PAP/CHAP Security

You can edit the `asppp.cf` file to establish security and to specify whether parts of the link will respond to Password Authentication Protocol (PAP), or Challenge-Handshake Authentication Protocol (CHAP),as described in “PPP Security” on page 103. The `asppp.cf` file is edited by adding a series of keywords. In this section, *authenticator* is the system starting the link or challenge, and is frequently the server. *Peer* is the other end of the link, and is often the client.

The keywords to be added are `require_authentication` and `will_do_authentication`. The authenticator or server generally require authentication and the peer or client generally do authentication.

TABLE 11–1 Authenticator Keywords and Associated Strings

require_authentication pap	require_authentication chap
pap_peer_id	chap_peer_secret
pap_peer_password	chap_peer_name

TABLE 11–2 Peer Keywords and Associated Strings

will_do__authentication pap	will_do_authentication chap
pap_id	chap_secret
pap_password	chap_name

▼ How to Install PAP/CHAP

1. **On the server, become superuser and prepare to edit the** `/etc/asppp.cf` **file.**

2. **Add the** `require_authentication` **keyword for each machine on the link to use either CHAP or PAP security.**
   a. **For each pap keyword add an associated** `pap_peer_id` **and** `pap_peer_password` **string.**
   b. **For each chap keyword add an associated** `chap_peer_secret` **and** `chap_peer_name` **string.**
      You can state the keywords explicitly, or if you prefer, you can use the default for the path. Refer to Table 11–3 to see what each keyword specifies. Examples can be found in Example 11–4.

3. **On each remote host on the link to use either PAP or CHAP security, add an entry in the remote host's** `/etc/asppp.cf` **file with the** `will_do_authentication` **keyword.**
   a. **For each pap keyword entry add an associated** `pap_id` **and** `pap_password` **string.**

b. For each chap keyword entry add an associated `chap_secret` **and** `chap_name` **string.**

You can state the keywords explicitly, or if you prefer, you can use the default for the path. Refer to Table 11–3 to see what each keyword specifies. Examples can be found starting with Example 11–4.

Rules for PAP/CHAP Keywords

- Either server or client can require authentication or offer to do authentication.
- If PAP and CHAP are both present, the authenticator first tries CHAP. If that fails, the link is terminated. The authenticator will not try PAP.
- The default value for PAP and CHAP authentication keywords is off. The syntax for keywords is:

```
require_authentication     off | pap[chap] | chap[pap]

will_do_authentication     off | pap[chap] | chap[pap]
```

- If you fail to specify `pap_id` and `pap_password` or `pap_peer_id` and `pap_peer_password` keywords and values for the associated path, the corresponding values are set to the NULL string.
- You must specify `chap_name`,`chap_secret`, `chap_peer_secret` and `chap_peer_name` keywords and values for that path.

TABLE 11–3 PAP/CHAP Keyword Definitions

Keywords	Value Definition
`require_authentication` *keywords*[1]	Specifies whether the peer must authenticate itself. If either `pap` or `chap` is present, the peer must participate in authentication or end the connection. The default value is off.
`pap_peer_id` *peername*[2]	Specifies the name of the peer to be authenticated for the current path. *peername* string is one or more octets[3]. To indicate a zero-length string, do not include the keyword.
`pap_peer_password` *string*[4]	Specifies password for peer in one or more octets. To indicate a zero-length string, do not include the keyword.

TABLE 11–3 PAP/CHAP Keyword Definitions *(continued)*

Keywords	Value Definition
`chap_peer_secret` *string*	Specifies the secret used with the challenge value to generate the response sent by the peer. The format is one or more octets, preferably at least 16.
`chap_peer_name` *peername*	Specifies the identity of the peer transmitting the packet. The name should not be NULL or terminated with CR/LF. The name is received from the peer in a response packet and consists of one or more octets.
`will_do_authentication` *keywords*	Specifies whether the system is willing to participate as the authenticated peer in the specified authentication process. If both `pap` and `chap` are present, then the system is willing to participate in either authentication protocol. The default value is off.
`pap_id` *peername*	Specifies the name of the system to be sent to the authenticator in the response packet. To indicate a zero-length string, do not include the keyword.
`pap_password` *string*	Specifies the password for the system to be sent to the authenticator in the response packet. To indicate a zero-length string, do not include the keyword.
`chap_secret` *string*	Contains the secret that is used with the received challenge value to generate the response sent to the authenticator. The format is one or more octets, preferably at least 16.
`chap_name` *peername*	Specifies the identity of the system. The name should not end with a NULL or CR/LF. The name is sent to the authenticator in a response packet.

1. *Keyword* alternatives are: `off|pap[chap] | chap[pap]`
2. *peername* is the name of the system at the other end of the point-to-point link from the authenticator. It takes the form of a string with the syntax specified in Footnote 4.
3. Octet is the more accurate definition of byte.
4. *string* is a single token without embedded white space. The standard ANSI C \ escape sequence may be used to embed special characters. Use \s for the space character. Any pound sign at the beginning of the string must be escaped (\#) to avoid interpretation as a comment. A NULL (\0) truncates the string.

PAP/CHAP Examples

Example 11–4 shows the `asppp.cf` file for the server `mojave` with PAP and CHAP authentication required. The peers are `nomada` (PAP) and `nomadb` (CHAP).

EXAMPLE 11–4 Code Example for Server mojave

```
ifconfig ipdptp0 plumb mojave nomada up
ifconfig ipdptp1 plumb mojave nomanb up
path
      peer_system_name tamerlane
      require_authentication pap  #tells nomada that mojave
                                  #requires pap authentication
      pap_peer_id desert
      pap_peer_password oasis
path
      peer_system_name lawrence
      require_authentication chap  #tells nomadb that mojave
                                   #requires chap authentication
      chap_peer_name another\sdesert
      chap_peer_secret secret\soasis\swith\007bell
```

Example 11–5 sample shows mojave's remote host nomada offering to do both PAP and CHAP authentication.

EXAMPLE 11–5 Code Example for Remote Host nomada

```
ifconfig ipdptp0 plumb tamerlane mojave up
path
      interface ipdptp0
      peer_system_name mojave
      will_do_authentication chap pap #nomada tells mojave
                                      #that it will do chap and
                                      #pap authentication
      pap_id desert
      pap_password oasis
      chap_name desert\srain
      chap_secret %$#@7&*(+|‘P’12
```

Example 11–6 shows mojave's remote host nomadb offering to do CHAP authentication.

EXAMPLE 11–6 Code Example for Remote Host nomadb

```
ifconfig ipdptp0 plumb nomadb mojave private up
path
     interface ipdptp0
     peer_system_name mojave
     will_do_authentication chap   #nomadb tells mojave that it
                                   #will do chap authentication
     chap_name another\sdesert
```

(continued)

(Continuation)

```
chap_secret secret\soasis\swith\007bell
```

Ideally, both CHAP and PAP are included in the configuration file, with the server requiring authentication and the remote host willing to do authentication. However this is reversible so that either side can require authentication. CHAP secrets need to be delivered by secure means. This generally involves handing them over in person.

Configuration Keywords

This section describes the configuration keywords available for the `asppp.cf` configuration file and the values you must define for them. Most of these keywords are optional. The required ones are indicated. For further explanations of the keywords, refer to RFCs 1331, 1332, 1333, and 1334.

Table 11–4 lists required keywords that must appear in all `asppp.cf` configuration files.

TABLE 11–4 Required Keywords for `asppp.cf`

Keywords	Value Definitions
`ifconfig` *parameters*	Tells the link manager to run the `ifconfig` command with the values supplied by *parameters*. See "`ifconfig` Section of the `asppp.cf` File" on page 125, "`ifconfig` Section for Multipoint Dial-in Server" on page 128, and the **`ifconfig`**(1M) man page for more information.
`path`	Specifies the beginning of the token sequences that are grouped together as attributes of this (current) path. The collection of attributes comprising the current path are terminated by the occurrence of a subsequent `path` keyword, `defaults` keyword, or by the end–of–file character.

TABLE 11–4 Required Keywords for `asppp.cf` *(continued)*

Keywords	Value Definitions
`interface` (`ipdptp`*n*, `ipdptp*`, or `ipd`*n*)	Specifies either an `ipdptp` (static point-to-point), `ipdptp*` (dynamic point-to-point), or `ipd` (multipoint) device for each interface in your network. For `ipdptp`*n* and `ipd`*n*, this keyword associates the specific interface defined by *n* with the current path. *n* must be a non-negative integer. It matches the interface defined in the `path` section with the interface stated in the `ifconfig` section. For the `ipdptp*` interface, the * indicates that the interface will match any point-to-point interface that is configured as "down."
`peer_system_name` *hostname* `peer_system_name` *username*	On dial-out machines, specifies the *hostname* of the remote endpoint that the local machine wants to call. This is the same as the system name in the `/etc/uucp/Systems` file. Associates the remote system name with the current path. This name is used to look up modem- and peer-specific information for outbound connections in the `/etc/uucp/Systems` file. On dial-in machines, this specifies the *username* that remote machines use when logging in to the dial-in machine. The appropriate path is determined by matching *username* with the login name that was used to obtain the connection.
`peer_ip_address` *hostname* `peer_ip_address` *ip-address*	Specifies the destination host address. It is required only for multipoint links. This address is associated with the current path. The value is ignored if the path specifies a point-to-point interface. The address format can be dotted decimal, hexadecimal, or symbolic.

Table 11–5 contains optional keywords for `asppp.cf` that you can use to further define your PPP configuration.

TABLE 11–5 Optional Keywords for `asppp.cf`

Keywords	Value Definitions
`debug_level` *0–9*	The integer between 0–9 defines how much debugging information should be written to the log file. The higher the number, the more output is generated.
`defaults`	Indicates that all following token sequences up to the next `path` keyword, or the end-of-file character, set default attributes that affect subsequently defined paths.
`default_route`	Tells the link manager to add the path's peer IP address to the route table as the default destination when the IP layer corresponding to the current path is fully operational. The route is removed when the IP layer is brought down.

TABLE 11–5 Optional Keywords for `asppp.cf` *(continued)*

Keywords	Value Definitions
`inactivity_timeout` *seconds*	Specifies the maximum number of seconds that the connection for the current path can remain idle before it is terminated. A zero can be specified to indicate no timeout. The default is 120 seconds.
`ipcp_async_map` *hex-number*	Specifies the asynchronous control-character map for the current path. *hex-number* indicates the natural (big-endian) form of the four octets that comprise the map. The default value is `0x FFFFFFFF`.
`ipcp_compression` (vj or off)	Specifies whether IP compression is enabled. The Van Jacobson compression algorithm (vj) is the default.
`lcp_compression` (on or off)	Specifies whether PPP address, control, and protocol field compression is enabled. The default is on.
`lcp_mru` *number*	Specifies the value of the desired maximum receive unit packet size. The number is the size in octets. The default is 1500.
`negotiate_address` (on or off)	Indicates whether local IP address assignment is obtained through negotiation and assigned dynamically or not. If enabled, the local address is obtained from the remote end of the PPP link. If so obtained, any local address other than 0.0.0.0 can be used to initially configure the interface. The default is not to negotiate (off).
`peer_ip_address` *hostname* `peer_ip_address` *ip-address*	Specifies the destination host address. This keyword is optional for point-to-point links only. *address* is associated with the current path. The address format can be dotted decimal, hexadecimal, or symbolic.
`version` *n*	Specifies that the contents of the configuration file correspond to format version *n*. If this keyword is present, it must be the first keyword in the file. If absent, the version is assumed to be 1. This book contains the definition of the version 1 format for the configuration file.

PART III Administering UUCP Communications

The UUCP file transfer system enables you to send files and electronic mail from one UNIX-based system to another. This part explains how to administer the complex UUCP system.

The materials in this part assume that you are a very experienced network administrator with some practical knowledge of modem administration and wide-area networks. The text assumes that if you are going to use UUCP over a telephone line, you are familiar with the procedures for adding hardware to your computer, have already connected modems to your machines, and are able to use `tip` or `cu` to dial out.

CHAPTER 12

UUCP Databases and Programs

This chapter introduces the UUCP programs and daemons. It then provides complete information for setting up the UUCP database files as part of UUCP configuration. Chapter 13 explains how to configure UUCP after the databases have been created.

The UNIX-to-UNIX Copy Program (UUCP) enables computers to transfer files and exchange mail with each other. It also enables computers to participate in large networks such as Usenet.

The Solaris environment provides the Basic Network Utilities (BNU) version of UUCP, also known as HoneyDanBer UUCP. The term *UUCP* denotes the complete range of files and utilities that make up the system, of which the program `uucp` is only a part. The UUCP utilities range from those used to copy files between computers (`uucp` and `uuto`) to those used for remote login and command execution (`cu` and `uux`).

UUCP Hardware Configurations

UUCP supports the following hardware configurations:

- **Direct links** – You can create a direct link to another computer by running RS-232 cables between serial ports on the two machines. Direct links are useful where two computers communicate regularly and are physically close—within 50 feet of each other. You can use a limited distance–modem to increase this distance somewhat.
- **Telephone lines** – Using an automatic call unit (ACU), such as a high-speed modem, your machine can communicate with other computers over standard phone lines. The modem dials the telephone number requested by UUCP. The recipient machine must have a modem capable of answering incoming calls.
- **Network** – UUCP can also communicate over a network running TCP/IP or other protocol family. After your computer has been established as a host on a network, it can contact any other host connected to the network.

This chapter assumes that your UUCP hardware has already been assembled and configured. If you need to set up a modem, refer to *System Administration Guide, Volume I* and the manuals that came with the modem for assistance.

UUCP Software

The UUCP software is automatically included when you run the Solaris installation program and select the entire distribution. Alternatively, you can add it using `pkgadd`. The UUCP programs can be divided into three categories: daemons, administrative programs, and user programs.

Daemons

The UUCP system has four daemons: `uucico`, `uuxqt`, `uusched` and `in.uucpd`. These daemons handle UUCP file transfers and command executions. You can also run them manually from the shell, if necessary.

- `uucico` – Selects the device used for the link, establishes the link to the remote computer, performs the required login sequence and permission checks, transfers data and execute files, logs results, and notifies the user by mail of transfer completions. `uucico` acts as the "login shell" for UUCP login accounts. When the local `uucico` daemon calls a remote machine, it communicates directly with the remote `uucico` daemon during the session.

  `uucp`, `uuto`, and `uux` programs execute the `uucico` daemon after all the required files have been created, to contact the remote computer. `uusched` and `Uutry` all execute `uucico`. (See the **`uucico`**(1M) man page for details.)
- `uuxqt` – Executes remote execution requests. It searches the spool directory for execute files (always named `X.`*file*) that have been sent from a remote computer. When an `X.`*file* file is found, `uuxqt` opens it to get the list of data files that are

required for the execution. It then checks to see if the required data files are available and accessible. If the files are available, `uuxqt` checks the `Permissions` file to verify that it has permission to execute the requested command. The `uuxqt` daemon is executed by the `uudemon.hour` shell script, which is started by `cron`. (See the **`uuxqt`**(1M) man page for details.)

- `uusched` – Schedules the queued work in the spool directory. `uusched` is initially run at boot time by the `uudemon.hour` shell script, which is started by `cron`. (See the **`uusched`**(1M) man page for details.) Before starting the `uucico` daemon, `uusched` randomizes the order in which remote computers are called.
- `in.uucpd` – Supports UUCP connections over networks. The `inetd` on the remote host invokes `in.uucpd` whenever a UUCP connection is established. `uucpd` then prompts for a login name. `uucico` on the calling host must respond with a login name. `in.uucpd` then prompts for a password, unless one is not required. (See the **`in.uucpd`**(1M) man page for details.)

Administrative Programs

Most UUCP administrative programs are in `/usr/lib/uucp`. Most basic database files are in `/etc/uucp`. The only exception is `uulog`, which is in `/usr/bin`. The home directory of the `uucp` login ID is `/usr/lib/uucp`. When running the administrative programs through `su` or `login`, use the `uucp` user ID. It owns the programs and spooled data files.

- `uulog` – Displays the contents of a specified computer's log files. Log files are created for each remote computer with which your machine communicates. The log files record each use of `uucp`, `uuto`, and `uux`. (See the **`uucp`**(1C) man page for details.)
- `uucleanup` – Cleans up the spool directory. It is normally executed from the `uudemon.cleanup` shell script, which is started by `cron`. (See the **`uucleanup`**(1M) man page for details.)
- `Uutry` – Tests call-processing capabilities and does moderate debugging. It invokes the `uucico` daemon to establish a communication link between your machine and the remote computer you specify. (See the **`Uutry`**(1M) man page for details.)
- `uucheck` – Checks for the presence of UUCP directories, programs, and support files. It can also check certain parts of the `/etc/uucp/Permissions` file for obvious syntactic errors. (See the **`uucheck`**(1M) man page for details.)

User Programs

The UUCP user programs are in `/usr/bin`. You do not need special permission to use these programs.

- `cu` – Connects your machine to a remote computer so that you can log in to both at the same time. `cu` enables you to transfer files or execute commands on either machine without dropping the initial link. (See the **`cu`**(1C) man page for details.)
- `uucp` – Lets you copy a file from one machine to another. It creates work files and data files, queues the job for transfer, and calls the `uucico` daemon, which in turn attempts to contact the remote computer. (See the **`uucp`**(1C) man page for details.)
- `uuto` – Copies files from the local machine to the public spool directory `/var/spool/uucppublic/receive` on the remote machine. Unlike `uucp`, which lets you copy a file to any accessible directory on the remote machine, `uuto` places the file in an appropriate spool directory and tells the remote user to pick it up with `uupick`. (See the **`uuto`**(1C) man page for details.)
- `uupick` – Retrieves files in `/var/spool/uucppublic/receive` when files are transferred to a computer using `uuto`. (See the **`uuto`**(1C) man page.)
- `uux` – Creates the work, data, and execute files needed to execute commands on a remote machine. (See the **`uux`**(1C) man page for details.)
- `uustat` – Displays the status of requested transfers (`uucp`, `uuto`, or `uux`). It also provides a means of controlling queued transfers. (See the **`uustat`**(1C) man page for details.)

Introducing the UUCP Database Files

A major part of UUCP setup is the configuration of the files making up the UUCP database. These files are in the `/etc/uucp` directory. You need to edit them to set up UUCP or PPP on your machine. The files include:

- `Config` – Contains a list of variable parameters. You can manually set these parameters to configure the network.
- `Devconfig` – Used to configure network communications.
- `Devices` – Contains information concerning the location and line speed of automatic call unit (modem), direct links, and network devices. It is used by PPP as well as UUCP.
- `Dialers` – Contains character strings required to negotiate with modems to establish connections with remote computers. It is used by PPP as well as UUCP.
- `Dialcodes` – Contains dial-code abbreviations that can be used in the phone number field of `Systems` file entries. Though not required, it can be used by PPP as well as UUCP.
- `Grades` – Defines job grades, and the permissions associated with each job grade, that users can specify to queue jobs to a remote computer.

- `Limits` – Defines the maximum number of simultaneous `uucico`s, `uuxqt`s, and `uusched`s permitted on your machine.
- `Permissions` – Defines the level of access granted to remote hosts that attempt to transfer files or execute commands on your machine.
- `Poll` – Defines machines that are to be polled by your system and when they are polled.
- `Sysfiles` – Assigns different or multiple files to be used by `uucico` and `cu` as `Systems`, `Devices`, and `Dialers` files.
- `Sysname` – Enables you to define a unique UUCP name for a machine in addition to its TCP/IP host name.
- `Systems` – Contains information needed by the `uucico` daemon, `cu`, and PPP to establish a link to a remote computer. This information includes the name of the remote host, the name of the connecting device associated with the remote host, time when the host can be reached, telephone number, login ID, and password.

Several other files can be considered part of the supporting database but are not directly involved in establishing a link and transferring files.

Configuring UUCP Files

The UUCP database consists of the files shown in “Introducing the `UUCP` Database Files” on page 170. However, basic UUCP configuration involves only the following critical files:

- `/etc/uucp/Systems`
- `/etc/uucp/Devices`
- `/etc/uucp/Dialers`

Because PPP uses some of the UUCP databases, you should understand at least these critical database files if you plan to configure PPP. After these databases are configured, UUCP administration is fairly straightforward. Typically, you edit the `Systems` file first, then edit the `Devices` file. You can usually use the default `/etc/uucp/Dialers` file, unless you plan to add dialers that aren’t in the default file. In addition, you might also want to use the following files for basic UUCP and PPP configuration:

- `/etc/uucp/Sysfiles`
- `/etc/uucp/Dialcodes`
- `/etc/uucp/Sysname`

Because these files work closely with one another, you should understand the contents of them all before you change any one of them. A change to an entry in one file might require a change to a related entry in another file. The remaining files listed in “Introducing the `UUCP` Database Files” on page 170 are not as critically intertwined.

Note - PPP uses only the files described in this section. It does not use the other UUCP database files.

The rest of this chapter explains the UUCP databases in detail.

/etc/uucp/Systems File

The /etc/uucp/Systems file contains the information needed by the uucico daemon to establish a communication link to a remote computer. It is the first file you need to edit to configure UUCP.

Each entry in the Systems file represents a remote computer with which your host communicates. A particular host can have more than one entry. The additional entries represent alternative communication paths that are tried in sequential order. In addition, by default UUCP prevents any computer that does not appear in /etc/uucp/Systems from logging in to your host.

Using the Sysfiles file, you can define several files to be used as Systems files. See the description of the Sysfiles file for details.

Each entry in the Systems file has the following format:

System-Name	*Time*	*Type*	*Speed*	*Phone*	*Chat-Script*

Example 12–1 shows the fields of the Systems file.

EXAMPLE 12–1 Fields in /etc/uucp/Systems

```
System-Name Time Type  Speed Phone   Chat-Script
Arabian     Any  ACUEC 38400 111222  Login: Puucp ssword:beledi
```

System-Name Field

This field contains the node name of the remote computer. On TCP/IP networks, this can be the machine's host name or a name created specifically for UUCP communications through the /etc/uucp/Sysname file. See "/etc/uucp/Sysname File" on page 191. In Example 12–1, the System-Name field contains an entry for remote host arabian.

Time Field

This field specifies the day of week and time of day when the remote computer can be called. The format of the Time field is:

```
daytime[;retry]
```

The *day* portion can be a list containing some of the following entries:

TABLE 12–1 Day Field

`Su Mo Tu We Th Fr Sa`	For individual days
`Wk`	For any weekday
`Any`	For any day
`Never`	Your host never initiates a call to the remote computer; the call must be initiated by the remote computer. Your host is then operating in *passive mode*.

Example 12–1 shows `Any` in the Time field, indicating that host `arabian` can be called at any time.

The *time* portion should be a range of times specified in 24-hour notation. (Example: `0800-1230` for 8:30 a.m. to 12:30 p.m.) If no *time* portion is specified, any time of day is assumed to be allowed for the call.

A time range that spans 0000 is permitted. For example, `0800-0600` means all times are allowed other than times between 6 a.m. and 8 a.m.

Retry Subfield

The *Retry* subfield enables you to specify the minimum time (in minutes) before a retry, following a failed attempt. The default wait is 60 minutes. The subfield separator is a semicolon (;). For example, `Any;9` is interpreted as call any time, but wait at least 9 minutes before retrying after a failure occurs.

If you do not specify a *retry* entry, an exponential back-off algorithm is used. What this means is that UUCP starts with a default wait time that grows larger as the number of failed attempts increases. For example, suppose the initial retry time is 5 minutes. If there is no response, the next retry is 10 minutes later. The next retry is 20 minutes later, and so on until the maximum retry time of 23 hours is reached. If *retry* is specified, that is always the retry time. Otherwise, the back-off algorithm is used.

Type Field

This field contains the device type that should be used to establish the communication link to the remote computer. The keyword used in this field is matched against the first field of `Devices` file entries as shown in Example 12–2. (Note that the fields listed in the table heading are for the `Systems` file and do not apply to the `Devices` file. For a table showing the same correspondences to fields in the `Devices` file, see Example 12–6.)

EXAMPLE 12–2 Type Field and `/etc/uucp/Devices` File

```
File Name System-Name  Time  Type     Speed  Phone     Chap-Script

Systems   arabian      Any   ACUEC, g 38400  1112222   ogin: Puucp ssword:beledi

Device    ACUEC        cua/a -        38400  usrv32bis-ec
```

You can define the protocol used to contact the system by adding it on to the Type field. The example above shows how to attach the protocol `g` to the device type `ACUEC`. (For information on protocols, see “Protocol Definitions in the `Devices` File” on page 184.)

Speed Field

This field (also known as the Class field) specifies the transfer speed of the device used in establishing the communication link. It can contain a letter and speed (for example, `C1200`, `D1200`) to differentiate between classes of dialers (refer to “Class Field” on page 180).

Some devices can be used at any speed, so the keyword `Any` can be used. This field must match the Class field in the associated `Devices` file entry as shown in Example 12–3:

EXAMPLE 12–3 Speed Field and `/etc/uucp/Devices` File

```
File Name System-Name Time  Type    Speed  Phone   Chap-Script

Systems   eagle       Any   ACU, g  D1200  NY3251  ogin: nuucp ssword: Oakgrass

Device    ACU         tty11 --      D1200  penril
```

If information is not required for this field, use a dash (`-`) as a place holder for the field.

Phone Field

This field allows you to specify the telephone number (token) of the remote computer for automatic dialers (port selectors). The telephone number consists of an optional alphabetic abbreviation and a numeric part. If an abbreviation is used, it must be one that is listed in the `Dialcodes` file, as shown in Example 12–4:

EXAMPLE 12–4 Phone Field Correspondence

```
File Name System-Name  Time  Type  Speed  Phone     Chap-Script

Systems   nubian       Any   ACU   2400   NY5551212 ogin: Puucp ssword:Passuan

Dialcodes NY 1-1212
```

In the `System-Name` string, an equals sign (=) tells the ACU to wait for a secondary dial tone before dialing the remaining digits. A dash (-) in the string instructs the ACU to pause four seconds before dialing the next digit.

If your computer is connected to a port selector, you can access other computers connected to that selector. The `Systems` file entries for these remote machines should not have a telephone number in the Phone field. Instead, this field should contain the token to be passed on to the switch. In this way, the port selector knows the remote machine with which your host wants to communicate. (This is usually just the system name.) The associated `Devices` file entry should have a `\D` at the end of the entry to ensure that this field is not translated using the `Dialcodes` file.

Chat-Script Field

This field (also called the Login field) contains a string of characters called a *chat-script*. The chat-script contains the characters the local and remote machines must pass to each other in their initial conversation. Chat-scripts have the format:

expect send [expect send] ....

expect represents the string that the local host expects to get from the remote host to initiate conversation. *send* is the string the local host sends after it receives the *expect* string from the remote host. A chat-script can have more than one expect-send sequence.

A basic chat-script might contain:

- Login prompt that the local host expects to get from the remote machine
- Login name that the local host sends to the remote machine in order to log in
- Password prompt that the local host expects to get from the remote machine
- Password that the local host sends to the remote machine

The *expect* field can be made up of subfields of the form:

expect[-send-expect]...

where *-send* is sent if the prior *expect* is not successfully read, and *-expect* following the *send* is the next expected string.

For example, with strings `login--login`, the UUCP on the local host expects `login`. If UUCP gets `login` from the remote machine, it goes to the next field. If it does not get `login`, it sends a carriage return, then looks for `login` again. If the local computer initially does not expect any characters, use the characters `""` (NULL string) in the *expect* field. All *send* fields are sent followed by a carriage-return unless the *send* string is terminated with a `\c`.

Here is an example of a `Systems` file entry that uses an *expect-send* string:

```
sonora Any ACUEC 9600 2223333 "" \r \r ogin:-BREAK-ogin: Puucpx ssword: xyzzy
```

This example tells UUCP on the local host to send two carriage-returns and wait for `ogin:` (for `Login:`). If `ogin:` is not received, send a `BREAK`. When you do get `ogin:` send the login name `Puucpx`. When you get `ssword:` (for `Password:`), send the password `xyzzy`.

Table 12–2 lists some useful escape characters.

TABLE 12–2 Escape Characters Used in `Systems` File Chat-Script

`\b`	Send or expect a backspace character.
`\c`	If at the end of a string, suppress the carriage return that is normally sent. Ignored otherwise.
`\d`	Delay 1–3 seconds before sending more characters.
`\E`	Start echo checking. (From this point on, whenever a character is transmitted, it waits for the character to be received before doing anything else.)
`\e`	Echo check-off.
`\H`	Ignore one hangup. Use this option for dialback modems.
`\K`	Send a BREAK character.
`\M`	Turn on `CLOCAL` flag.
`\m`	Turn off `CLOCAL` flag.
`\n`	Send or expect a newline character.

TABLE 12–2 Escape Characters Used in `Systems` File Chat-Script *(continued)*

`\N`	Send a NULL character (ASCII NUL).
`\p`	Pause for approximately 1/4 to 1/2 second.
`\r`	Send or expect a carriage return.
`\s`	Send or expect a space character.
`\t`	Send or expect a tab character.
`EOT`	Send an EOT followed by newline twice.
`BREAK`	Send a break character.
`\`*ddd*	Send or expect the character represented by the octal digits (*ddd*).

Enabling Dialback Through the Chat-Script

Some companies set up dial-in servers to handle calls from remote computers. For example, your company might have a dial-in server with a dialback modem that employees can call from their home computers. After the dial-in server identifies the remote machine, it disconnects the link to the remote machine and then calls the remote machine back. The communications link is then reestablished.

You can facilitate dialback by using the `\H` option in the `Systems` file chat-script at the place where dialback should occur. Include the `\H` as part of an expect string at the place where the dial-in server is expected to hang up.

For example, suppose the chat-script that calls a dial-in server contains the following string:

```
INITIATED\Hogin:
```

The UUCP dialing facility on the local machine expects to get the characters `INITIATED` from the dial-in server. After the `INITIATED` characters have been matched, the dialing facility flushes any subsequent characters it receives until the dial-in server hangs up. The local dialing facility then waits until it receives the next part of the expect string, the characters `ogin:`, from the dial-in server. When it receives the `ogin:`, the dialing facility then continues through the chat-script.

You need not have a string of characters directly preceding or following the `\H`, as shown in the sample string above.

Hardware Flow Control

You can also use the pseudo-send `STTY=value` string to set modem characteristics. For instance, `STTY=crtscts` enables hardware flow control. `STTY` accepts all `stty` modes. See the **`stty`**(1) and **`termio`**(7I) man pages for complete details.

The following example would enable hardware flow control in a `Systems` file entry:

```
unix Any ACU 2400 12015551212 "" \r login:-\r-login:-\r-login:
nuucp password: xxx "" \ STTY=crtscts
```

This pseudo-send string can also be used in entries in the `Dialers` file.

Setting Parity

In some cases, you have to reset the parity because the system that you are calling checks port parity and drops the line if it is wrong. The expect-send couplet `""` `P_ZERO` sets the high-order bit (parity bit) to 0. For example:

```
unix Any ACU 2400 12015551212 "" P_ZERO "" \r login:-\r-login:-\r-login:
nuucp password: xxx
```

In the same manner, `P_EVEN` sets parity to even (the default), `P_ODD` sets odd parity, and `P_ONE` sets the parity bit to 1.

The parity couplet can be inserted anywhere in the chat-script. It applies to all information in the chat-script following the `""` `P_ZERO`. It can also be used in entries in the `Dialers` file.

`/etc/uucp/Devices` File

The `/etc/uucp/Devices` file contains information for all the devices that can be used to establish a link to a remote computer. These devices include ACUs—which includes modern, high-speed modems—direct links, and network connections.

Each entry in the `Devices` file has the following format:

Type	*Line*	*Line2*	*Class*	*Dialer-Token-Pairs*

Here is an entry in `/etc/uucp/Devices` for a US Robotics V.32bis modem attached to port A and running at 38,400 bps.

```
ACUEC cua/a - 38400 usrv32bis-ec
```

Each field is described below.

Type Field

This field describes the type of link that the device establishes. It can contain one of the keywords described in the sections that follow:

`Direct` Keyword

The `Direct` keyword appears mainly in entries for `cu` connections. This keyword indicates that the link is a direct link to another computer or a port selector. Make a separate entry for each line that you want to reference through the `-l` option of `cu`.

`ACU` Keyword

The `ACU` keyword indicates that the link to a remote computer (whether through `cu`, UUCP, or PPP) is made through a modem. This modem can be connected either directly to your computer or indirectly through a port selector.

Port Selector

This is a variable that is replaced in the Type field by the name of a port selector. Port selectors are devices attached to a network that prompt for the name of a calling modem, then grant access. The file `/etc/uucp/Dialers` contains caller scripts only for the `micom` and `develcon` port selectors. You can add your own port selector entries to the `Dialers` file. (See “`/etc/uucp/Dialers` File” on page 185 for more information.)

Sys-Name

This variable is replaced by the name of a machine in the Type field, indicating that the link is a direct link to this particular computer. This naming scheme is used to associate the line in this `Devices` entry to an entry in `/etc/uucp/Systems` for the computer *Sys-Name*.

Type Field and /etc/uucp/Systems File

Example 12–5 shows a comparison between the fields in /etc/uucp/Devices and fields in /etc/uucp/Systems. The titles of each column apply only to fields in the Devices file.

The keyword used in the Type field of the Devices file is matched against the third field of the Systems file entries, as indicated in Example 12–5. In the Devices file, the Type field has the entry ACUEC, indicating an automatic call unit, in this case a V.32bis modem. This value is matched against the third field in the Systems file, which also contains the entry ACUEC. (See "/etc/uucp/Systems File" on page 172 for more information.)

EXAMPLE 12–5 Type Field and /etc/uucp/Systems File Equivalent

```
File Name Type   Line  Line2 Class Dialer-Token-Pairs

Devices   ACUEC  cua/a -     38400 usrv32bis-ec

System    nubian Any   ACUEC 38400 9998888 '''' \d\d\r\n\c-ogin-\r\n\c-
ogin.......
```

Line Field

This field contains the device name of the line (port) associated with the Devices entry. For instance, if the modem associated with a particular entry were attached to the /dev/cua/a device (serial port A), the name entered in this field would be cua/a. There is an optional modem control flag, M, that can be used in the Line field to indicate that the device should be opened without waiting for a carrier. For example:

```
cua/a,M
```

Line2 Field

This field is a placeholder. Always use a dash (-) here. 801 type dialers, which are not supported in the Solaris environment, use the Line2 field. Non-801 dialers do not normally use this configuration, but still require a hyphen in this field.

Class Field

The Class field contains the speed of the device, if the keyword ACU or Direct is used in the Type field. However, it can contain a letter and a speed (for example, C1200, D1200) to differentiate between classes of dialers (Centrex or Dimension PBX).

This is necessary because many larger offices can have more than one type of telephone network: one network might be dedicated to serving only internal office communications while another handles the external communications. In such a case, it becomes necessary to distinguish which line(s) should be used for internal communications and which should be used for external communications.

The keyword used in the Class field of the `Devices` file is matched against the Speed field of `Systems` file as shown in Example 12–6. Note that the titles of each column apply only to fields in the `Devices` file.

EXAMPLE 12–6 Class Field and `/etc/uucp/Systems` Correspondence

```
File Name  Type   Line  Line2  Class  Dialer-Token-Pairs

Devices    ACU    cua/a -      D2400  hayes

System     gobi   Any   ACUEC  D2400  3251 ogin: nuucp ssword: taheya
```

Some devices can be used at any speed, so the keyword `Any` can be used in the Class field. If `Any` is used, the line matches any speed requested in the Speed field of the `Systems` file. If this field is `Any` and the `Systems` file Speed field is `Any`, the speed defaults to 2400 bps.

Dialer-Token-Pairs Field

The Dialer-Token-Pairs (DTP) field contains the name of a dialer and the token to pass it. The DTP field has this syntax:

dialer token [dialer token]

The *dialer* portion can be the name of a modem, a port monitor, or it can be `direct` or `uudirect` for a direct-link device. You can have any number of dialer-token pairs; if not present, it is taken from a related entry in the `Systems` file. The *token* portion can be supplied immediately following the dialer portion.

The last dialer token pair might not be present, depending on the associated dialer. In most cases, the last pair contains only a *dialer* portion. The *token* portion is retrieved from the Phone field of the associated `Systems` file entry.

A valid entry in the *dialer* portion can be defined in the `Dialers` file or can be one of several special dialer types. These special dialer types are compiled into the software and are therefore available without having entries in the `Dialers` file. Table 12–3 shows the special dialer types which include:

TABLE 12–3 Dialer-Token Pairs

TCP	TCP/IP network
TLI	Transport Level Interface Network (without STREAMS)
TLIS	Transport Level Interface Network (with STREAMS)

See "Protocol Definitions in the Devices File" on page 184 for more information.

Structure of the Dialer-Token-Pairs Field

The DTP field can be structured four different ways, depending on the device associated with the entry:

- Directly connected modem

  If a modem is connected directly to a port on your computer, the DTP field of the associated Devices file entry has only one pair. This pair would normally be the name of the modem. This name is used to match the particular Devices file entry with an entry in the Dialers file. Therefore, the Dialer field must match the first field of a Dialers file entry as shown in Example 12–7. (The titles of each column apply only to fields in the Devices file.)

EXAMPLE 12–7 Dialers Field and /etc/uucp/Dialers Correspondence

```
File Name Type  Line  Line2 Class Dialer-Token-Pairs

Devices   ACU   cua/b -     2400  hayes

Dialers   hayes =,-,  ""          \\dA\pTE1V1X1Q0S2=255S12=255\r\c
                                  \EATDT\T\r\c CONNECT
```

Notice that only the dialer portion (hayes) is present in the DTP field of the Devices file entry. This means that the *token* to be passed on to the dialer (in this case the phone number) is taken from the Phone field of a Systems file entry. (\T is implied, as described in Example 12–9.)

- Direct link – For a direct link to a particular computer, the DTP field of the associated entry would contain the keyword direct. This is true for both types of direct-link entries, Direct and *Sys-Name* (refer to "Type Field" on page 179).
- Computers on the same port selector – If a computer with which you want to communicate is on the same port selector switch as your computer, your computer must first access the switch. The switch then makes the connection to the other computer. This type of entry has only one pair. The *dialer* portion is used to match

a `Dialers` file entry as shown in Example 12–8. (The titles of each column apply only to fields in the `Devices` file.)

EXAMPLE 12–8 Dialers Field and `/etc/uucp/Dialers` Correspondence

```
File Name  Type     Line  Line2  Class  Dialer-Token-Pairs

Devices    develcon cua/a -      1200   develcon

Dialers    develcon ,""   ""            \pr\ps\c est:\007 \E\D\e \007
```

As shown, the *token* portion is left blank. This indicates that it is retrieved from the `Systems` file. The `Systems` file entry for this computer contains the token in the Phone field, which is normally reserved for the phone number of the computer. (Refer to "`/etc/uucp/Systems` File" on page 172.) This type of DTP contains an escape character (`\D`), which ensures that the contents of the Phone field not interpreted as a valid entry in the `Dialcodes` file.

- Modems connected to port selector – If a high-speed modem is connected to a port selector, your computer must first access the port selector switch. The switch makes the connection to the modem. This type of entry requires two dialer-token-pairs. The *dialer* portion of each pair (fifth and seventh fields of entry) is used to match entries in the `Dialers` file, as shown in Example 12–7. (Notice that the titles of each column apply only to fields in the `Devices` file.)

EXAMPLE 12–9 Dialers Field and `/etc/uucp/Dialers` Correspondence

```
File Name  Type     Line  Line2  Class     Dialer-Token-Pairs

Devices    ACU      cua/b -      1200      develcon    vent        ventel

Dialers    develcon ""    ""     \pr\ps\c  est:\007    \E\D\e      \007

Dialers    ventel   =&-%   t""   \r\p\r\c  $           <K\T%\r>\c  ONLINE!
```

In the first pair, `develcon` is the dialer and `vent` is the token that is passed to the Develcon switch to tell it which device (such as Ventel modem) to connect to your computer. This token is unique for each port selector since each switch can be set up differently. After the Ventel modem has been connected, the second pair is accessed, where Ventel is the dialer and the token is retrieved from the `Systems` file.

Two escape characters can appear in a DTP field:

- `\T` – Indicates that the Phone (*token*) field should be translated using the `/etc/uucp/Dialcodes` file. This escape character is normally placed in the `/etc/uucp/Dialers` file for each caller script associated with a modem (Hayes,

US Robotics, and so on). Therefore, the translation does not take place until the caller script is accessed.

- `\D` – Indicates that the Phone (*token*) field should not be translated using the `/etc/uucp/Dialcodes` file. If no escape character is specified at the end of a `Devices` entry, the `\D` is assumed (default). A `\D` is also used in the `/etc/uucp/Dialers` file with entries associated with network switches (`develcon` and `micom`).

Protocol Definitions in the `Devices` File

You can define the protocol to use with each device in `/etc/uucp/Devices`. This is usually unnecessary because you can use the default or define the protocol with the particular system you are calling. (Refer to "`/etc/uucp/Systems` File" on page 172.) If you do specify the protocol, you must use the form:

Type,Protocol [parameters]

For example, you can use `TCP,te` to specify the TCP/IP protocol.

Table 12–4 shows the available protocols for the `Devices` file:

TABLE 12–4 Protocols Used in `/etc/uucp/Devices`

Protocol	Description
`t`	This protocol is commonly used for transmissions over TCP/IP and other reliable connections. It assumes error-free transmissions.
`g`	This is UUCP's native protocol. It is slow, reliable, and good for transmission over noisy telephone lines.
`e`	This protocol assumes transmission over error-free channels that are message-oriented (as opposed to byte-stream–oriented, like TCP/IP).
`f`	This protocol is used for transmission over X.25 connections. It relies on flow control of the data stream, and is meant for working over links that can (almost) be guaranteed to be error-free, specifically X.25/PAD links. A checksum is carried out over a whole file only. If a transport fails, the receiver can request retransmission(s).

Here is an example showing a protocol designation for a device entry:

```
TCP,te - - Any TCP -
```

This example indicates that, for device TCP, try to use the t protocol. If the other end refuses, use the e protocol.

Neither e nor t is appropriate for use over modems. Even if the modem assures error-free transmission, data can still be dropped between the modem and the CPU.

/etc/uucp/Dialers File

The /etc/uucp/Dialers file contains dialing instructions for many commonly used modems. You probably do not need to change or add entries to this file unless you plan to use a nonstandard modem or plan to customize your UUCP environment. Nevertheless, you should understand what is in the file and how it relates to the Systems and Devices file.

The text specifies the initial conversation that must take place on a line before it can be made available for transferring data. This conversation, often referred to as a chat-script, is usually a sequence of ASCII strings that is transmitted and expected, and it is often used to dial a phone number.

As shown in the examples in "/etc/uucp/Devices File" on page 178 the fifth field in a Devices file entry is an index into the Dialers file or a special dialer type (TCP, TLI, or TLIS). The uucico daemon attempts to match the fifth field in the Devices file with the first field of each Dialers file entry. In addition, each odd-numbered Devices field, starting with the seventh position is used as an index into the Dialers file. If the match succeeds, the Dialers entry is interpreted to perform the dialer conversation.

Each entry in the Dialers file has the following format:

dialer	*substitutions*	*expect-send*

Example 12–10 shows the entry for a US Robotics V.32bis modem.

EXAMPLE 12–10 /etc/uucp/Dialers File Entry

```
Dialer       Substitution  Expaec-Send
usrv32bis-e  =,-,  ""      dA\pT&FE1V1X1Q0S2=255S12=255&A1&H1&M5&B2&W\r\c OK\r
                           \EATDT\T\r\c CONNECT\s14400/ARQ STTY=crtscts
```

The Dialer field matches the fifth and additional odd-numbered fields in the Devices file. The Substitutions field is a translate string: the first of each pair of characters is

mapped to the second character in the pair. This is usually used to translate = and - into whatever the dialer requires for “wait for dial tone” and “pause.”

The remaining expect-send fields are character strings.

Example 12–11 shows some sample entries in the `Dialers` file, as distributed when you install UUCP as part of the Solaris installation program.

EXAMPLE 12–11 Excerpts From `/etc/uucp/Dialers`

```
penril =W-P "" \d > Q\c : \d- > s\p9\c )-W\p\r\ds\p9\c-) y\c : \E\TP > 9\c OK

ventel =&-% "" \r\p\r\c $ <K\T%%\r>\c ONLINE!

vadic =K-K "" \005\p *-\005\p-*\005\p-* D\p BER? \E\T\e \r\c LINE

develcon "" "" \pr\ps\c est:\007

\E\D\e \n\007 micom "" "" \s\c NAME? \D\r\c GO

hayes =,-, "" \dA\pTE1V1X1Q0S2=255S12=255\r\c OK\r \EATDT\T\r\c CONNECT

#   Telebit TrailBlazer
tb1200 =W-, "" \dA\pA\pA\pTE1V1X1Q0S2=255S12=255S50=2\r\c OK\r \EATDT\T\r\c CONNECT\s1200
tb2400 =W-, "" \dA\pA\pA\pTE1V1X1Q0S2=255S12=255S50=3\r\c OK\r \EATDT\T\r\c CONNECT\s2400
tbfast =W-, "" \dA\pA\pA\pTE1V1X1Q0S2=255S12=255S50=255\r\c OK\r \EATDT\T\r\c CONNECT\sFAST

# USrobotics, Codes, and DSI modems

dsi-ec  =,-,    "" \dA\pTE1V1X5Q0S2=255S12=255*E1*F3*M1*S1\r\c OK\r \EATDT\T\r\c
CONNECT\sEC STTY=crtscts,crtsxoff

dsi-nec =,-,    "" \dA\pTE1V1X5Q0S2=255S12=255*E0*F3*M1*S1\r\c OK\r \EATDT\T\r\c CONNECT
STTY=crtscts,crtsxoff

usrv32bis-ec =,-,  "" \dA\pT&FE1V1X1Q0S2=255S12=255&A1&H1&M5&B2&W\r\c OK\r \EATDT\T\r\c
CONNECT\s14400/ARQ STTY=crtscts,crtsxoff

usrv32-nec =,-, "" \dA\pT&FE1V1X1Q0S2=255S12=255&A0&H1&M0&B0&W\r\c OK\r \EATDT\T\r\c
CONNECT STTY=crtscts,crtsxoff

codex-fast =,-, "" \dA\pT&C1&D2*MF0*AA1&R1&S1*DE15*FL3S2=255S7=40S10=40*TT5&W\r\c OK\r
\EATDT\T\r\c CONNECT\s38400 STTY=crtscts,crtsxoff

tb9600-ec =W-,  "" \dA\pA\pA\pTE1V1X1Q0S2=255S12=255S50=6\r\c OK\r
\EATDT\T\r\cCONNECT\s9600 STTY=crtscts,crtsxoff

tb9600-nec =W-, "" \dA\pA\pA\pTE1V1X1Q0S2=255S12=255S50=6S180=0\r\c OK\r \EATDT\T\r\c
CONNECT\s9600 STTY=crtscts,crtsxoff
```

Table 12–5 lists escape characters commonly used in the send strings in the `Dialers` file:

TABLE 12–5 Backslash Characters for `/etc/uucp/Dialers`

Character	Description
`\b`	Send or expect a backspace character
`\c`	No newline or carriage return
`\d`	Delay (approximately 2 seconds)
`\D`	Phone number or token without `Dialcodes` translation
`\e`	Disable echo checking
`\E`	Enable echo checking (for slow devices)
`\K`	Insert a Break character
`\n`	Send newline
`\nnn`	Send octal number. Additional escape characters that can be used are listed in the section "`/etc/uucp/Systems` File" on page 172.
`\N`	Send or expect a NULL character (ASCII NUL)
`\p`	Pause (approximately 12–14 seconds)
`\r`	Return.
`\s`	Send or expect a space character
`\T`	Phone number or token with `Dialcodes` translation

Here is a `penril` entry in the `Dialers` file:

```
penril =W-P "" \d > Q\c : \d- > s\p9\c )-W\p\r\ds\p9\c-) y\c : \E\TP > 9\c OK
```

First, the substitution mechanism for the phone number argument is established, so that any `=` is replaced with a `W` (wait for dial tone) and any `-` with a `P` (pause).

The handshake given by the remainder of the line works as listed:

- `""` – Wait for nothing. (that is, proceed to the next thing)
- `\d` – Delay 2 seconds, then send a carriage-return

- `>` – Wait for a `>`
- `Q\c` – Send a `Q` without a carriage-return
- `:` – Expect a `:`
- `\d-` – Delay 2 seconds, send a `-` and a carriage-return
- `>` – Wait for a `>`
- `s\p9\c` – Send an `s`, pause, send a `9` with no carriage-return
- `)-W\p\r\ds\p9\c-)` – Wait for a `)`. If it is not received, process the string between the `-` characters as follows. Send a `W`, pause, send a carriage-return, delay, send an `s`, pause, send a `9`, without a carriage-return, then wait for the `)`.
- `y\c` – Send a `y` with no carriage-return
- `:` – Wait for a `:`
- `\E\TP` - Enable echo checking. (From this point on, whenever a character is transmitted, it waits for the character to be received before doing anything else.) Then, send the phone number. The `\T` means take the phone number passed as an argument and apply the `Dialcodes` translation and the modem function translation specified by field 2 of this entry. Then send a `P` and a carriage-return.
- `>` – Wait for a `>`
- `9\c` – Send a `9` without a newline
- `OK` – Wait for the string `OK`

Hardware Flow Control

You can also use the pseudo-send `STTY=value` string to set modem characteristics. For instance, `STTY=crtscts` enables outbound hardware flow control, `STTY=crtsxoff` enables inbound hardware flow control, and `STTY=crtscts,crtsxoff` enables both outbound and inbound hardware flow control.

`STTY` accepts all the `stty` modes. See the **`stty`**(1) and **`termio`**(7I) man pages.

The following example would enable hardware flow control in a `Dialers` entry:

```
dsi =,--, "" \dA\pTE1V1X5Q0S2=255S12=255*E1*F3*M1*S1\r\c OK\r \EATDT\T\r\c
CONNECT\sEC STTY=crtscts
```

This pseudo-send string can also be used in entries in the `Systems` file.

Setting Parity

In some cases, you have to reset the parity because the system that you are calling checks port parity and drops the line if it is wrong. The expect-send couplet ~~ P_ZERO sets parity to zero:

```
foo =,-, "" P_ZERO "" \dA\pTE1V1X1Q0S2=255S12=255\r\c OK\r\EATDT\T\r\c CONNECT
```

In the same manner, P_EVEN sets it to even (the default); P_ODD sets it to odd; and P_ONE sets it to one. This pseudo-send string can also be used in entries in the Systems file.

Other Basic Configuration Files

The files in this section can be used in addition to the Systems, Devices, and Dialers file when doing basic UUCP configuration.

/etc/uucp/Dialcodes File

The /etc/uucp/Dialcodes file enables you to define dial-code abbreviations that can be used in the Phone field in the /etc/uucp/Systems file. You can use the Dialcodes files to provide additional information about a basic phone number that is used by several systems at the same site.

Each entry has the format:

abbreviation dial-sequence

where *abbreviation* represents the abbreviation used in the Phone field of the Systems file and *dial-sequence* represents the dial sequence passed to the dialer when that particular Systems file entry is accessed. Table 12–6 shows the correspondences between the two files.

TABLE 12–6 Correspondences between Dialcodes and Systems Files

	Field Names					
Dialcodes	*Abbreviation*	Dial-Sequence				
Systems	System-Name	Time	Type	Speed	*Phone*	Chat-Script

Table 12–7 contains sample entries in a Dialcodes file.

TABLE 12–7 Entries in the Dialcodes File

Abbreviation	Dial-sequence
NY	1=212
jt	9+847

In the first row, NY is the abbreviation to appear in the Phone field of the Systems file. For example, the Systems file might have the entry:

```
NY5551212
```

When uucico reads NY in the Systems file, it searches the Dialcodes file for NY and obtains the dialing sequence 1=212. This is the dialing sequence needed for any phone call to New York City. It includes the number 1, an equal sign (=) meaning pause and wait for a secondary dial tone, and the area code 212. uucico sends this information to the dialer, then returns to the Systems file for the remainder of the phone number, 5551212.

The entry jt 9=847- would work with a Phone field in the Systems file such as jt7867. When uucico reads the entry containing jt7867 in the Systems file, it sends the sequence 9=847-7867 to the dialer, if the token in the dialer-token pair is \T.

/etc/uucp/Sysfiles File

The /etc/uucp/Sysfiles file lets you assign different files to be used by uucp and cu as Systems, Devices, and Dialers files. (For more information on cu, see the **cu**(1C) man page.) You might want to use Sysfiles for:

- Different Systems files, so that requests for login services can be made to different addresses than uucp services.
- Different Dialers files, so that you can assign different handshaking for cu and uucp.
- Multiple Systems, Dialers, and Devices files. The Systems file in particular can become large, making it more convenient to split it into several smaller files.

The format of the Sysfiles file is:

```
service=w systems=x:x dialers=y:y devices=z:z
```

w represents uucico, cu, or both separated by a colon. *x* represents one or more files to be used as the Systems file, with each file name separated by a colon and read in the order presented. *y* represents one or more files to be used as the Dialers file. *z* is one or more files to be used as the Devices file.

Each file name is assumed to be relative to the /etc/uucp directory, unless a full path is given.

Below is a sample /etc/uucp/Sysfiles that defines a local Systems file (Local_Systems) in addition to the standard /etc/uucp/Systems file:

```
service=uucico:cu systems=Systems :Local_Systems
```

When this entry is in /etc/uucp/Sysfiles, both uucico and cu first look in the standard /etc/uucp/Systems. If the system they are trying to call doesn't have an entry in that file, or if the entries in the file fail, then they look in /etc/uucp/Local_Systems.

Given the above entry, cu and uucico share the Dialers and Devices files.

When different Systems files are defined for uucico and cu services, your machine stores two different lists of Systems. You can print the uucico list using the uuname command or the cu list using the uuname –C command. Another example of the file, where the alternate files are consulted first and the default files are consulted in case of need is:

```
service=uucico systems=Systems.cico:Systems
  dialers=Dialers.cico:Dialers \
devices=Devices.cico:Devices
  service=cu systems=Systems.cu:Systems \
dialers=Dialers.cu:Dialers \
  devices=Devices.cu:Devices
```

/etc/uucp/Sysname File

Every machine that uses UUCP must have an identifying name, often referred to as the *node name*. This is the name that appears in the remote machine's /etc/uucp/Systems file along with the chat-script and other identifying information. Normally, UUCP uses the same node name as is returned by the uname -n command, which is also used by TCP/IP.

You can specify a UUCP node name independent of the TCP/IP host name by creating the /etc/uucp/Sysname file. The file has a one-line entry containing the UUCP node name for your system.

/etc/uucp/Permissions File

The /etc/uucp/Permissions file specifies the permissions that remote computers have with respect to login, file access, and command execution. There are options that restrict the remote computer's ability to request files and its ability to receive files queued by the local machine. Another option is available that specifies the commands that a remote machine can execute on the local computer.

Structuring Entries

Each entry is a logical line, with physical lines terminated by a backslash (\) to indicate continuation. Entries are made up of options delimited by blank space. Each option is a name-value pair in the following format:

name=value

Values can be colon-separated lists. No blank space is allowed within an option assignment.

Comment lines begin with a pound sign (#), and they occupy the entire line up to a newline character. Blank lines are ignored (even within multiple-line entries).

There types of Permissions file entries are:

- LOGNAME – Specifies the permissions that take effect when a remote computer logs in to (calls) your computer.

Note - When a remote machine calls you, its identity is questionable unless it has a unique login and verifiable password.

- MACHINE – Specifies permissions that take effect when your computer logs in to (calls) a remote computer.

LOGNAME entries contain a LOGNAME option and MACHINE entries contain a MACHINE option. One entry can contain both options.

Considerations

When using the Permissions file to restrict the level of access granted to remote computers, you should consider the following:

- All login IDs used by remote computers to log in for UUCP communications must appear in one and only one LOGNAME entry.
- Any site that is called whose name does not appear in a MACHINE entry, has the following default permissions or restrictions:

- Local send and receive requests are executed.
- The remote computer can send files to your computer's `/var/spool/uucppublic` directory.
- The commands sent by the remote computer for execution on your computer must be one of the default commands, usually `rmail`.

REQUEST Option

When a remote computer calls your computer and requests to receive a file, this request can be granted or denied. The `REQUEST` option specifies whether the remote computer can request to set up file transfers from your computer. The string `REQUEST=yes` specifies that the remote computer can request to transfer files from your computer. The string `REQUEST=no` specifies that the remote computer cannot request to receive files from your computer. This is the default value; it is used if the `REQUEST` option is not specified. The `REQUEST` option can appear in either a `LOGNAME` (remote computer calls you) entry or a `MACHINE` (you call remote computer) entry.

SENDFILES Option

When a remote computer calls your computer and completes its work, it can attempt to take work your computer has queued for it. The `SENDFILES` option specifies whether your computer can send the work queued for the remote computer.

The string `SENDFILES=yes` specifies that your computer can send the work that is queued for the remote computer as long as itis logged in as one of the names in the `LOGNAME` option. This string is *mandatory* if you have entered `Never` in the Time field of `/etc/uucp/Systems`. This designation sets up your local machine in passive mode; it is not allowed to initiate a call to this particular remote computer. (See "`/etc/uucp/Systems` File" on page 172 for more information.)

The string `SENDFILES=call` specifies that files queued in your computer are sent only when your computer calls the remote computer. The `call` value is the default for the `SENDFILES` option. This option is only significant in `LOGNAME` entries since `MACHINE` entries apply when calls are made out to remote computers. If the option is used with a `MACHINE` entry, it is ignored.

MYNAME Option

This option enables you to designate a unique UUCP node name for your computer in addition to its TCP/IP host name, as returned by the `hostname` command. For instance, if you have unknowingly given your host the same name as that of some other system, you might want to set the `MYNAME` option of the `Permissions` file. Or

if you want your organization to be known as `widget` but all your modems are connected to a machine with the host name `gadget`, you can have an entry in `gadget`'s `Permissions` file that says:

```
service=uucico systems=Systems.cico:Systems
  dialers=Dialers.cico:Dialers \
  devices=Devices.cico:Devices
service=cu systems=Systems.cu:Systems \
  dialers=Dialers.cu:Dialers \
  devices=Devices.cu:Devices
```

Now the system `world` can log in to the machine `gadget` as if it were logging in to `widget`. In order for machine `world` to know you also by the aliased name `widget` when you call it, you can have an entry that says:

```
MACHINE=world MYNAME=widget
```

You can also use the `MYNAME` option for testing purposes, since it allows your machine to call itself. However, since this option could be used to mask the real identity of a machine, you should use the `VALIDATE` option, as described in "`VALIDATE` Option" on page 197.

`READ` and `WRITE` Options

These options specify the various parts of the file system that `uucico` can read from or write to. You can designate `READ` and `WRITE` options with either `MACHINE` or `LOGNAME` entries.

The default for both the `READ` and `WRITE` options is the `uucppublic` directory, as shown in the following strings:

```
READ=/var/spool/uucppublic WRITE=/var/spool/uucppublic
```

The strings `READ=/` and `WRITE=/` specify permission to access any file that can be accessed by a local user with Other permissions.

The value of these entries is a colon-separated list of path names. The `READ` option is for requesting files, and the `WRITE` option is for depositing files. One of the values must be the prefix of any full path name of a file coming in or going out. To grant permission to deposit files in `/usr/news` as well as the public directory, use the following values with the `WRITE` option:

```
WRITE=/var/spool/uucppublic:/usr/news
```

If the `READ` and `WRITE` options are used, all path names must be specified because the path names are not added to the default list. For instance, if the `/usr/news` path

name were the only one specified in a WRITE option, permission to deposit files in the public directory would be denied.

You should be careful which directories you make accessible for reading and writing by remote systems. For example, the /etc directory contains many critical system files; remote users should not have permission to deposit files in this directory.

NOREAD and NOWRITE Options

The NOREAD and NOWRITE options specify exceptions to the READ and WRITE options or defaults. The entry:

```
READ=/ NOREAD=/etc WRITE=/var/spool/uucppublic
```

permits reading any file except those in the /etc directory (and its subdirectories—remember, these are prefixes). It permits writing only to the default /var/spool/uucppublic directory. NOWRITE works in the same manner as the NOREAD option. You can use the NOREAD and NOWRITE options in both LOGNAME and MACHINE entries.

CALLBACK Option

You can use the CALLBACK option in LOGNAME entries to specify that no transaction takes place until the calling system is called back. There are two reasons to set up CALLBACK: For security purposes, if you call back a machine, you can be sure it is the right machine. For accounting purposes, if you are doing long data transmissions, you can choose the machine that is billed for the longer call.

The string CALLBACK=yes specifies that your computer must call the remote computer back before any file transfers can take place.

The default for the CALLBACK option is CALLBACK=no. If you set CALLBACK to yes, then the permissions that affect the rest of the conversation must be specified in the MACHINE entry corresponding to the caller. Do not specify these permissions in the LOGNAME, or in the LOGNAME entry that the remote machine might have set for your host.

Note - If two sites have the CALLBACK option set for each other, a conversation never gets started.

COMMANDS Option

Caution - The COMMANDS option can compromise the security of your system. Use it with extreme care.

You can use the COMMANDS option in MACHINE entries to specify the commands that a remote computer can execute on your machine. The uux program generates remote execution requests and queue them to be transferred to the remote computer. Files and commands are sent to the target computer for remote execution. This is an exception to the rule that MACHINE entries apply only when your system calls out.

Note that COMMANDS is not used in a LOGNAME entry; COMMANDS in MACHINE entries defines command permissions, whether you call the remote system or it calls you.

The string COMMANDS=rmail specifies the default commands that a remote computer can execute on your computer. If a command string is used in a MACHINE entry, the default commands are overridden. For instance, the entry:

```
MACHINE=owl:raven:hawk:dove COMMANDS=rmail:rnews:lp
```

overrides the COMMAND default so that the computers named owl, raven, hawk, and dove can now execute rmail, rnews, and lp on your computer.

In addition to the names as specified above, there can be full path names of commands. For example:

```
COMMANDS=rmail:/usr/local/rnews:/usr/local/lp
```

specifies that command rmail uses the default search path. The default search path for UUCP is /bin and /usr/bin. When the remote computer specifies rnews or /usr/local/rnews for the command to be executed, /usr/local/rnews is executed regardless of the default path. Likewise, /usr/local/lp is the lp command that is executed.

Including the ALL value in the list means that any command from the remote computers specified in the entry will be executed. If you use this value, you give the remote computers full access to your machine.

Caution - This allows far more access than normal users have. You should use this value only when both machines are at the same site, are closely connected, and the users are trusted.

The string:

```
COMMANDS=/usr/local/rnews:ALL:/usr/local/lp
```

illustrates two points:

- The ALL value can appear anywhere in the string.

- The path names specified for `rnews` and `lp` are used (instead of the default) if the requested command does not contain the full path names for `rnews` or `lp`.

You should use the `VALIDATE` option whenever you specify potentially dangerous commands like `cat` and `uucp` with the `COMMANDS` option. Any command that reads or writes files is potentially dangerous to local security when executed by the UUCP remote execution daemon (`uuxqt`).

VALIDATE Option

Use the `VALIDATE` option in conjunction with the `COMMANDS` option whenever you specify commands that are potentially dangerous to your machine's security. (`VALIDATE` is merely an added level of security on top of the `COMMANDS` option, though it is a more secure way to open command access than ALL.)

`VALIDATE` provides a certain degree of verification of the caller's identity by cross-checking the host name of a calling machine against the login name it uses. The string:

```
LOGNAME=Uwidget VALIDATE=widget:gadget
```

ensures that if any machine other than `widget` or `gadget` tries to log in as `Uwidget`, the connection is refused. The `VALIDATE` option requires privileged computers to have a unique login and password for UUCP transactions. An important aspect of this validation is that the login and password associated with this entry are protected. If an outsider gets that information, that particular `VALIDATE` option can no longer be considered secure.

Carefully consider which remote computers you will grant privileged logins and passwords for UUCP transactions. Giving a remote computer a special login and password with file access and remote execution capability is like giving anyone on that computer a normal login and password on your computer. Therefore, if you cannot trust someone on the remote computer, do not provide that computer with a privileged login and password.

The `LOGNAME` entry:

```
LOGNAME=uucpfriend VALIDATE=eagle:owl:hawk
```

specifies that if one of the remote computers that claims to be `eagle`, `owl`, or `hawk` logs in on your computer, it must have used the login `uucpfriend`. If an outsider gets the `uucpfriend` login and password, masquerading is easy.

But what does this have to do with the `COMMANDS` option, which appears only in `MACHINE` entries? It links the `MACHINE` entry (and `COMMANDS` option) with a `LOGNAME` entry associated with a privileged login. This link is needed because the execution daemon is not running while the remote computer is logged in. In fact, it is an asynchronous process that does not know which computer sent the execution

request. Therefore, the real question is, how does your computer know where the execution files came from?

Each remote computer has its own spool directory on your local machine. These spool directories have write permission given only to the UUCP programs. The execution files from the remote computer are put in its spool directory after being transferred to your computer. When the `uuxqt` daemon runs, it can use the spool directory name to find the `MACHINE` entry in the `Permissions` file and get the `COMMANDS` list. Or, if the computer name does not appear in the `Permissions` file, the default list is used.

This example shows the relationship between the `MACHINE` and `LOGNAME` entries:

```
MACHINE=eagle:owl:hawk REQUEST=yes \
COMMANDS=rmail:/usr/local/rnews \
READ=/ WRITE=/
LOGNAME=uucpz VALIDATE=eagle:owl:hawk \
REQUEST=yes SENDFILES=yes \
READ=/ WRITE=/
```

The value in the `COMMANDS` option means that remote users can execute `rmail` and `/usr/local/rnews`.

In the first entry, you must assume that when you want to call one of the computers listed, you are really calling either `eagle`, `owl`, or `hawk`. Therefore, any files put into one of the `eagle`, `owl`, or `hawk` spool directories is put there by one of those computers. If a remote computer logs in and says that it is one of these three computers, its execution files are also put in the privileged spool directory. You therefore have to validate that the computer has the privileged login `uucpz`.

`MACHINE` Entry for `OTHER`

You might want to specify different option values for remote machines that are not mentioned in specific `MACHINE` entries. The need might arise when many computers are calling your host, and the command set changes from time to time. The name `OTHER` for the computer name is used for this entry as shown in this example:

```
MACHINE=OTHER \
COMMANDS=rmail:rnews:/usr/local/Photo:/usr/local/xp
```

All other options available for the `MACHINE` entry can also be set for the computers that are not mentioned in other `MACHINE` entries.

Combining MACHINE and LOGNAME

You can combine MACHINE and LOGNAME entries into a single entry where the common options are the same. For example, the two entries:

```
MACHINE=eagle:owl:hawk REQUEST=yes \
READ=/ WRITE=/
```

and:

```
LOGNAME=uupz REQUEST=yes SENDFILES=yes \
READ=/ WRITE=/
```

share the same REQUEST, READ, and WRITE options. You can merge them, as shown:

```
MACHINE=eagle:owl:hawk REQUEST=yes \
logname=uucpz SENDFILES-yes \
READ=/ WRITE=/
```

Combining MACHINE and LOGNAME entries makes the Permissions file more manageable and efficient.

Forwarding

When sending files through a series of machines, the intermediary machines must have the command uucp among their COMMANDS options. That is, if you type the command:

```
% uucp sample.txt oak\!willow\!pine\!/usr/spool/uucppublic
```

This forwarding operation works only if machine willow permits oak to execute the program uucp, and if oak permits your machine to do the same. The machine pine, being the last machine designated, does not have to permit the command uucp. Machines are not normally set up this way.

/etc/uucp/Poll File

The /etc/uucp/Poll file contains information for polling remote computers. Each entry in the Poll file contains the name of a remote computer to call, followed by a tab character or a space, and finally the hours the computer should be called. The format of entries in the Poll file are:

sys-name hour ...

For example, the entry

```
eagle 0 4 8 12 16 20
```

provides polling of computer eagle every four hours.

The uudemon.poll script processes the Poll file but does not actually perform the poll. It merely sets up a polling work file (always named C.*file*) in the spool directory. The uudemon.poll script starts the scheduler, and the scheduler examines all work files in the spool directory.

/etc/uucp/Config File

The /etc/uucp/Config file enables you to override certain parameters manually. Each entry in the Config file has this format:

parameter=value

See the Config file provided with your system for a complete list of configurable parameter names.

The following Config entry sets the default protocol ordering to Gge and changes the G protocol defaults to 7 windows and 512-byte packets.

```
Protocol=G(7,512)ge
```

/etc/uucp/Grades File

The /etc/uucp/Grades file contains the definitions for the job grades that can be used to queue jobs to a remote computer. It also contains the permissions for each job grade. Each entry in this file represents a definition of an administrator-defined job grade that lets users queue jobs.

Each entry in the `Grades` file has the following format:

User-job-grade System-job-grade Job-size Permit-type ID-list

Each entry contains fields that are separated by blank space. The last field in the entry is made up of subfields also separated by spaces. If a entry takes up more than one physical line, then you can use a backslash to continue the entry onto the following line. Comment lines begin with a pound sign (#) and occupy the entire line. Blank lines are always ignored.

User-job-grade Field

This field contains an administrative-defined user job grade name of up to 64 characters.

System-job-grade Field

This field contains a one-character job grade to which *User-job-grade* is mapped. The valid list of characters is A–Z, a–z, with A having the highest priority and z the lowest.

Relationship Between User and System Job Grades

The user job grade can be bound to more than one system job grade. It is important to note that the `Grades` file is searched sequentially for occurrences of a user job grade. Therefore, any multiple occurrences of a system job grade should be listed according to the restriction on the maximum job size.

While there is no maximum number for the user job grades, the maximum number of system job grades allowed is 52. The reason is that more than one *User-job-grade* can be mapped to a *System-job-grade*, but each *User-job-grade* must be on a separate line in the file. Here is an example:

```
mail N Any User Any netnews N Any User Any
```

Given this configuration in a `Grades` file, these two *User-job-grade* will share the same *System-job-grade*. Since the permissions for a *Job-grade* are associated with a *User-job-grade* and not a *System-job-grade*, two *User-job-grade*s can share the same *System-job-grade*s and have two different sets of permissions.

Default Grade

You can define the binding of a default *User-job-grade* to a system job grade. You must use the keyword default as user job grade in the *User-job-grade* field of the

Grades file and the system job grade that it is bound to. The Restrictions and ID fields should be defined as Any so that any user and any size job can be queued to this grade. Here is an example:

```
default a Any User Any
```

If you do not define the default user job grade, then the built-in default grade Z is used. Because the restriction field default is Any, multiple occurrences of the default grade are not checked.

Job-size Field

This field specifies the maximum job size that can be entered in the queue. *Job-size* is measured in bytes and can be a list of the options listed in Table 12–8:

TABLE 12–8 Job-size Field

nnnn	Integer specifying the maximum job size for this job grade
*n*K	Decimal number representing the number of kilobytes (K is an abbreviation for kilobyte)
*n*M	Decimal number representing the number of megabytes (M is an abbreviation for megabyte)
Any	Keyword specifying that there is no maximum job size

Here are some examples:

- 5000 represents 5000 bytes
- 10K represents 10 Kbytes
- 2M represents 2 Mbytes

Permit-type Field

This field contains a keyword that denotes how to interpret the ID list. Table 12–9 lists the keywords and their meanings:

TABLE 12–9 Permit-type Field

Keyword	ID List Contents
`User`	Login names of users permitted to use this job grade
`Non-user`	Login names of users not permitted to use this job grade
`Group`	Group names whose members are permitted to use this group
`Non-group`	Group names whose members are not permitted to use this job grade

ID-list Field

This field contains a list of login names or group names that are to be permitted or denied queuing to this job grade. The list of names are separated by blank space and terminated by a newline character. The keyword `Any` is used to denote that anyone is permitted to queue to this job grade.

Other UUCP Configuration Files

This section describes three less-frequently modified files that impact the use of UUCP facilities.

`/etc/uucp/Devconfig` File

The `/etc/uucp/Devconfig` file enables you to configure devices by service—`uucp` or `cu`. `Devconfig` entries define the STREAMS modules that are used for a particular device. They have the format:

`service=`*x* `device=`*y* `push=`*z*[:*z*...]

x can be `cu`, `uucico`, or both separated by a colon. *y* is the name of a network and must match an entry in the `Devices` file. *z* is replaced by the names of STREAMS modules in the order that they are to be pushed onto the Stream. Different modules and devices can be defined for `cu` and `uucp` services.

The following entries are for a STARLAN network and would most commonly be used in the file:

```
service=cu       device=STARLAN     push=ntty:tirdwr
service=uucico   device=STARLAN     push=ntty:tirdwr
```

This example pushes `ntty`, then `tirdwr`.

`/etc/uucp/Limits` File

The `/etc/uucp/Limits` file controls the maximum number of simultaneous `uucico`s, `uuxqt`s, and `uusched`s that are running in the `uucp` networking. In most cases, the default values are fine and no changes are needed. If you want to change them, however, use any text editor.

The format of the `Limits` file is:

`service=`*x* `max=`*y*:

x can be `uucico`, `uuxqt` or `uusched`, and *y* is the limit permitted for that service. The fields can be in any order and in lowercase.

The following entries should most commonly be used in the `Limits` file:

```
service=uucico max=5
service=uuxqt max=5
service=uusched max=2
```

The example allows five `uucico`s, five `uuxqt`s, and two `uusched`s running on your machine.

`remote.unknown` File

The other file that affects the use of communication facilities is the `remote.unknown` file. This file is a binary program that executes when a machine not found in any of the `Systems` files starts a conversation. It logs the conversation attempt and drop the connection.

Caution - If you change the permissions of the `remote.unknown` file so it cannot execute, your system accepts connections from any system.

This program executes when a machine that is not in any of the `Systems` starts a conversation. It logs the conversation attempt but fails to make a connection. If you change the permissions of this file so it cannot execute (`chmod 000 remote.unknown`), your system accepts any conversation requests. This is not a trivial change, and you should have very good reasons for doing it.

Administrative Files

The UUCP administrative files are described below. These files are created in spool directories to lock devices, hold temporary data, or keep information about remote transfers or executions.

- *Temporary data files* (`TM`) – These data files are created by UUCP processes under the spool directory `/var/spool/uucp/`*x* when a file is received from another computer. The directory *x* has the same name as the remote computer that is sending the file. The names of the temporary data files have the format:

  `TM.`*pid.ddd*

  where *pid* is a process ID and *ddd* is a sequential three-digit number starting at 0.

  When the entire file is received, the `TM.`*pid.ddd* file is moved to the path name specified in the `C.`*sysnxxxx* file (discussed below) that caused the transmission. If processing is abnormally terminated, the `TM.`*pid.ddd* file can remain in the *x* directory. These files should be automatically removed by `uucleanup`.

- *Lock files* (`LCK`) – Lock files are created in the `/var/spool/locks` directory for each device in use. Lock files prevent duplicate conversations and multiple attempts to use the same calling device. Table 12–10 shows the different types of UUCP lock files.

TABLE 12–10 UUCP Lock Files

File Name	Description
`LCK..`*sys*	*sys* represents the name of the computer using the file
`LCK.`*dev*	*dev* represents the name of a device using the file
`LCK.`*LOG*	*LOG* represents a locked UUCP log file

These files can remain in the spool directory if the communications link is unexpectedly dropped (usually on computer crashes). The lock files is ignored (removed) after the parent process is no longer active. The lock file contains the process ID of the process that created the lock.

- *Work file* (`C.`) – Work files are created in a spool directory when work (file transfers or remote command executions) has been queued for a remote computer. The names of work files have the format:

  `C.`*sysnxxxx*

where *sys* is the name of the remote computer, *n* is the ASCII character representing the grade (priority) of the work, and *xxxx* is the four-digit job sequence number assigned by UUCP. Work files contain the following information:

- Full path name of the file to be sent or requested
- Full path name of the destination or user or file name
- User login name
- List of options
- Name of associated data file in the spool directory; if the `uucp –C` or `uuto –p` option was specified, a dummy name (`D.0`) is used
- Mode bits of the source file
- Remote user's login name to be notified upon completion of the transfer

- *Data file* (`D.`) – Data files are created when you specify on the command line to copy the source file to the spool directory. The names of data files have the following format:

  - `D.`*systmxxxxyyy* – Where *systm* is the first five characters in the name of the remote computer, *xxxx* is a four-digit job sequence number assigned by `uucp`. The four digit job sequence number can be followed by a subsequence number, *yyy* that is used when there are several `D.` files created for a work (`C.`) file.

- `X.` *(execute file)* - Execute files are created in the spool directory prior to remote command executions. The names of execute files have the following format:

  `X.`*sysnxxxx*

  sys is the name of the remote computer. *n* is the character representing the grade (priority) of the work. *xxxx* is a four-digit sequence number assigned by UUCP. Execute files contain the following information:

  - Requester's login and computer name
  - Names of files required for execution
  - Input to be used as the standard input to the command string
  - Computer and file name to receive standard output from the command execution
  - Command string
  - Option lines for return status requests

CHAPTER 13

Configuring and Maintaining UUCP

This chapter explains how to start up UUCP operations afteryou have modified the database file relevant to your machines. The chapter contains procedures and troubleshooting information for setting up and maintaining UUCP on machines running the Solaris environment.

Adding UUCP Logins

For incoming UUCP (`uucico`) requests from remote machines to be handled properly, each machine has to have a login on your system.

Here is a typical entry that you might put into the `/etc/passwd` file for a remote machine permitted to access your system with a UUCP connection:

```
Ugobi:*:5:5:gobi:/var/spool/uucppublic:/usr/lib/uucp/uucico
```

By convention, the login name of a remote machine is the machine name preceded by the uppercase letter `U`. Note that the name should not exceed eight characters, so that in some cases you might have to truncate or abbreviate it.

The previous entry shows that a login request by `Ugobi` is answered by `/usr/lib/uucp/uucico`. The home directory is `/var/spool/uucppublic`. The password is obtained from the `/etc/shadow` file. You must coordinate the

password and the login name with the UUCP administrator of the remote machine. The remote administrator must then add an appropriate entry, with login name and unencrypted password, in the remote machine's `Systems` file.

Similarly, you must coordinate your machine's name and password with the UUCP administrators of all machines that you want to reach through UUCP.

Starting UUCP

UUCP comes with four shell scripts that poll remote machines, reschedule transmissions, and clean up old log files and unsuccessful transmissions. The scripts are:

- `uudemon.poll`
- `uudemon.hour`
- `uudemon.admin`
- `uudemon.cleanup`

These shell scripts should execute regularly to keep UUCP running smoothly. The `crontab` file to run the scripts is automatically created in `/usr/lib/uucp/uudemon.crontab` as part of the Solaris installation process, if you select the full installation. Otherwise, it is created when you install the UUCP package.

You can also run the UUCP shell scripts manually. The following is the prototype `uudemon.crontab` file that you can tailor for a particular machine:

```
#
#ident  "@(#)uudemon.crontab    1.5     97/12/09 SMI"
#
# This crontab is provided as a sample. For systems
# running UUCP edit the time schedule to suit, uncomment
# the following lines, and use crontab(1) to activate the
# new schedule.
#
#48 8,12,16 * * * /usr/lib/uucp/uudemon.admin
#20 3 * * * /usr/lib/uucp/uudemon.cleanup
#0 * * * * /usr/lib/uucp/uudemon.poll
#11,41 * * * * /usr/lib/uucp/uudemon.hour
```

Note - By default, UUCP operations are disabled. To enable UUCP, edit the time schedule and uncomment the appropriate lines in the `uudemon.crontab` file.

To activate the uudemon.crontab file, become superuser and type:

```
# su uucp
# crontab < /usr/lib/uucp/uudemon.crontab
```

uudemon.poll Shell Script

The default uudemon.poll shell script reads the /etc/uucp/Poll file once an hour. If any machines in the Poll file are scheduled to be polled, a work file (C.*sysnxxxx*) is placed in the /var/spool/uucp/*nodename* directory, where *nodename* represents the UUCP node name of the machine.

The shell script is scheduled to run once an hour, before uudemon.hour, so that the work files are there when uudemon.hour is called.

uudemon.hour Shell Script

The default uudemon.hour shell script:

- Calls the uusched program to search the spool directories for work files (C.) that have not been processed and schedules these files for transfer to a remote machine.
- Calls the uuxqt daemon to search the spool directories for execute files (X.) that have been transferred to your computer and were not processed at the time they were transferred.

By default, uudemon.hour runs twice an hour. You might want it to run more often if you expect high failure rates of calls to remote machines.

uudemon.admin Shell Script

The default uudemon.admin shell script does the following:

1. Runs the uustat command with p and q options. The q reports on the status of work files (C.), data files (D.), and execute files (X.) that are queued. The p prints process information for networking processes listed in the lock files (/var/spool/locks).
2. Sends resulting status information to the uucp administrative login via mail.

uudemon.cleanup Shell Script

The default uudemon.cleanup shell script does the following:

1. Takes log files for individual machines from the /var/uucp/.Log directory, merges them, and places them in the /var/uucp/.Old directory with other old log information.
2. Removes work files (C.) seven days old or older, data files (D.) Seven days old or older, and execute files (X.) two days old or older from the spool files.
3. Returns mail that cannot be delivered to the sender.
4. Mails a summary of the status information gathered during the current day to the UUCP administrative login (uucp).

Running UUCP Over TCP/IP

To run UUCP on a TCP/IP network, you need to make a few modifications, as described in this section.

Activating UUCP in /etc/inetd.conf

Make sure that the following entry in /etc/inetd.conf is not preceded by a comment mark (#):

```
uucp stream tcp nowait root /usr/sbin/in.uucpd in.uucpd
```

Tailoring Systems File Entries for TCP/IP

Entries in the /etc/uucp/Systems file should have the following fields:

System-Name Time TCP Port networkname Standard-Login-Chat

A typical entry would look like this:

```
rochester Any TCP - ur-seneca login: Umachine password: xxx
```

Notice that the *networkname* field permits you to specify explicitly the TCP/IP host name. This is important for some sites. In the example above, the site has the UUCP node name rochester is different from its TCP/IP host name ur-seneca. Moreover, there could easily be a completely different machine running UUCP that has the TCP/IP host name of rochester.

The Port field in the Systems file should have the entry --. This is equivalent to listing it as uucp. In almost every case, the *networkname* is the same as the system name, and the Port field is --, which says to use the standard uucp port from the

services database. The in.uucpd daemon expects the remote machine to send its login and password for authentication, and it prompts for them much as getty and login do.

Checking /etc/inet/services for UUCP

The following entry in /etc/inet/services sets up a port for UUCP:

```
uucp 540/tcp uucpd # uucp daemon
```

You should not have to change the entry. However, if your machine runs NIS or NIS+ as its name service, you should change the /etc/nsswitch.conf entry for /etc/services to check files first, then check nis or nisplus.

Security, Maintenance, and Troubleshooting

After you have set up UUCP, maintenance is straightforward. This section explains ongoing UUCP tasks with regard to security, maintenance, and troubleshooting.

Setting Up UUCP Security

The default /etc/uucp/Permissions file provides the maximum amount of security for your UUCP links. The default Permissions file contains no entries.

You can set additional parameters for each machine to define:

- Ways it can receive files from your machine
- Directories for which it has read and write permission
- Commands it can use for remote execution

A typical Permissions entry is:

```
MACHINE=datsun LOGNAME=Udatsun VALIDATE=datsun
COMMANDS=rmail REQUEST=yes SENDFILES=yes
```

This entry allows files to be sent and received (to and from the “normal” UUCP directories, not from anywhere in the system) and causes the UUCP user name to be validated at login time.

Regular UUCP Maintenance

UUCP does not require much maintenance. Apart from making sure that the `crontab` file is in place, as described in the section "`uudemon.poll` Shell Script" on page 209, all you have to worry about is the growth of mail files and the public directory.

Email for UUCP

All email messages generated by the UUCP programs and scripts go to the user ID `uucp`. If you do not log in frequently as that user, you might not realize that mail is accumulating (and consuming disk space). To solve this, make an alias in `/etc/aliases` and redirect that email either to `root` or to yourself and others responsible for maintaining UUCP. Don't forget to run the `newaliases` command after modifying the `aliases` file.

Public Directory

The directory `/var/spool/uucppublic` is the one place in every system to which UUCP by default is able to copy files. Every user has permission to change to `/var/spool/uucppublic` and read and write files in it. However, its sticky bit is set, so its mode is 01777. As a result, users cannot remove files that have been copied to it and that belong to `uucp`. Only you, as UUCP administrator logged in as `root` or `uucp`, can remove files from this directory. To prevent the uncontrolled accumulation of files in this directory, you should make sure to clean it up periodically.

If this is inconvenient for users, encourage them to use `uuto` and `uupick` rather than removing the sticky bit, which is set for security reasons. (See the **`uuto`**(1C) man page for instructions for using `uuto` and `uupick`.) You can also restrict the mode of the directory to only one group of people. If you do not want to run the risk of someone filling your disk, you can even deny UUCP access to it.

Troubleshooting UUCP

These procedures describe how to solve common UUCP problems.

Checking for Faulty Modems or ACUs

You can check if the modems or other ACUs are not working properly in several ways.

- Run `uustat –q`. This will give counts and reasons for contact failure.
- Run `cu –d –l`*`line`*, where *line* is `/dev/cua/a`. This lets you call over a particular line and print debugging information on the attempt. The line must be defined as

`direct` in the `/etc/uucp/Devices` file. (You must add a telephone number to the end of the command line if the line is connected to an autodialer or the device must be set up as `direct`.)

Checking the `/etc/uucp/Systems` File

Verify that you have up-to-date information in your `Systems` file if you are having trouble contacting a particular machine. Some things that might be out of date for a machine are its:

- Phone number
- Login ID
- Password

Debugging Transmissions

If you cannot contact a particular machine, you can check out communications to that machine with `Uutry` and `uucp`.

1. **To try to make contact, type `/usr/lib/uucp/Uutry --r` *machine* and press Return.**

   Replace *machine* with the host name of the machine you are having problems contacting. This command:

   a. **Starts the transfer daemon (`uucico`) with debugging. You can get more debugging information if you are `root`.**

   b. **Directs the debugging output to `/tmp/`*machine*.**

   c. **Prints the debugging output to your terminal (`tail –f`).**

      Press Control-c to end output. You can copy the output from `/tmp/`*machine* if you want to save it.

2. **If `Uutry` doesn't isolate the problem, try to queue a job by typing `uucp ---r` *file machine*`\!`*/dir/file* and press Return.**

   Replace *file* by the file you want to transfer, *machine* by the machine you want to copy to, and */dir/file* where the file will be placed on the other machine. The `r` option queues a job but does not start the transfer.

3. **Now use `Uutry` again.**

   If you still cannot solve the problem, you might need to call your local support representative. Save the debugging output; it will help diagnose the problem.

You might also want to decrease or increase the level of debugging provided by `Uutry` through the `–x` *n* option, where *n* indicates the debug level. The default debug level for `Uutry` is 5.

Debug level 3 provides basic information as to when and how the connection is established, but not much information about the transmission itself. Debug level 9, on the other hand, provides exhaustive information about the transmission process. Be aware that debugging occurs at both ends of the transmission. If you intend to use a level higher than 5 on a moderately large text, get in touch with the administrator of the other site and agree on a time for doing so.

Checking Error Messages

UUCP has two types of error messages: `ASSERT` and `STATUS`.

When a process is aborted, `ASSERT` error messages are recorded in `/var/uucp/.Admin/errors`. These messages include the file name, `sccsid`, line number, and text. These messages usually result from system problems.

STATUS error messages are stored in the `/var/uucp/.Status` directory. The directory contains a separate file for each remote machine your computer attempts to communicate with. These files contain status information on the attempted communication and whether it was successful.

Checking Basic Information

Several commands are available for checking basic networking information:

- `uuname` – Use this command to list those machines your machine can contact.
- `uulog` – Use this command to display the contents of the log directories for particular hosts.
- `uucheck –v` – Run this command to check for the presence of files and directories needed by `uucp`. This command also checks the `Permissions` file and outputs information on the permissions you have set up.

UUCP Error Messages

This section lists the error messages associated with UUCP.

UUCP ASSERT Error Messages

Table 13–1 lists ASSERT error messages.

TABLE 13–1 ASSERT Error Messages

Error Message	Description/Action
CAN'T OPEN	An `open( )` or `fopen( )` failed.
CAN'T WRITE	A `write( )`, `fwrite( )`, `fprint( )`, or similar command, failed.
CAN'T READ	A `read( )`, `fgets( )`, or similar command failed.
CAN'T CREATE	A `creat( )` call failed.
CAN'T ALLOCATE	A dynamic allocation failed.
CAN'T LOCK	An attempt to make a `LCK` (lock) file failed. In some cases, this is a fatal error.
CAN'T STAT	A `stat( )` call failed.
CAN'T CHMOD	A `chmod( )` call failed.
CAN'T LINK	A `link( )` call failed.
CAN'T CHDIR	A `chdir( )` call failed.
CAN'T UNLINK	An `unlink( )` call failed.
WRONG ROLE	This is an internal logic problem.
CAN'T MOVE TO CORRUPTDIR	An attempt to move some bad `C.` or `X.` files to the `/var/spool/uucp/.Corrupt` directory failed. The directory is probably missing or has wrong modes or owner.
CAN'T CLOSE	A `close( )` or `fclose( )` call failed.
FILE EXISTS	The creation of a `C.` or `D.` file is attempted, but the file exists. This occurs when there is a problem with the sequence file access. Usually indicates a software error.
NO uucp SERVICE NUMBER	A TCP/IP call is attempted, but there is no entry in `/etc/services` for UUCP.
BAD UID	The user ID is not in the password database. Check name service configuration..
BAD LOGIN_UID	Same as previous.
BAD LINE	There is a bad line in the `Devices` file; there are not enough arguments on one or more lines.

TABLE 13–1 ASSERT Error Messages *(continued)*

Error Message	Description/Action
SYSLST OVERFLOW	An internal table in `gename.c` overflowed. A single job attempted to talk to more than 30 systems.
TOO MANY SAVED C FILES	Same as previous.
RETURN FROM `fixline ioctl`	An `ioctl(2)`, which should never fail, failed. There is a system driver problem.
BAD SPEED	A bad line speed appears in the `Devices` or `Systems` file (Class or Speed field).
BAD OPTION	There is a bad line or option in the `Permissions` file. It must be fixed immediately.
PKCGET READ	The remote machine probably hung up. No action need be taken.
PKXSTART	The remote machine aborted in a nonrecoverable way. This can usually be ignored.
TOO MANY LOCKS	There is an internal problem. Contact your system vendor.
XMV ERROR	There is a problem with some file or directory. It is likely the spool directory, since the modes of the destinations were suppose to be checked before this process was attempted.
CAN'T FORK	An attempt to make a `fork` and `exec` failed. The current job should not be lost but will be attempted later (`uuxqt`). No action is needed.

UUCP STATUS Error Messages

Table 13–2 is a list of the most common STATUS error messages.

TABLE 13–2 UUCP STATUS Messages

Error Message	Description/Action
OK	Status is okay.
NO DEVICES AVAILABLE	There is currently no device available for the call. Check to see that there is a valid device in the `Devices` file for the particular system. Check the `Systems` file for the device to be used to call the system.

TABLE 13–2 UUCP STATUS Messages *(continued)*

Error Message	Description/Action
WRONG TIME TO CALL	A call was placed to the system at a time other than what is specified in the Systems file.
TALKING	Self-explanatory.
LOGIN FAILED	The login for the given machine failed. It could be a wrong login or password, wrong number, a very slow machine, or failure in getting through the Dialer-Token-Pairs script.
CONVERSATION FAILED	The conversation failed after successful startup. This usually means that one side went down, the program aborted, or the line (link) was dropped.
DIAL FAILED	The remote machine never answered. It could be a bad dialer or the wrong phone number.
BAD LOGIN/MACHINE COMBINATION	The machine called us with a login/machine name that does not agree with the Permissions file. This could be an attempt to masquerade!.
DEVICE LOCKED	The calling device to be used is currently locked and in use by another process.
ASSERT ERROR	An ASSERT error occurred. Check the /var/uucp/.Admin/errors file for the error message and refer to the section “UUCP Error Messages” on page 214.
SYSTEM NOT IN Systems FILE	The system is not in the Systems file.
CAN’T ACCESS DEVICE	The device tried does not exist or the modes are wrong. Check the appropriate entries in the Systems and Devices files.
DEVICE FAILED	The device could not be opened.
WRONG MACHINE NAME	The called machine is reporting a different name than expected.
CALLBACK REQUIRED	The called machine requires that it calls your machine.
REMOTE HAS A LCK FILE FOR ME	The remote machine has a LCK file for your machine. It could be trying to call your machine. If it has an older version of UUCP, the process that was talking to your machine might have failed, leaving the LCK file. If it has the new version of UUCP and is not communicating with your machine, then the process that has a LCK file is hung.
REMOTE DOES NOT KNOW ME	The remote machine does not have the node name of your machine in its Systems file.

TABLE 13–2 UUCP STATUS Messages *(continued)*

Error Message	Description/Action
`REMOTE REJECT AFTER LOGIN`	The login used by your machine to login does not agree with what the remote machine was expecting.
`REMOTE REJECT, UNKNOWN MESSAGE`	The remote machine rejected the communication with your machine for an unknown reason. The remote machine might not be running a standard version of UUCP.
`STARTUP FAILED`	Login succeeded, but initial handshake failed.
`CALLER SCRIPT FAILED`	This is usually the same as `DIAL FAILED`. However, if it occurs often, suspect the caller script in the `Dialers` file. Use `Uutry` to check.

UUCP Numerical Error Messages

Table 13–3 lists the exit code numbers of error status messages produced by the `/usr/include/sysexits.h` file. Not all are currently used by `uucp`.

TABLE 13–3 UUCP Error Messages by Number

Message Number	Description	Meaning
64	Base value for error messages	Error messages begin at this value.
64	Command Line Usage Error	The command was used incorrectly, for example, with the wrong number of arguments, a bad flag, or a bad syntax.
65	Data Format Error	The input data was incorrect in some way. This should only be used for user's data and not system files.
66	Cannot Open Input	An input file (not a system file) did not exist, or was not readable. This could also include errors like "No message" to a mailer (if it cared to catch it).
67	Address Unknown	The user specified did not exist. This might be used for mail addresses or remote logins.
68	Host Name Unknown	The host did not exist. This is used in mail addresses or network requests.

TABLE 13–3 UUCP Error Messages by Number *(continued)*

Message Number	Description	Meaning
69	Service Unavailable	A service is unavailable. This can occur if a support program or file does not exist. This message also can be a catchall message when something doesn't work and you don't know why.
70	Internal Software Error	An internal software error has been detected. This should be limited to non-operating system related errors if possible.
71	System Error	An operating system error has been detected. This is intended to be used for conditions like "cannot fork","cannot create pipe." For instance, it includes `getuid` returning a user that does not exist in the `passwd` file.
72	Critical OS File Missing	Some system file like `/etc/passwd` or `/etc/utmp` does not exist, cannot be opened, or has some error such as syntax error.
73	Can't Create Output File	A user specified output file cannot be created.
74	Input/Output Error	An error occurred while doing I/O on some file.
75	Temporary Failure. User is invited to retry	Temporary failure, indicating something that is not really an error. In `sendmail`, this means that a mailer, for example, could not create a connection, and the request should be reattempted later.
76	Remote Error in Protocol	The remote system returned something that was "not possible" during a protocol exchange.
77	Permission Denied	You do not have sufficient permission to perform the operation. This is not intended for file system problems, which should use `NOINPUT` or `CANTCREAT`, but rather for higher level permissions. For example, `kre` uses this to restrict students who can send mail to.
78	Configuration Error	There is an error in the configuration.
79	Entry Not Found	Entry not found.
79	Maximum Listed Value	Highest value for error messages.

PART IV Dynamic Host Configuration Protocol

The Dynamic Host Configuration Protocol (DHCP) allows a host to get an Internet Protocol (IP) address and other Internet configuration parameters without any need for preconfiguration by the user. This new protocol improves on the traditional Internet architecture, where the system administrator must assign or change each IP address individually.

DHCP reduces the cost of managing networks by eliminating the need for the administrator to assign or change addresses again and again.

CHAPTER 14

Understanding DHCP

This chapter introduces the Dynamic Host Configuration Protocol (DHCP) and describes both the client and server sides of the protocol. It discusses Bootstrap Protocol (BOOTP) relay agents, which can be used in the operation of DHCP.

What is DHCP?

DHCP provides a host with an Internet Protocol (IP) address and other Internet configuration parameters without any need for preconfiguration by the user. This new protocol improves on the traditional Internet architecture, where the system administrator must assign or change each IP address individually. The manual process is expensive, difficult, error-prone and time-consuming.

DHCP reduces the cost of managing networks by eliminating the need for the administrator to assign or change IP addresses again and again. Dynamic IP addresses are chosen from a pool of unused IP addresses, and are automatically assigned to a host for temporary or permanent use. DHCP also reclaims that IP address for use by other clients when it is no longer needed or when the time period for its use is up.

The packet formats for DHCP and BOOTP are the same, although BOOTP packets are fixed length and DHCP packets are variable length. The DHCP packet length is negotiated between the client and the server.

The Dynamic Host Configuration working group of the Internet Engineering Task Force (IETF) has been working for approximately five years on the problems presented by the current IP address assignment architecture. The IETF is in the process of standardizing DHCP. It currently has the status of several Requests For Comment (RFCs), including RFCs 1542, 2131, and 2132.

The Internet has grown so rapidly that users are running out of network addresses to support it. In response to this problem, Classless Inter-Domain Routing (CIDR) was developed. IP addresses had been separated into class A, B, and C for large, medium, and small networks. As the class B IP addresses were depleted, the CIDR design came into use. CIDR was based on the idea that an organization should get the exact number of class C IP addresses it needs, rather than be assigned one class B network, consisting of 65,536 addresses.

The class C network numbers allocated following the CIDR strategy are not random. They are contiguous and share the same prefixes. This helps alleviate many of the problems caused by manipulating very large routing tables.

With the CIDR strategy, blocks of IP addresses are allocated to individual ISPs, not to individual requestors or companies, as was previously the case. So it becomes important to renumber easily, in order to change ISPs easily. DHCP makes it easy to renumber networks, and therefore easier to change ISPs.

DHCP is a technology that enables several useful features, including:

- Automatic network configuration, such that after client machines are powered up on a network that supports DHCP, the clients acquire what they need. For example, their IP addresses, default routers, subnet masks, the DNS domain, DNS servers, NIS+ domain, NIS+ servers, Timezones, time servers, and all the other information necessary to operate without any need for individual configuration by an administrator.
- Automatic IP address management, including assignment, reclamation, reconfiguration, and renumbering of IP addresses. Since all TCP/IP parameters are managed centrally, and the DHCP service manages the assignment and reuse of IP addresses automatically, minimal administrator involvement is necessary.
- Vastly simplified system administration through the centralized location of network configuration information. The TCP/IP configuration information can be stored in a central place, instead of being distributed among all the clients in the network. A network can be renumbered simply and quickly, usually in only a few days, using relatively short IP address leases.

DHCP can also exploit existing BOOTP relay functionality since DHCP is based on the BOOTP. This permits network administrators to configure their routers to forward BOOTP/DHCP traffic to remote BOOTP/DHCP servers. Therefore, network parameter servers are no longer needed on every network segment, as was true of the in,rarpd (see **`in.rarpd`**(1M)) and `bootparams` configuration services.

A network administrator can use the command to quickly and easily configure DHCP and BOOTP services on a Solaris server. The command bootstraps the DHCP service and configures local and remote networks. Local networks are those to which

the server is directly connected. Remote networks are those to which the server is not directly connected, but are accessed through BOOTP relay agents.

Serving clients on remote networks requires the configuration of a BOOTP relay agent on the client's network. BOOTP relay agent functionality is present in many popular routers and switches. If your router does not support this feature, you can run the `in.dhcpd` daemon (see **`in.dhcpd`**(1M)) in relay agent mode on any Solaris machine on the client's network capable of running `in.dhcpd`. This is true starting with the Solaris 2.6 release. Figure 14–1 shows an overview of DHCP and BOOTP.

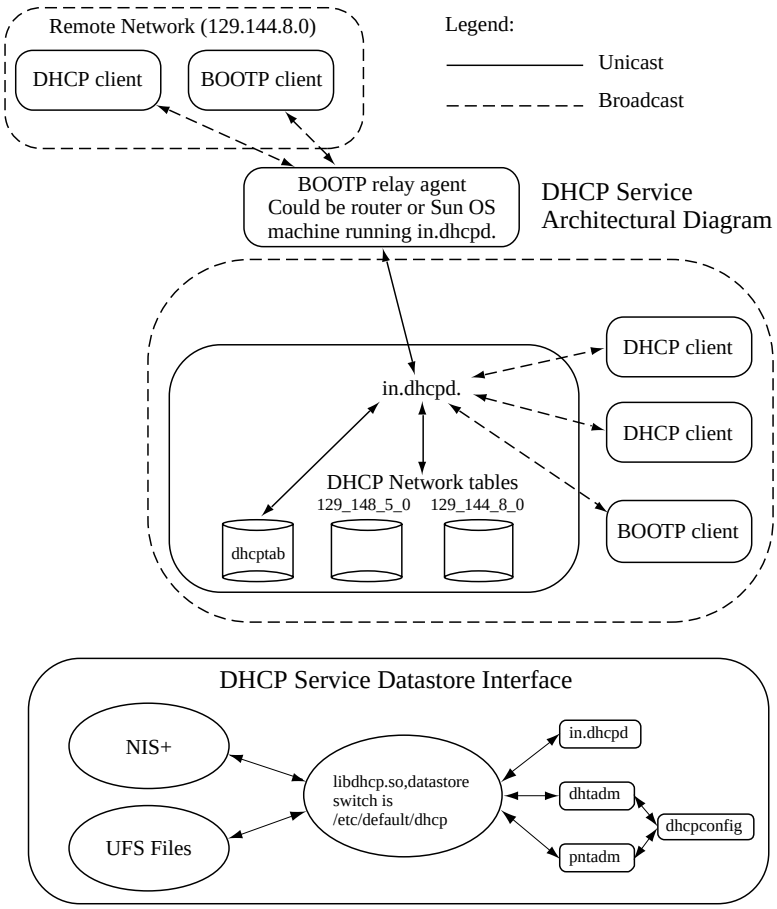


Figure 14–1 DHCP Architectural Diagram

The DHCP Client

The DHCP protocol has two functions with regard to the client. It delivers sufficient information to clients for them to establish an endpoint for network communications, and it supplies other parameters needed by system- and application-level software.

Delivering Client Information

To perform the first function, the DHCP protocol supplies an IP address valid for the network attached to the client's hardware interface. The right to use this IP address is given to the client for a finite period of time, called a lease. This differs from the traditional static configuration. If the client wants to use the IP address for a period of time longer than the original lease, it must periodically negotiate a lease extension with the server through DHCP. When the client no longer needs the IP address, the user of the machine can relinquish its lease, returning it to the pool of available IP addresses. Otherwise, the IP address is reclaimed automatically when its lease expires.

The implementation of the client side of the DHCP protocol on Solaris must meet several criteria. Bootstrapping a Sun workstation is a complex process because of the number and diversity of services that must be configured and invoked. Any DHCP solution must co-exist with other methods already in use, particularly the Reverse Address Resolution Protocol (RARP) and static configuration. It must know that the superuser can change the address of a network interface after the workstation has booted. It must be able to configure multiple interfaces. And it must respond to human control and be able to report on the status and provide the statistics of the protocol.

The Solaris DHCP client meets these criteria by implementing several features. Since leases must be renewed days or weeks after the initial boot, an agent responsible for DHCP on the client must run as a daemon. This daemon, the DHCP agent or dhcpagent (see **dhcpagent**(1M)) is responsible for all the interactions of the protocol. It sends and receives all the DHCP protocol packets when talking to the server. The daemon:

- Constructs and sends packets
- Listens for responses from servers
- Caches the configuration information received
- Releases or renews leases
- Configures the interfaces with sufficient information to enable communications with the network through the interface

This is where the responsibilities of the agent end. The daemon knows nothing of any higher-level services that the client might be running.

When the agent starts, it assumes nothing about which interfaces are to be configured by DHCP. It waits for instructions from some other entity. These instructions are passed to the agent by a control protocol, which also returns status and other information from the agent to the controller. The controller allows the user to control the behavior of the agent, and implements this control through new features of the **`ifconfig`**(1M) command.

The `ifconfig` command has new command line options specific to DHCP, which start or terminate DHCP on an interface. After DHCP is started on an interface, the agent sends packets to and receives them from a server as the protocol dictates.

In the simplest example, the interface is successfully configured by DHCP. The agent notes the duration of the lease, informs `ifconfig` that the interface was configured, writes the configuration it received to disk, and goes back to sleep.

At some predetermined future time, usually 50 percent into the lease's lifetime, the agent reawakens and negotiates an extension to the lease. This renegotiation can occur an unlimited number of times while the workstation is running. Eventually, the system is halted. At that time, `ifconfig` can tell the agent to relinquish the lease. If the lease is relinquished, the configuration information stored on the disk is removed, since it is no longer valid.

The agent can keep track of leases on many different interfaces simultaneously. There is no requirement that they all be renewed at the same time.

The example above is the simplest one, but circumstances might be more complicated. The agent might not receive any responses to its protocol messages. In that case, the agent can use a configuration previously stored on disk, as long as the lease associated with the configuration has not expired. If no valid configuration is found, the agent can continue to retry DHCP using a predefined retransmission schedule, or it can fail to configure the interface. What it does depends on whether the interface was designated as a primary interface. If it was designated as a primary interface, the agent continues to retry DHCP. If it was not designated as a primary interface, the agent fails the `ifconfig` command.

In addition, the agent must take into account that human intervention might have occurred. If the agent awakens to discover that the IP address and interface status no longer conform to the DHCP configuration received, then the agent drops the interface from its active list. No further DHCP operations will occur on it until the agent is again asked to acquire a lease for the interface.

Supplying Additional Information

To perform its second function, delivering application and system-level information, the Solaris DHCP client uses another program, **`dhcpinfo`**(1). Since the agent does not know about these services, any configuration information it receives via the DHCP protocol is stored, waiting to be retrieved by `dhcpinfo`.

The `dhcpinfo` command takes a command line argument with a specified parameter, interrogates the agent as to the value of that parameter, and echoes the result to its standard output as a (human readable) text string. However, the chief consumer of the `dhcpinfo` answers is not the user, but the Solaris startup scripts, since the output lends itself easily to shell command substitution and output redirection.

Data supplied by DHCP can be host-wide or interface-specific. On a client with a single DHCP-configurable interface, this distinction is meaningless. But on a host with many interfaces, questions of interpretation arise regarding `dhcpinfo` parameters. For example, the agent could configure two interfaces and find that the NIS+ domain name returned for the two differs. This situation is resolved by dividing interfaces into two categories: the primary interface and secondary interfaces.

The primary interface is the preferred one for a host-wide configuration. When `dhcpinfo` is asked for a value, it consults the primary interface. It does the same in the case of interface-specific data. The values returned are those that were received on the primary interface. For example, if `dhcpinfo` is asked for the IP address, it echoes the IP address of the primary interface to standard output. An interface is designated as primary by command line arguments to `ifconfig`.

The `dhcpinfo` command allows other command line options to override this default behavior. One of these options allows an interface name to be explicitly specified. In that case, the values returned are those delivered by DHCP for that interface.

Because much of the host-wide data is critically important to successful booting of a Solaris client, the designation of an interface as primary implies that the system cannot boot unless the agent can configure that interface. The `ifconfig` command is instructed by command line arguments to wait indefinitely until `dhcpagent` has finished configuring the primary interface.

DHCP Server

The DHCP server manages the IP address space of networks directly connected to that server. To extend this environment into other networks, DHCP servers or BOOTP relay agents must be set up on those networks.

A DHCP server can act as a primary or a secondary server. To be a primary server, it must have a range of IP addresses for which it is responsible.

Note - The term *primary* is used differently for the client and the server.

When a DHCP server is added to a network that already has a primary DHCP server, the new server can be configured to provide primary and secondary service, or secondary service only. If the server is configured for both services, both servers can perform the duties of a primary server, (they can give out IP addresses) as long as each is primarily responsible for a different IP range. Each server can act as a

secondary server for the other, by confirming existing configurations supplied by a primary server when the primary server is unable to respond to requests for confirmation. Every primary server automatically acts as a secondary server.

A DHCP server's range of IP addresses is specified during the installation and configuration of the software on the server. As a primary DHCP server, the server can give out an IP address to a client requesting a new configuration from the range of IP addresses for which it is responsible. When a client asks for confirmation of its existing configuration, the server responsible for that client's IP address confirms the configuration. Acting as a secondary server, it can confirm configurations that were supplied by another DHCP server on the network.

To provide secondary service, the DHCP server confirms configurations that were supplied by another DHCP server on the network. It does this when the primary server responsible for those IP addresses cannot respond. After a waiting period, the secondary server responds in its place.

DHCP servers can be configured as secondary only. If you decide you want to configure a DHCP server as a secondary server only, you can do this through the `dhcpconfig` program, by choosing to configure the server without a range of IP addresses that it can give out to clients requesting a new configuration. In this configuration, the DHCP servers should be using NIS+ for their data storage.

DHCP service is enabled and configured on the machine on which it is run with the `dhcpconfig` utility. This utility allows you to set startup options, configure the DHCP service database type and location, and initialize the `dhcptab` and `dhcp_network` tables for any locally attached or remote networks.

When `dhcpconfig` is invoked, it presents a menu offering the option of configuring the DHCP service, configuring a BOOTP relay agent, removing the DHCP configuration or relay service configuration, or exiting. When the administrator selects one of the menu options, he or she is presented with a series of questions to collect the required information. Then `dhcpconfig` performs the appropriate steps to turn on the selected functions.

Multiple DHCP servers on the same network operate much more efficiently if they share DHCP databases through NIS+ or NFS. Sharing allows DHCP servers to communicate through a common datastore, increasing redundancy and balancing load among cooperating servers.

When a new DHCP client is added to the network, the client broadcasts a message intended to locate all available DHCP and/or BOOTP servers within reach. Any DHCP server that receives the message first checks to see if any IP addresses are available for assignment. If they are, the server verifies that a potential IP address is not already in use. If it is not, the server offers the IP address and other configuration information to the client. If the IP address is in use, the server marks this IP address as unusable, notifies the network administrator of its status, and selects another IP address.

The client selects an IP address offered to it based on its own criteria, and broadcasts a message that identifies its selection.

Server Databases

The DHCP/BOOTP server uses two types of databases: the `dhcptab` database and the dhcp_network databases (see **`dhcp_network`**(4).

The `dhcptab` database contains macros defined using a termcap-like syntax. This syntax permits network administrators to define groups of DHCP configuration parameters to be returned to clients. There are currently 77 predefined parameters.

A DHCP/BOOTP server returns hostname, network broadcast address, network subnet mask, or IP maximum transfer unit (MTU), if this information is requested by a client attached to the same network as the server. This information does not have to be explicitly configured in the `dhcptab`. The `dhtadm` command manages the `dhcptab` service configuration table.

If there are two servers sharing a distributed `dhcptab` table, the administrator can configure the DHCP parameters in the table so the servers back each other up, provided that they are in the same NIS+ domain. However, each should be primarily responsible for a different range of IP addresses. Each network might require a BOOTP relay agent as well, so its clients can reach the server on the other network.

The `dhcp_network` databases contain client identifier-to-IP address mappings. These databases are named after the network they support. There is one `dhcp_network` database for each network that offers DHCP/BOOTP services. The `dhcp_network` databases are located dynamically by the server and consulted during runtime. A client request received from a network for which no `dhcp_network` database exists is ignored.

The `dhcp_network` database maps a DHCP client's client identifier to an IP address and the configuration parameter associated with that IP address. This database is located by the DHCP server at runtime by generating a `dhcp_network` database name by using the IP network address and subnet mask for the network where the DHCP request originated. For example, a `dhcp_network` database that supports the 10.0.0.0 network would be called 10_0_0_0. The `dhcp_network` databases can exist as NIS+ tables or ASCII files. Use the `pntadm` command to manage the `dhcp_network` databases.

The in.dhcpd daemon has two run modes, DHCP server (with optional BOOTP compatibility mode) and BOOTP relay agent mode (see **`in.dhcpd`**(1M).

BOOTP Relay Agents

Multiple networks, and the use of netmasks to identify them, complicate the functioning of TCP/IP-based networks. For instance, broadcasting using IP cannot take place through the gateways that link networks. So clients on one network cannot broadcast DHCP or BOOTP requests to servers on other networks. A BOOTP

relay agent must direct the initial requests through the gateway to the server, then return the replies from the server to the clients.

If your router doesn't have a built-in BOOTP relay agent, and you want clients in other networks to have the advantage of the services installed on the DHCP server, you can install BOOTP relay agents on those networks. This allows clients to access DHCP servers from a network that is not running a DHCP server.

The `in.dhcpd` daemon can be run as a BOOTP relay agent. If you specify BOOTP relay agent mode, the option argument specifies a comma-separated list of IP addresses or the hostnames of DHCP or BOOTP servers to which the relay agent must forward BOOTP requests. When the daemon is started in this mode, any DHCP databases are ignored, and the daemon acts as a BOOTP relay agent.

A BOOTP relay agent listens to UDP port 68, and forwards BOOTP request packets received on this port to the destinations specified on the command line. The relay agent can run on any machine that has knowledge of local routers, so it does not have to be an Internet gateway machine.

The `–r IPaddr | hostname ...` option enables the BOOTP relay agent. The proper entries need to be made to the `netmasks` database so that the DHCP server served by the BOOTP relay agents can identify the subnet mask of the foreign BOOTP/DHCP client's network.

After you install the BOOTP relay agent, entries must be added to the distributed DHCP databases so the DHCP servers can service clients sending requests through the BOOTP relay agent.

The macro option (`–M`) for PNTADM command is a mechanism that permits the network administrator to select configuration parameters to be returned to clients using a particular IP address. It can also be used to deliver a macro with server-specific information by including this macro definition in all `dhcp_network` database entries owned by a specific server.

Leases

The DHCP/BOOTP server calculates a client's IP address lease using information contained in the `dhcptab` and `dhcp_network` databases. The server consults the `LeaseTim` and `LeaseNeg` symbols in the `dhcptab` database, and the `Flags` and `Lease` fields of the chosen `dhcp_network` database record.

The server first examines the `Flags` field for the identified `dhcp_network` record. If the `PERMANENT` or `BOOTP` flag is on, then the client's lease is considered permanent.

If the `PERMANENT` flag is not on, then the server checks to see if the client's lease, as represented by the `Lease` field in the `dhcp_network` record, has expired. If it has not, the server checks to see if the client has requested a new lease. If the `LeaseNeg` symbol has not been included in the client's `dhcptab` parameters, then the client's

requested lease extension is ignored, and the lease is set to be the time remaining as shown in the `Lease` field.

If the `LeaseNeg` symbol has been included, the server extends the client's lease to the value it requested, provided this requested lease is less than or equal to the current time plus the value of the client's `LeaseTim` `dhcptab` parameter. If the client's requested lease is greater than policy allows (the policy is the value of `LeaseTim`), then the client is given a lease equal to the current time, plus the value of `LeaseTim`. If `LeaseTim` is not set, then the default `LeaseTim` value is one hour.

CHAPTER 15

Moving to DHCP

This chapter discusses the differences between DHCP, BOOTP or RARP protocols. It describes the advantages of DHCP and explains how to migrate to DHCP.

Why Move to DHCP?

A user who is used to BOOTP or RARP might wonder about the differences and advantages of DHCP. The main difference between DHCP and the older protocols is that the older protocols were designed for manual pre-configuration of the host information in a server database, while DHCP allows dynamic allocation of IP addresses and configurations to newly attached hosts.

In addition, DHCP's leasing mechanism permits automatic recovery and reallocation of IP addresses. DHCP is a superset of BOOTP, offering greater flexibility. DHCP builds on BOOTP using the same protocol packet format and mechanisms with certain additions. In this way, DHCP can leverage the BOOTP relay agent functionality already built into routers, and support BOOTP clients directly.

RARP allows a machine to discover its own IP address, which is one of the protocol parameters typically passed to the client system by DHCP or BOOTP. The disadvantage of RARP is that it doesn't support other parameters, and a server providing it can serve only directly attached networks.

DHCP and BOOTP traffic can utilize BOOTP relay agent functionality built into common routers. This means the network administrator does not have to place a BOOTP service on every network segment.

When administrators try to support manually configured IP addresses, they are faced with a number of difficulties:

- There is no way to detect reliably whether an IP address is still in use.
- Any time the network topology changes, such as adding a new network IP address, the administrator has to add new IP addresses manually.
- Hosts configured on one network and then moved to another are not able to communicate without having their configuration manually changed.

Advantages of DHCP

DHCP servers offer a number of advantages over earlier methods of getting IP addresses. Here are the features a DHCP server can offer.

1. Automatic management of IP addresses, including the prevention of duplicate IP address problems
2. Allows support for BOOTP clients, so you can easily transition your networks from BOOTP to DHCP
3. Allows the administrator to set lease times, even on manually allocated IP addresses.
4. Allows limiting which MAC addresses are served with dynamic IP addresses
5. Allows the administrator to configure additional DHCP option types, over and above what is possible with BOOTP
6. Allows the definition of the pool or pools of IP addresses that can be allocated dynamically. A user might have a server that forces the pool to be a whole subnet or network. The server should not force such a pool to consist of contiguous IP addresses.
7. Allows the association of two or more dynamic IP address pools on separate IP networks (or subnets). This is the basic support for secondary networks. It allows a router to act as a BOOTP relay for an interface which has more than one IP network or subnet IP address.

Here are some features that are not part of the DHCP server itself, but related to the way it is administered.

1. Central administration of multiple servers
2. The ability to make changes while the server is running and leases are being tracked. For example, you can add or take away IP addresses from a pool, or you can modify parameters.

3. The ability to make global modifications (those that apply to all entries) to parameters, or to make modifications to groups of clients or pools
4. The maintenance of a lease audit trail, such as a log of the leases granted

DHCP supports four strategies for IP address allocation. These are independent features. A particular server can offer any or none of them.

- Manual. The unique client identifier-to-IP address binding has been made by an administrator. Therefore the DHCP service should not reallocate IP addresses of this type to other clients after the lease expires. This type of IP address allocation is useful when the administrator wants a host to maintain the same IP address but still wants to detect when an IP address is no longer being used. An example is a host that provides a service located by the IP address, like mail.
- Permanent. The server's administrator creates a configuration for the server that includes only IP addresses, and gives this configuration to clients. After an IP address is associated with a MAC address, the association is permanent unless the server's administrator intervenes. Allocating permanent IP addresses has the drawback that such IP addresses cannot be reclaimed automatically.
- Dynamic (through leases with limited duration). The server tracks leases and gives IP addresses to DHCP clients automatically as they become available when leases expire. No interaction is needed by the administrator. This is the preferred IP address type for non-BOOTP clients.
- BOOTP. Addresses that are reserved for use by BOOTP clients. This allows an administrator to enter a pool of IP addresses intended only for BOOTP clients.

Migration

Since DHCP is based on BOOTP and the BOOTP packet structure, migrating to DHCP is easy for most sites. Many DHCP servers support both old BOOTP and new DHCP clients.

Since the Solaris DHCP server handles BOOTP queries as well as DHCP queries, a BOOTP client can boot from a DHCP server. If a DHCP client is written to use the answers from a BOOTP server, a DHCP client can boot from a BOOTP server. The TCP/IP stack included with Windows 95 does not have this capability.

Subnets

DHCP client messages are sent to remote servers by BOOTP relay agents, which are often a feature of an IP router. Through the BOOTP relay agent, the DHCP server can tell which subnet a request came from. The BOOTP relay agent records which subnet

the message came from in the DHCP message header. Then the DHCP server can use it to determine which network the client is on.

You cannot run a BOOTP server and a DHCP server on the same machine, because they both use the same port number. You can use the Solaris DHCP server to serve BOOTP clients by turning on BOOTP compatibility mode.

With the DHCP protocol, a client that already has a leased or permanent IP address can get another lease on a temporary basis on another subnet. This is helpful for machines that sometimes must be moved from one location to another. This option is available if the server implementation supports such a feature.

Routers

DHCP requires non-volatile storage. This makes the task of DHCP service compatible with servers, but incompatible with dedicated routers. There are a number of server types that can be configured to both relay and serve DHCP, especially all-in-one Internet Gateways designed to be web servers, firewalls, and so forth. But there are no dedicated routers.

The DHCP RFC specifies that DHCP is not intended for use in configuring routers. The reasons are that in maintaining and troubleshooting a router, it is important to know its exact configuration, rather than leaving that to be established automatically, and that you do not want your router's operation to depend on the working of yet another server.

You may be able to configure some types of more general purpose computers or servers to get their IP addresses from DHCP and to act as routers. In addition, there are remote access servers, which are usually not true routers, which use DHCP to get IP addresses to give to their clients.

CHAPTER 16

Administration of DHCP

This chapter describes how to administer DHCP, including setting up a network running DHCP, determining a lease time policy, and adding BOOTP relay agents. It also talks about the types of databases DHCP uses and how to create macros within certain databases. It discusses the various options that are implemented in or can be added to DHCP.

Collecting Information Before Setting Up a DHCP Service

To set up a network running DHCP, you must first collect information about your existing network. This includes information about its topology, such as routers, switches, other networks, and services such as name services, file and print services, and so on.

If you plan to support clients on remote networks (clients on a different network from the networks on which you plan to deploy your DHCP services), you must also collect the remote networks' subnet masks, providing the remote network is subnetted. Be sure your `netmasks` (see **`netmasks`**(4)) table, which will be used by your DHCP service, has been updated with this information. You must also collect the IP addresses of the routers on the remote network, or configure clients on the remote network to use router discovery.

After you get all the necessary information, you must decide whether to store data that will be moved across the network in NIS+ or in files. NIS+ is the preferred storage for a multiple service environment, or for an enterprise environment. Files is the preferred storage for a single server, or small environments. After you have collected this information, run **`dhcpconfig`**(1M) and configure your remote network.

Choosing a Data Store for DHCP Data

Configuring DHCP name services involves determining which data store resource the DHCP server will use to store its tables and to access host information. The `dhcpconfig` script sets the DHCP service in the `/etc/default/dhcp` file. The runtime daemon and administrative utilities will use this file to determine which name service to contact during processing.

How the Datastore Service is Selected

The `dhcpconfig` command first determines whether NIS+ or files is currently being used by the server system. If NIS+ is currently being used by the system, then `nisplus` is the default value in the `Enter data store` prompt. Otherwise, `files` is the default.

If you choose NIS+ and the server is *not* running NIS+, a warning message is displayed and you are told how to set up NIS+. The `dhcpconfig` script continues

(although it is likely that errors will occur in the next section when creating DHCP tables).

NIS+ should be used if you have an environment with multiple servers, or an enterprise environment. With NIS+, data can be shared among servers. Files can be used if you have only a single server unless you arrange to share data using NFS.

Create Initial DHCP Tables

The `dhcpconfig` script creates the following empty DHCP tables in the datastore you selected as shown in Table 16–1.

TABLE 16–1 Tables Created by the `dhcpconfig` Script

`dhcptab`	DHCP configuration information table
`dhcp_network`	DHCP client mapping tables, one per network served by the DHCP server

DHCP Tables

DHCP uses two types of databases: network tables and a `dhcptab` configuration macros table. These databases are NIS+ tables if you are using NIS+, or files if you are not using NIS+.

DHCP Network Tables

A DHCP network table contains information related to IP address allocation. Each network has a separate network table. The tables, called `dhcp_network` tables in DHCP, derive their names from the IP address of the network they serve. For example, the network table for the network 120.146.5.0 is `120_146_5_0`, with underscores replacing periods in the IP address notation.

Each subnet in a DHCP network has a `dhcp_network` table containing entries for the clients in the subnet. When a client boots and a DHCP server answers its request for parameters, information is recorded as a `dhcp_network` entry for the client. Among other information, the table includes the client's IP address and a pointer into the `dhcptab` table.

A network table contains the following specific information:

- IP addresses, both assigned and unassigned
- Client identifier (for assigned records only)
- Lease expiration time
- Flag that indicates the type of lease: dynamic, permanent, manual, unusable or BOOTP only
- Name of the `dhcptab` configuration macro for each IP address
- IP address of the server that owns the original client IP address

The network table functions as a list of the IP addresses that DHCP servers can assign on a particular network. Each network has its own network table. The key element in the network table is the list of IP addresses. All other elements in the table are significant in relation to the IP address. For example, the client ID identifies the client to which a particular IP address is currently assigned. If the IP address is not currently assigned, then the client ID for that IP address is zero. The expiration time is also zero. When the IP address is assigned, then the client ID and lease expiration time are filled in.

In certain implementations, the client ID becomes the hardware address of the client machine, with a prefix that indicates the network type. For example, a client with an Ethernet address would have `0102608BA614C1` as its client ID, where `01` indicates that the client is an Ethernet network. Other implementations of DHCP may use other identifiers, such as DNS names or property numbers. The important thing is that the client IDs must be unique within the network.

When an IP address is assigned, the lease expiration time for that IP address is set to a specific date and time, or it is marked “No Expiration.”

The `lease` flag and the `dhcptab` configuration macro name are the same, regardless of whether the IP address is currently assigned to a client. When a client gets a particular IP address, it also gets the type of lease specified by the `lease` flag and the configuration specified by the property name. The `lease` flag indicates the conditions under which the IP address can be assigned. The `pntadm` command manages the `dhcp_network` table. Example 16–1 shows an example of `pntadm` output.

EXAMPLE 16–1 Sample Output: `pntadm` –P *129.146.86.0*

```
Client ID      Flags Client IP       Server IP       Lease      Macro    Comment
                                                     Explanation

010800207CBA2C  04   129.146.86.153  129.146.86.181  Zero       mrcoffee
0108002022519C  00   129.146.86.205  129.146.86.181  7/3/1996   inet11
01080011043B65  08   129.146.86.29   129.146.86.181  Zero       inet11
0100A024A9BCEE  08   129.146.86.198  129.146.86.181  7/22/1996  inet11
0100A024A791DE  00   129.146.86.200  129.146.86.181  8/4/1996   inet11
0100A02463D6EC  00   129.146.86.199  129.146.86.181  8/1/1996   inet11
```

```
0100A024636AB7  00   129.146.86.201  129.146.86.181  8/3/1996   inet11
010080C72EE4A3  00   129.146.86.206  129.146.86.181  7/5/1996   inet11
010020AF4A3B31  0    129.146.86.214  129.146.86.181  Zero       hobbs
00              00   129.146.86.202  129.146.86.181  Zero       inet11
```

The dhcptab ConfigurationTable

The `dhcptab` table contains information related to client configuration. The table is organized as a series of macro definitions that contain all of the information necessary to configure a network client. A client gets its configuration when it is assigned an IP address from the network table. The macro name associated with the IP address corresponds to a macro name in the `dhcptab` table. After a client gets an IP address from the network table, it gets its network configuration from the `dhcptab` table.

During the initial configuration of the DHCP server, the `dhcptab` table is created with macros for each configured network. Each of these macros contains information specific to the network, including subnet mask, network broadcast address, IP packet time to live, maximum datagram size, default router, static routes, DNS domain, NIS domain, DNS servers, and NIS servers, if these are available when the server is configured.

You can control how client machines access a network by changing the information contained in the macros. For example, changing the name of the macro that a particular client machine uses changes the network configuration of that machine. In a different example, changing a single option within a macro changes the reactions of all the machines that use that macro set. The ability to manage IP addresses is one of the major features of DHCP. The `dhtadm` command manages the `dhcptab` server configuration table. Example 16–2 shows an example of `dhtadm` output.

EXAMPLE 16–2 Sample Output: `dhtadm –P`

```
Name          Type    Value

mrcoffee      Macro  :Subnet=255.255.255.0:Router=129.146.86.1:Broadcst=129.146.86.255: \
                     :BootSrvA=129.146.86.175:BootFile="/export/root/JavaDesktop/kona": \
                     :NISservs=129.146.86.33:NISdmain=sunsoft.eng.sun.com: \
                     :DNSdmain=Eng.Sun.COM: \
                     :DNSserv=129.146.1.151 129.146.1.152 129.144.1.57 129.144.134.19: \
                     :Include=Locale: \
                     :Timeserv=129.144.1.3:LeaseTim=3600:T1Time=1800: \
                     :T2Time=3060:

Locale        Macro  :UTCoffst=25200:SN_TZ="PST8PDT":

inet11        Macro  :Include=Locale:Timeserv=129.146.86.181:LeaseTim=259200: \
                     :DNSdmain=Eng.Sun.COM: \
                     :DNSserv=129.146.1.151 129.146.1.152 129.144.1.57 129.144.134.19:

hobbs         Macro  :Subnet=255.255.255.0:Router=129.146.86.1:Broadcst=129.146.86.255: \
                     :BootSrvA=129.146.86.32:BootFile="819256D6.PREP":

129.146.89.0 Macro  :Subnet=255.255.255.0:Router=129.146.89.1:Broadcst=129.146.89.255: \
                     :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.89.33: \
```

```
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.88.0 Macro  :Subnet=255.255.255.0:Router=129.146.88.1:Broadcst=129.146.88.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.88.33: \
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.87.0 Macro  :Subnet=255.255.255.0:Router=129.146.87.1:Broadcst=129.146.87.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.87.33:
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.86.0 Macro  :Broadcst=129.146.86.255:Subnet=255.255.255.0:MTU=1500: \
                    :Router=129.146.86.1:NISdmain=sunsoft.eng.sun.com: \
                    :NISservs=129.146.86.33:NetBNms=129.146.171.31:NetBNdT=8: \
                    :BootSrvA=129.146.86.32:

129.146.85.0 Macro  :Subnet=255.255.255.0:Router=129.146.85.1:Broadcst=129.146.85.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.85.33: \
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.84.0 Macro  :Subnet=255.255.255.0:Router=129.146.84.1:Broadcst=129.146.84.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.84.33: \
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.83.0 Macro  :Subnet=255.255.255.0:Router=129.146.83.1:Broadcst=129.146.83.255: \
                    :NISdmain=sunsoft.eng.sun.com: \
                    :NISservs=129.146.83.33:NetBNms=129.146.171.31:NetBNdT=8:

129.146.82.0 Macro  :Subnet=255.255.255.0:Router=129.146.82.1:Broadcst=129.146.82.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.82.33: \
                    :NetBNms=129.146.171.31:NetBNdT=8:

129.146.81.0 Macro  :Subnet=255.255.255.0:Router=129.146.81.1:Broadcst=129.146.81.255: \
                    :NISdmain=sunsoft.eng.sun.com:NISservs=129.146.81.33: \
                    :NetBNms=129.146.171.31:NetBNdT=8:

SN_TZ        Symbol Vendor=SUNW,13,ASCII,1,0
```

Configure Each Subnet for DHCP

This section discusses using `dhcpconfig` to configure subnets, based on your responses to three questions for each subnet:

- What range of IP addresses do you want to be searched for unused IP addresses to allocate?
- Do you want the DHCP daemon to respond to requests for a specific subnet?
- For each monitored subnet, how many clients do you want to be assigned dynamically-allocated IP addresses?

How Each Subnet for DHCP is Configured

The `dhcpconfig` script creates a table—called the `dhcp_network` table—for each subnet being configured on the server system. The table name is the same as the IP address, but with decimal points replaced by underscores. For example, the subnet `129.148.5.0` has a `dhcp_network` table `129_148_5_0` in the name service being used by DHCP. For NIS+, this is a table in the `org_dir` object. For files, this is a file in the `/var/dhcp` directory.

Each client system being managed by DHCP has an entry in the `dhcp_network` table (the table corresponding to the subnet on which the client machine is attached). Entries may be *permanent*, with the IP address permanently assigned to the machine. Or, entries may be *dynamic*, where the DHCP server assigns an IP address when the client is first configured and provides a *lease*, a specified amount of time for which the IP address can be used. It is these dynamic clients that this step attempts to set up. Permanent clients can be set up with `pntadm` after the DHCP environment is fully configured.

Start the DHCP Service Daemon

This section describes three functions performed by the `dhcpconfig` script:

- Installs the `start/stop` script for the DHCP daemon processes into the `/etc/init.d` directory
- Sets up links to this script in the `/etc/rc{0,3}.d` directories
- Starts the daemon processes

The start/stop script is named `dhcp` and the links are `S34dhcp` (to start the daemons) and `K34dhcp` (to stop the daemons). This follows standard SVR4 procedure for daemon process execution at boot time.

One daemon process, `in.dhcpd`, is started. The `in.dhcpd` daemon is the DHCP server process, which responds to the client DHCP requests and forwards the network configurations, which have been established in the `dhcptab` table.

Lease Time Policy

DHCP provides a mechanism for dynamically allocating IP addresses. These IP addresses carry a lease period, which you can set to permanent or temporary. Your site policy must include decisions about the number of temporary and permanent IP addresses, and the lease period of temporary IP addresses.

To reap the most benefit from your DHCP service, it's best to allow DHCP to dynamically manage your IP address assignment for you. With DHCP, the client and

the server negotiate a loan of an IP address configuration for a certain time period, known as a lease time. You can set a lease time policy based on server, network, client vendor class, or individual client IP address through the use of the `LeaseTim` and `LeaseNeg` symbols in certain macro definitions in your `dhcptab`.

The `LeaseNeg` and `LeaseTim` symbols allow you to set policy for your site. `LeaseTim` is a relative time, such as 24 hours, or 2 hours, or 10 hours. When a client is assigned an IP address (or renegotiates a lease on an IP address it is already assigned), the `LeaseTim` value is added to the absolute time the client received its DHCP reply. Absolute time is the time now, such as September 27, 1996. The `LeaseTim` value plus the absolute current time is stored in the client's `dhcp_network` record as an absolute future time when the client's lease on its IP address expires.

The `LeaseTim` symbol setting defines the maximum lease time interval you allow to clients. Typically, this value should remain relatively small, so that: clients and servers stay in synch; IP addresses that are not being used are reclaimed in the most timely fashion; and the renumbering of networks happens more smoothly.

However, the value must be large enough so that if your DHCP server becomes unavailable, your clients continue to function until the machine(s) running the DHCP service can be repaired. One to 3 days is an optimal `LeaseTim` policy. Select values that work well in your environment.

The `LeaseNeg` symbol determines whether or not a client can renegotiate its lease with the server before the lease expires. If this symbol is present, then the client can renegotiate its lease. `LeaseNeg` allows clients to operate on the network without lease-related interrupts of existing connections.

Omitting `LeaseNeg` is useful for environments where you have more machines than you have IP addresses, and thus want to enforce a time limit on the use of any IP address. Enforcing a time limit on machines in a Computer Science class lab is an example of this. Like `LeaseTim`, `LeaseNeg` can be used in a variety of different macros in your `dhcptab`. See **`dhcptab`**(4) and **`dhcp_network`**(4) for more information.

Machines that export services such as mail or web pages must retain their IP address. However, you'd still like to be able to detect when the IP address used by this node is no longer being used (perhaps when the machine is retired). You can achieve this by marking this node's `dhcp_network` record as being manually assigned (by you) and by setting the node's flag field to MANUAL. For example, if the hostname is *gandalf* and the network is *10.50.0.0*, type **`pntadm gandalf –f MANUAL 10.50.0.0`**.

You can allocate IP addresses with permanent leases. However, you will not be able to use the DHCP service to automatically reclaim these IP addresses for you. Therefore, keep the number of permanent IP addresses to a minimum, manageable number.

The DHCP service uses this field to determine when `dhcp_network` record entries have expired and can be reclaimed. You can alter this value through the `e` option of the `pntadm` command. Through this command, you can set a client's lease expiration

time to the past, although we recommend that you only set it into the future to avoid adversely affecting the client and the client's user(s).

Each time the DHCP service allocates a dynamic IP address or renegotiates a lease on an existing binding, this field in the `dhcp_network` table is updated.

The `lease` flag indicates the conditions under which the IP address can be assigned. The flag setting can be a combination of the following:

`0 (Dynamic)`	The IP address lease has an expiration time. When the lease expires it can be renewed, if that is indicated by the site policy. If the current client does not renew the lease, then the IP address can be assigned to another client. When the flag is set to 0, the client can request that the lease time be changed.
`1 (Permanent)`	The IP address lease is assigned permanently, and the client cannot change the lease time. However, the client using the IP address can release it. When it is released, it can be assigned to another client.
`2 (Manual)`	The IP address is assigned to a specific client machine. It cannot be released by the client. As long as the flag is set to 2, the IP address can be reassigned only if an administrator changes it manually.
`4 (Unusable)`	The IP address is unusable. You can set the flag to 4 to prevent an IP address from being assigned. The DHCP server marks an IP address as unusable if it attempts to locate the IP address and finds that it is already in use. Before it assigns an IP address, the DHCP server normally `ping`s it to see if it is already in use for some reason. This setting is configurable in `dhcpconfig`.

The flag can also have a combination of settings. For example, if the flag is set to `3`, it is a combination of `1` and `2`; that is, it is both permanent and manual. The IP address has a permanent lease, and was assigned by the administrator.

Setting Up a BOOTP Relay Agent

First, determine if your router or routers has a built-in relay agent. If the router does, read the documentation to understand how to use the relay agent. If your router does not have a built-in relay agent, choose a Solaris 2.6 machine on the client's

network to act as the relay agent. Install `SUNWdhcsr` and `SUNWdhcsu` on the machine. Then run `dhcpconfig` and select `Configure BOOTP relay agent`.

Enter the IP addresses or hostnames of the BOOTP/DHCP servers to which you want to send BOOTP/DHCP requests.

Standard DHCP Options

The Solaris DHCP server implements all of the standard DHCP options. These options contain network information such as:

- Server names
- Router address
- DNS Domain Name
- TCP Time to Live
- Connection options
- Server options
- IP layer options
- Time options

Vendor Options

Vendor options are DHCP options that are defined by the DHCP client software vendor. When a client broadcasts a request for a configuration, the client includes its vendor client class. If this client class matches any client classes in the `dhcptab` database, then the options specified for that class are sent to the client, along with other configuration options. The Solaris DHCP server can be configured to support any DHCP client vendor's options.

Adding Vendor and Site Options

To create additional vendor or site options, you must define:

- Vendor class, which is the name used to distinguish clients by vendor. The class name is an ASCII character string. It is not specified when you are defining a site option.

- Value type, which specifies the type of data contained in this option. The supported data types are:
  - ASCII text
  - Octet, an ASCII representation of binary data
  - IP, the dotted decimal form of an Internet address
  - Number, an 8-bit, 16-bit, 32-bit, or 64-bit number
- Option Code, which is the DHCP option number you want to assign to the new options. Vendor codes can be between 1 and 254; site codes can be between 128 and 254.
- Granularity, which specifies how many objects of this value type make up a single instance of this option. For example, the static route symbol is a list of routes. Each route consists of two IP addresses, so the value type is defined as *IP* and the granularity is defined as *2*.
- Length, which specifies the minimal granularity permissible in this option. For example, a subnet mask can be only one IP address, so the length for the subnet mask option is 1. A value of zero means that a variable number of items, up to 16, is permitted.

Because site options are specific to your site, you can create any meaningful option. In the case of vendor options, however, you can add only options that are meaningful to a specific client vendor. Some options are predefined, but others must be created. In that case, you may need to create a list of vendor options on the server that are appropriate to the specific vendor. The list typicall is provided by the client vendor.

Creating Macro Definitions

When you create a macro for the `dhcptab` table, you must specify all of the relevant standard, vendor, and site options. You do not have to specify all the options available. How many you specify depends on how your network is configured.

IP Address Leases

IP address leases are assigned as temporary by default. Temporary leases are useful if users and their machines change subnets frequently, or if systems come in and out of use fairly often.

Each site can specify whether the temporary leases on the site are renewable. You can set this site policy in the properties table with the `LeaseNeg` symbol. If you omit

this symbol, the client cannot renegotiate its lease when it expires. If a client does not renew its IP address when it expires, it can be reused.

Customization Examples

To change an NIS server value for the network *126.147.100.0*:

1. **Edit the macro** `129.147.100.0` **with**:

```
dhtadm -M -m 129.147.100.0 -e 'NISserv = 129.147.100.1 129.147.100.2'
```

2. **Type**:

```
/etc/init.d/dhcp stop
```

3. **Type**:

```
/etc/init.d/dhcp start
```

Or, instead of steps 2 and 3, use the –`t` option to `in.dhcpd`.

To add addresses from *10-15* to *129.147.100.0*

```
for addr in 10 11 12 13 14 15
do
 pntadm -A 129.147.100.$addr -m server -h hundred-$addr 129.147.100.0
done
```

To add a symbol definition for a timezone; SN_TZ

1. **Type**:

```
dhtadm -A -s SN_TZ -d  'Vendor="SUNW.PCW.LAN SUNW.Solaris", 13, ASCII, 1, 0'
```

2. **Type:**

```
dhtadm -M -m Locale -e ':SN_TZ = "EST5EDT4":'
```

3. **Type:**

```
/etc/init.d/dhcp stop
```

4. **Type:**

```
/etc/init.d/dhcp start
```

or –`t` **option**

To delete the `Timeserv` value from the *jurassic* macro:

1. **Type:**

```
dhtadm -D -m jurassic -e 'Timeserv='
```

2. **Type:**

```
/etc/init.d/dhcp stop
```

3. **Type:**

```
/etc/init.d/dhcp start
```

or –`t` **option**

Always return hostnames to the client of the server *jurassic*.

1. **Type:**

```
dhtadm -M -m jurassic -e 'Hostname= _NULL_VALUE_'
```

2. **Type**:

```
/etc/initd/dhcp stop
```

3. **Type**:

```
/etc/init.d/dhcp start
```

or –t **option**

If it is important to maintain the hostname-to-IP address association for a host named *canoepoint* to an IP address association, mark the *canoepoint* entry on the *peds* network as MANUAL.

1. **Type**:

```
pntadm -M canoepoint -f MANUAL peds
```

or

2. **Type**:

```
pntadm -M canoepoint -f 02 peds
```

In order to mark *129.147.100.87* as BOOTP and permanent:

1. **Type**:

```
pntadm -M 129.147.100.87  -f 'BOOTP + PERMANENT' 129.147.100.0
```

or

2. **Type**:

```
pntadm -M 129.147.100.87 -f 09 129.147.100.0
```

Maintenance

This shell script first checks any IP addresses marked as unusable to verify that they are not in use. If they are not, the script then reclaims the IP addresses.

```
#!/bin/ksh
# This shell script reclaims addresses which were marked as unusable, after
# first verifying that they're no longer in use.

if [ ${#} -eq 0 ]
then
     echo "reclaim <network> ..." >&2
     exit 1
fi

while [ ${#} -ne 0 ]
do
     pntadm -P ${1} | awk ' $2 == 04 { printf("%s %s\n", $1, $3); }' |
     while read cid addr
     do
        if [ ${?} -ne 0 ]
        then
             pntadm -M ${addr} -i 00 -f DYNAMIC -e 0 ${1}
             if [ ${?} -eq 0 ]
             then
                 echo "${addr} has been reclaimed from client ${cid}."
             fi
             else
                 echo "${addr} is in use!" >&2
             fi
     done
     shift
done
exit 0
```

Enabling the Solaris DHCP Client

By default, the Solaris DHCP client is disabled. To enable it, you must create a DHCP enable file for each network interface you want to configure with DHCP. The format of the DHCP enable file is: `/etc/dhcp.`*interface_name*, where *interface_name* is the name of the network interface you want configured by DHCP.

For example, if you would like to configure network interface *le1* using DHCP, you would create the empty file `/etc/dhcp.le1`. If you have multiple network interfaces that you would like to configure using DHCP, you must create a DHCP enable file for each interface.

Increasing Boot Process Suspension Time

Using DHCP to configure an interface may increase the boot time. In particular, if no DHCP server is present to answer the client's requests, a delay of approximately 30 seconds occurs for each interface. If you want your Solaris DHCP client to suspend the booting process until the network interface is configured (regardless of how long this takes), edit the network interface's DHCP enable file (`/etc/dhcp.`*interface_name*) and add the phrase `wait forever`.

If you want your client to suspend its booting process for a shorter period of time, you can specify the number of seconds to wait instead of using the keyword `forever`. For example, if you want to allow DHCP one hour to configure the network interface before the booting process continues, specify `wait 3600`.

Note - Even if the suspend time is exhausted, the Solaris DHCP client will continue asynchronously to configure the network interface until it is successful. To avoid this, you can specify the `drop` option to the **`ifconfig`**(1M) command. For example: `ifconfig` *le0* `dhcp drop`. This will remove the specified interface (in this case, *le0)* from the control of the DHCP agent, which should cause the asynchronous address allocation attempts to terminate.

Designating a Network Interface as Primary

Many DHCP configuration parameters are not specific to a network interface. Instead, the parameters specify more general information. Examples of this type of general parameter are: NIS server, NIS domain, DNS servers, and DNS domain. If your Solaris machine has only a single network interface, there does not need to be a distinction between the general and interface-specific parameters.

However, if your machine has multiple network interfaces (it is multihomed), and DHCP is to configure more than one interface, then it is possible to receive multiple sets of general configuration parameters that may conflict. For example, which DNS parameters should be used? Those received when using DHCP to configure interface *le0* or those received for *le1*?

The Solaris DHCP client solves this problem by allowing you to specify one network interface as the primary network interface. Interface-specific parameters (such as subnet mask) will be retrieved from the DHCP parameters for that specific interface. General parameters are retrieved only from the DHCP information received on the primary interface.

To designate a network interface as the primary interface, add the keyword `primary` to the DHCP enable file for that interface. For example, suppose you want to use *qe2* as the primary interface. Edit `/etc/dhcp.qe2` and add the word `primary`.

If the keyword `primary` is not added (no interface has been designated as primary), the Solaris machine receives parameters from the first interface that is configured successfully.

Network Topologies That Limit Effective Use of DHCP/BOOTP

DHCP and BOOTP clients initially have no information about the local IP network, and therefore use the 0.0.0.0 (the default network address) for their IP address. The clients send their DHCP or BOOTP requests to the 255.255.255.255 IP address (broadcast address) which will be received by all IP devices attached to the local IP network.

DHCP and BOOTP servers determine the client's IP network attachment based on following factors:

1. Which network hardware interface the DHCP or BOOTP request was received on?

2. Was the DHCP or BOOTP request received from a BOOTP relay agent?

   BOOTP relay agents insert the IP address of their network hardware interface that is attached to the same IP network as the DHCP or BOOTP client. The absence of this IP address signals to the server that the client is on a directly-attached IP network. The presence of this IP address indicates that the client is attached to an IP network remote from the server and that the server is to send responses back to the client using the BOOTP relay agent's IP address.

3. Is the IP network the client is attached to subnetted?

   The servers, using the IP address as a key, consults the contents of the netmasks table (which contains subnet mask information) using either:

   - The IP address of the server's network hardware interface if the client is on a directly-attached IP network (indicated by an IP address of 0.0.0.0 in the packet's relay address field)
   - The IP address specified if a BOOTP relay agent specified its IP address in the client's request

   (See **`netmasks`**(4) for information on netmasks.)

This procedure for determining the client's IP network attachment is only effective if there is only one IP network present on the network hardware media (for example, Ethernet). DHCP does not work well in IP network environments where, either through the use of multiple network hardware interfaces or multiple logical interfaces, there is more than one IP network sharing the same network hardware media. In this case, a DHCP client's request appears on all network hardware interfaces, making the client "appear" to be attached to all of the IP networks simultaneously. Since DHCP servers dynamically allocate IP addresses to requesting clients, the server is unable to determine which IP address to allocate to the client. DHCP clients, attempting to validate IP addresses they presently hold, will be seen to originate on all the logical IP networks, not just the network the client has been assigned to.

Such network topologies should be avoided, either though the use of Variable Length Subnet Masks (VLSM) to preserve the one-to-one mapping of IP network to network hardware media through more efficient subnetting, or by configuring the DHCP or BOOTP service to serve just one of the logical IP networks. See **`netmasks`**(4) for additional information.

CHAPTER 17

Troubleshooting DHCP

This chapter describes how to troubleshoot problems you may encounter while using DHCP. It includes solutions to problems you may have when installing and configuring the first DHCP server. To further help you troubleshoot server problems, this chapter also includes background information about the DHCP server configuration script (`dhcpconfig`) - the purpose of various script components and how the script executes installation procedures. It also describes problems you may encounter as you add your first and subsequent DHCP clients to the network.

Strategies and Tips

The following troubleshooting techniques are helpful in solving problems when you cannot isolate the cause:

- Use the snoop command to monitor network traffic.
- Run the DHCP client in debug mode.
- Run the DHCP server in debug mode.
- Reboot the DHCP client.
- Stop the DHCP server. Then start it again.

This chapter describes these techniques in more detail. It also tells you where to get more information when you cannot solve a problem using this guide.

Using snoop to Monitor Network Traffic

You can use the snoop command to monitor network traffic.

▼ To Use snoop to Monitor Network Traffic

1. **Log in to the root account on a Solaris server or BOOTP/DHCP relay agent on the same subnet as the client.**

2. **Use the** snoop **command to trace network traffic. For example**:

```
snoop -o /tmp/output udp port 67 or udp port 68
```

3. **Boot the client and watch the DHCP message exchange between the client and server(s).**

4. **Type**:

```
snoop -i /tmp/output -x 0 -v
```

You can limit the scope of snoop by specifying the client's hardware address. A version of snoop that understands the DHCP/BOOTP protocols is available starting in Solaris version 2.5.

Running the DHCP Client in Debug Mode

Running the DHCP client in debug mode reveals much of the ongoing dialogue between the client and the server. Refer to the documentation for the product on which you are running the client.

▼ To Run a Solaris Client in Debug Mode

Debugging the DHCP client is only possible after it has booted. If DHCP problems are experienced, you must boot with DHCP disabled. The steps here can be performed only once after the host has booted, preferably in single-user mode.

1. **The DHCP agent can be configured to log details of the packets exchanged with the server. To do this, the agent must be started with debug mode turned on:**

```
/sbin/dhcpagent -n -d3 &
```

The -d3 flag turns on debug at leve1 3, and the -n flag says "don't configure the interface even if DHCP is successful".

Note - Level 3 and levels below that return appropriate information for the user. Levels above level 3 are appropriate only for developers or those with even more expertise, since they return raw packets of information.

---

2. **Only one instance of** dhcpagent **can run at a time, so before the agent can be started in this manner, any previously invoked agent must be stopped. To do this, find the agent's process ID and send it the terminate signal:**

```
kill -TERM process_id_of_dhcpagent
```

3. **After an agent has been started in debug mode, try to configure an interface manually by typing:**

```
ifconfig interface_name auto_dhcp
```

The packets that are sent, and any that are received, will be displayed.

Note - During the time that DHCP tries to configure an interface, the interface is unable to send or receive packets. Other network services, such as NIS or NFS, may be adversely affected while the interface is down.

▼ To Run the DHCP Server in Debug Mode

♦ **Stop and restart the DHCP server in debug mode.**

For example:

1. **Stop the server using the shutdown script:**

```
/etc/init.d/dhcp stop
```

2. **Restart the server in debug/verbose mode, using the** `-d` **and** `-v` **flags in addition to any flags specified in the** `/etc/init.d/dhcp` **startup script. For example, if the** `i` **option is present, type the command in the following format:**

```
/usr/lib/inet/in.dhcpd -i interface_names  -d -v
```

Restarting the DHCP Client

Once you have run the DHCP client in debug mode, you can try rebooting. Rebooting resets the network hardware and software.

▼ To Restart the DHCP Client

1. **Reboot the client.**

▼ To Restart the DHCP Server

1. **Log in to the DHCP server as root.**

2. **Type:**

```
/etc/init.d/dhcp stop
```

Wait about 10 seconds.

3. **Type:**

```
/etc/init.d/dhcp start
```

▼ To Restart the DHCP Server After Debugging is Completed

1. **Restart the DHCP server daemons.**
2. **Log in to the DHCP server as root.**
3. **Type:**

```
/etc/init.d/dhcp stop
```

Wait about 10 seconds.

4. **Type:**

```
/etc/init.d/dhcp start
```

Common Problems

This section describes some of the more common problems you may encounter with DHCP, and what to do about them.

Problem

The DHCP client is sending out DHCPDISCOVER or DHCPREQUEST messages, but the DHCP server is not responding.

Verification: Check the server machine's console. It may not have any IP addresses left to allocate.

Solution: Add more IP addresses.

Verification: Check the server machine's console. If the server is stating that the client is unrecognized, then the DHCP server's databases may have been flushed, with the result that the server fails to recognize the client.

Solution: Remove any DHCP cache file on the client.

1. **Interrupt the boot by typing `Control –C`.**

2. **Remove the cache by typing:**

```
cd /etc/dhcp;
rm interface_name.dhc
```

3. **Restart the initialization process by typing**

```
ifconfig interface_name dhcp release
```

Verification: Check the server machine's console. Perhaps support for the client's network has not been added to the DHCP databases.

Solution: Add support for the client's network, using `dhcpconfig`.

Verification: The client is on a network separate from that of the DHCP server, and a BOOTP relay agent has not been installed or configured.

Solution: Install and configure a BOOTP relay agent. In addition, you may need to add an entry to the **`netmasks`**(4) database for the remote network.

Problem

The client logs a message that the address is already in use.

Verification: Check whether the address is in use elsewhere. If the client continues to log the same message, it is likely that the server is not checking the address, or is

ignoring the client's message which declines the address. Check to be sure you are not using the `in.dhcpd` command with the `n` option.

Solution: Find out whether the server gave out the bad address. Either the server is malfunctioning, or another user has illicitly used the same address.

Problem

The following error message is displayed:

`DHCP renewal on` *interface_name* `failed`

Verification: The DHCP client was unable to renew a lease on the specified interface.

Solution: Make sure that the DHCP server is still running correctly.

Problem

The following message is displayed:

`Address of interface` *name* `has changed`

Verification: The address or status of the interface is not what the DHCP agent expects to see. The address was probably altered manually.

Solution: There is no solution. The agent will stop trying to configure the interface.

Where to Get More Help

If after using these instructions you need further assistance, please call your local Solaris sales or service representative. To ensure that you receive the best possible service, have the following information ready before calling for help.

- Exact error message you received (if any)
- Version of the operating system running on the client
- Machine type
- Type of network (Ethernet, Token Ring, FDDI or PPP)

Troubleshooting the DHCP Server

This section discusses problems you may have with your DHCP server.

When Using Files

Follow the instructions below if you have problems while using `files` as a name service.

Problem

You cannot access the `/var/dhcp` directory; it either does not exist or you do not have UNIX file permissions to read it.

Verification: Use the following command:

```
ls -d /var/dhcp
```

Solution: The DHCP server hasn't yet been configured. Run `dhcpconfig`.

When Using NIS+

Follow the instructions below if you have problems while using NIS+ as a name service.

Problem

The root object does not exist in the NIS+ domain.

Verification: Enter the command:

```
niscat -o org_dir
```

Solution: Refer to Solaris NIS+ setup documentation.

Problem

The `root` account does not have access rights to create a table under the `org_dir` object.

Verification: Enter the command:

```
niscat -o org_dir
```

Solution: Use the `nischmod` command to change the permissions on the `table.org_dir.domainname.`

Problem

The `root` account does not have access rights to create a table under the `org_dir` object. Usually, this means the `root` account's principal name is *not* a member of the owning group for the `org_dir` object, or no owning group exists.

Verification: Enter this command to find the owning group name: **`niscat -o`** *org_dir*

Solution:

1. **Enter `nisgrpadm -l` *group* to see the group members.**

2. **If the current system's principal name is not in the group, enter: `nisgrpadm -a` *group principalname* to add it. Typically, the group is *admin.* If it is not, edit the `dhcpconfig` script and change the group to match the group name in use.**

3. **Enter `/usr/lib/nis/nisctl -fg` to flush the cache for immediate update.**

Problem

The domain name is unset.

Verification: Enter the command:

```
domainname
```

If the command lists an empty string, no domain name has been set for the domain.

Solution: Use the `domainname` command to set the proper domain name. Place the domain name value in the `/etc/default` domain.

Problem

The `NIS_COLD_START` file does not exist.

Verification: Enter the following command on the server system:

```
strings /var/nis/NIS_COLD_START
```

Solution: Create a NIS+ client. Refer to the Solaris NIS+ QuickStart documentation.

Problem

You choose NIS+ and the site is *not* running NIS+.

Verification: Log on to the server. Type in the command:

```
ps -ef | grep nis
```

If NIS+ is running you will see output similar to: `/usr/sbin/rpc.nisd -YB`.

Solution: Create a NIS+ server:

1. **On the client, set up the NIS+ root master server for the domain. For example:**

```
/usr/lib/nis/nisserve -r
```

2. **Populate the NIS+ tables from the local `/etc` files. For example:**

```
nispopulate -F /etc
```

3. **On the server, verify that NIS+ is running. For example:**

```
/usr/lib/nis/nisstat
nisls org_dir
niscat hosts.org_dir
```

Cannot Use NIS+ as Name Service

One or more of the following error messages are displayed:

```
!!! warning !!! trailing dot ignored - use dns domain name
syntax

Error 20 from NIS+; unable to use NIS+ as name service.
```

These messages mean either that there is no such name in the NIS+ domain, or the NIS+ domain does not exist. Use the information below to find and solve errors in the configuration of NIS+.

Problem

The domain name for the server system ends with a period.

Verification: Enter the `nisdefaults` command to determine whether there are two trailing periods after the domain name.

Solution:

1. **Edit the** `/etc/defaultdomain` **file by removing the trailing period (.) from the domain name.**

2. **Reboot your system, and rerun the** `dhcpconfig` **script.**

Problem

A host name includes the domain name. For example, setting a host to `myhost.Faxco.COM` instead of `myhost`.

Verification: Enter the `nisdefaults` command to show a host name with the domain name included twice.

Solution:

1. **If your host name is set incorrectly, enter the** `sys-unconfig` **command to remove the configuration settings and halt the system.**

2. **Reboot the system and supply the correct settings for host name and domain name.**

Problem

The root account does not have create access to the `org_dir` object in the NIS+ domain.

Verification: Enter the command:

```
niscat -o org_dir
```

Solution: Use the `nischmod` command to change the permissions on the `table.org_dir.domainname`.

I/O Error Accessing File Name Service

The following error message is displayed:

`File system I/O error` *number* `accessing file datastore.`

If you receive this error message, look through the list of error messages below, which are returned by the operating system when it tries to open, read, or write a file in `/var/dhcp`.

Problem

The error number is `2 (ENOENT)`.

Verification: The file or directory does not exist.

Solution: Enter the `dhcpconfig` command to create it.

Problem

The error number is `13 (EACCES)`.

Verification: A UNIX permission error occurred accessing the file or directory.

Solution: Use the `su` command and change the UNIX permissions.

User Has no DES Credentials

Problem

The following error message is displayed:

`The user` *user* `does not have DES credentials in the NIS+ name service.`

Verification: The current system's `root` account does not have valid Data Encryption Standard (DES) credentials in the NIS+ `cred` table.

Solution: Use the `nisaddcred` command to add the credentials for the `root` account. You must enter the UNIX netname and NIS+ principal name on the command line.

The following example shows how to add DES credentials for the system *mercury* in the domain *Faxco.COM*.

```
nisaddcred -p unix.mercury@Faxco.COM \
-P mercury.Faxco.COM. DES Faxco.COM
```

The command prompts for the root password (which is required to generate an encrypted secret key).

No Permission to Create Table in Data Store

The following error message is displayed:

`You do not have permission to create the` *tablename* `table in the` *servicename* `data store.`

If you have a problem creating tables in the data store, check the information below.

Problem

The `root` account does not have access rights to create a table under the `org_dir` object.

Verification: Usually, this means the `root` account's principal name is *not* a member of the owning group for the `org_dir` object, or no owning group exists.

Solution:

1. **Enter `niscat -o` *org_dir* to see the name of the owning group.**
2. **Enter `nisgrpadm -l` *admin* to see the group members.**
3. **If the current system's principal name is not in the group, enter `nisgrpadm -a group` *principalname* to add it.**
4. **Enter `/usr/lib/nis/nisctl -f g` to flush the cache for immediate update.**

Unable to Determine Name Servers

Solutions to problems in finding a name server during configuration of the DHCP server are listed below.

Problem

The `dhcpconfig` script could not match server names with IP addresses.

Verification: Find the IP address of the server by using the command `getent hosts` *name*.

Solution: Create the entries in the `hosts` database.

Problem

The `dhcpconfig` script is using the wrong name service for the server.

Verification: Look at the `hosts` entry in the `/etc/nsswitch.conf` file to see which name service is used to look up IP addresses (`xfn`, `files`, `nis`, `nisplus`, `dns`).

Solution: Change the `hosts` directive in the `/etc/nsswitch.conf` file to the correct name service. Stop and restart `nscd`.

Problem

The `dhcpconfig` script did not check the name service.

Verification: The name service preceding the `[NOTFOUND=RETURN]` directive in the `/etc/nsswitch.conf` file is authoritative. If the specified name service does not find an entry, any name services listed after this directive are not checked.

Solution: Remove the `[NOTFOUND=RETURN]` directive from the `/etc/nsswitch.conf` file and run the `dhcpconfig` script again. Stop and restart `nscd`.

Errors Trying to Set Up DHCP Table

One of the following error messages is displayed:

`The user` *username* `does not have permission to update the dhcptab table in the` *servicename* `resource.`

`Error 10 from the Table subsystem accessing dhcptab table, message: NIS+ error while executing nis_modify_entry for` *[key=SUNW.PCNFS.5.1.1,flag=m],dhcptab.org_dir.island.ocean.*`: Permission denied Error trying to set up DHCP table, exiting.`

`Error 10 from the Table subsystem accessing dhcptab table, message: NIS+ error while executing nis_modify_entry for` *[key=SUNW.PCNFS.5.1.1,flag=m],dhcptab.org_dir.island.ocean.*`: Object with same name exists Error trying to set up DHCP table, exiting.`

If you receive one of these error messages, check the information below for solutions to problems trying to set up DHCP tables during the configuration of the DHCP server.

Problem

You do not have access rights to add entries into DHCP tables from NIS+ or the UNIX file system.

Verification: Check permissions and set appropriate access rights for the DHCP table.

Solution: Make sure the administrator is a member of the appropriate administrative group and has write access to the NIS+ master server.

No Permission to Access `dhcp_network` Table

The following error message is displayed:

`You do not have permission to create {update} the` *tablename* `table in the` *servicename* `data store.`

If you receive this message, check the information below regarding a problem. Listed below are solutions to problems accessing the `dhcp_network` table during the configuration of the DHCP server.

Problem

You do not have access rights to add entries into the `dhcp_network` table from NIS+ or the UNIX file system.

Verification: Check permissions and set appropriate access rights for the `dhcp_network` table.

Solution: Make sure the administrator is a member of the appropriate administrative group and has write access to the NIS+ master server.

Troubleshooting a DHCP Client

When troubleshooting a DHCP client, you must understand certain issues about configuring the client and client-server communication. DHCP may fail to configure the client properly, either because DHCP could not communicate with a server, or because, although configuration responses were received, they were incorrect. Problems can also occur later in the life of a DHCP lease if the client cannot renew its IP addresses.

Client Cannot Communicate With the Server

When a client and a server cannot communicate with each other, the consequences depend on whether or not the client has a configuration cached from an earlier DHCP transaction. If it has, and if the lease is still valid, the client will use the cached data to configure the interface.

However, because the client has received no outside confirmation that this configuration is valid, there is no guarantee that the IP address, router address, and other information are valid. If the interface is connected to a network other than the one on which the configuration was received, one of two things can happen. Either errors may appear when other network services are started, or it may be impossible to communicate with other hosts on the network.

On the other hand, if no cache with an unexpired lease exists, the interface is not configured.

DHCP Configurations Received Are Invalid

Configurations can be invalid for two reasons:

1. The client determines by ARP that the IP address offered to it is in use elsewhere. In this case, the client will send a DHCPDECLINE message to the server. If the server offers more than two bad addresses, `dhcpagent` fails.

2. The client gets offers, but when it tries to confirm them, the server sends a DHCPNAK message instead of a confirmation. If the client receives DHCPNAK messages more than twice, `dhcpagent` fails. This indicates a malfunctioning server.

Isolate the Problem to the Client or Server

Perform the following actions to isolate the problem to either the client or the server machine.

Problem

The DHCP server machine is not working.

Verification: Log in to another machine on the same subnet as the client, and use the `ping` command to try to reach the server.

Solution: Diagnose the problem on the server machine.

Problem

The DHCP server is not running.

Verification: Log in to the server and enter the command:

```
ps -ef | grep dhcp
```

Solution:

1. **Stop and restart the DHCP server.**

2. **Enter the command:**

```
/etc/init.d/dhcp stop
```

3. **Wait about 10 seconds. Then enter the command:**

```
/etc/init.d/dhcp start
```

Problem

The boot process hangs during DHCP.

Verification: The interface is marked *primary*, but no valid DHCP transaction has occurred.

Solution: Interrupt DHCP by typing **control-C**. The boot continues.

Note - Although booting continues, the host may be incorrectly configured for the networks to which it is attached.

Client Cannot Reach DHCP Server

Problem

After configuring the DHCP client software and rebooting the client, you are unable to reach a server on the network from the client. All DHCP network commands fail and you see messages that the client is trying to reach the DHCP server and failing.

Typical error messages include:

```
DHCP or BOOTP server not responding
```

```
A request to access nonexistent dhcp_network database:
databasename in datastore: datastore.
```

```
No more IP addresses for network_address network.
```

Verification: To pinpoint exactly what the problem is, perform the following actions.

1. **Run the client in debug mode.**
2. **Attempt to configure the interface manually to verify that the hardware is functioning.**
3. **Run the DHCP server in debug mode.**
4. **Use** `snoop` **to trace messages sent between the DHCP server and client.**
5. **Find out if the problem is on the client or server machines.**
6. **Look at the error message and choose a solution from the information below.**

Run Client in Debug Mode

Run the client in debug mode. Refer to the documentation for the product you are running.

Solaris Client:

1. **Invoke**:

```
/sbin/dhcpagent -d3
```

DOS Client

On a PC-NFS DOS client:

1. **Edit the** `AUTOEXEC.BAT` **file by replacing** `SNCLIENT` **with** `SNCLIENT /D`**.**
2. **Reboot the client.**

Configure the Interface Manually

After `dhcpagent` has been started in debug mode, you can try to configure an interface manually by typing:

```
ifconfig interface_name auto_dhcp
```

Packets that are sent, and any that are received, will be displayed.

Run the Server in Debug Mode

1. **Log in to the root account on a DHCP server on the same subnet as the client.**
2. **Kill and restart the DHCP server in debug mode. For example**:

```
/etc/init.d/dhcp stop
/usr/lib/inet/in.dhcpd -d -v
```

Or, if the `i` **option is present, enter the command in the following format**:

```
/usr/lib/inet/in.dhcpd -i interface_names -d -v
```

Use snoop to Monitor Network Traffic

1. **Log in to the root account on a DHCP server or BOOTP relay agent on the same subnet as the client.**

2. **Use the** snoop **command to trace network traffic. For example:**

```
snoop -o /tmp/output udp port 67 or udp port 68
```

or

```
snoop -o /tmp/output udp port bootps or udp port bootpc
```

plus the per-interface argument, if there is one.

3. **Boot the client and watch the network messages on the server.**

4. **Type:**

```
snoop -i /tmp/output -x 0 -v
```

to view the packet traces.

Look up Error Messages

Look at the output from running the in.dhcpd command in debug mode and use the error message or condition you see to find a solution from the information below.

Problem

You see one of the following error messages:

```
Datagram received on network device: le0
```

```
ICMP ECHO reply to OFFER candidate: ip_address disabling
```

Verification: Before the DHCP server offers an IP address to a client, it verifies that the IP address is not in use by pinging the IP address. If a client replies, the IP address is in use.

Solution: Make sure the IP addresses you configured are not already in use.

Problem

You see the following error message:

No more IP addresses for *network_address* network

Verification: There are no available IP addresses in the client's `dhcp_network` table.

Solution: Use the `dhcpconfig` command to allocate more IP addresses. If the DHCP daemon is monitoring multiple subnets, be sure the additional IP addresses are for the subnet where the client is located.

Problem

There is a bad client id: *id_name* in the `dhcp_network` database.

Verification: The client ID (MAC address) in the `dhcp_network` table is incorrect.

Solution: If you are using Ethernet, the client ID is 01 followed by the Ethernet address. Make sure that all letters in this address are capitalized. A 00 means the address has not been assigned.

Problem

You see the following error message:

`Request to access nonexistent dhcp_network database:` *database_name* `in datastore:` *nisplus_datastore*`.`

Verification: The `dhcpconfig` script did not create a `dhcp_network` table for a subnet during the configuration of the DHCP server. This can happen if you set up an isolated LAN, such as a server and two clients, as a test network.

Solution: Use the `dhcpconfig` command to initialize the `dhcp_network` table and new IP addresses.

Problem

You receive the error message:

`Client` *client_id* `is trying to verify unrecorded address` *ip_address*`, ignored.`

Verification: There are two possible reasons for getting this message:

1. You can receive this message if your `dhcp_network` tables have been deleted. If you are using only the Solaris DHCP server, then this is typically the reason.
2. You can receive it if you are not using NIS+ for datastore, so information is not shared. Make sure that the server is sharing data.

If you have a group of heterogenous servers, then ignore this message.

Solution: Remove old cache files on the client by typing:

```
ifconfig interface_name dhcp release
```

Problem

DHCP is started, but some required network services will not start.

Verification: The DHCP server is not supplying the configurations required.

Solution: Find out why the server does not send the parameters that are required. Configure the server to do so.

Problem

DHCP is started, but certain network services, such as NIS and NIS+, report errors or hang. The host cannot communicate with other hosts on the network.

Verification: The `dhcpagent` command was unable to communicate with DHCP (presumably because DHCP was unavailable) and has used cached data.

Solution: Remove the cache. Type:

```
ifconfig interface_name dhcp release
```

Since removing the cache does not solve the problem of getting the proper configuration, the host may have to be configured by hand. At boot time, DHCP should be disabled by removing the trigger file by typing:

```
rm /etc/dhcp.interface_name
```

Problem

The client boots and works correctly, but the following message appears:

`DHCP renewal on` *interface_name* `failed`

Verification: DHCP is working, but `dhcpagent` cannot contact the server to extend the lease.

Solution: Find out why the server is not responding now. This could be because the router value configured in the `dhcptab` is incorrect or out of date for the client network.

Problem

Messages about failed DHCP renewals are received. Then the following message appears on the console:

`DHCP lease expired on` *interface_name*`: interface is now down`

Network services may hang at this point.

Verification: The lease has expired. The client has not been able to extend the lease after several attempts.

Solution: Find out why the server is not responding. Reboot the client.

Some Clients Do Not Boot From DHCP Server in BOOTP Compatability Mode

Problem

The DHCP daemon is running in BOOTP compatibility mode (–b option).

Verification: BOOTP does not use a lease time. The DHCP server looks for free addresses with the BOOTP flag set to allocate the BOOTP clients.

Solution: Allocate BOOTP addresses. Use `dhcpconfig` to change the daemon options.

Diagnose NIS+ Configuration Problems

Use the information below to fix errors in the configuration of the NIS+ name service that prevent the client from accessing a server during boot.

Problem

No name service is configured for the client in the `dhcptab` table.

Verification: Log in to the server and type the command:

```
dhtadm -P | grep ip_address
```

Check for entries such as `NISdmain`, `DNSdmain`, and `NISservs`. Make sure the addresses entered for them are correct. For example:

```
# dhtadm -P | grep 129.148.3.129.148.3.m:Subnet=255.255.255.0:Router=129.148.3.11:
Broadcast=129.148.3.255:NISdmain=''island.ocean'':NISservs=129.148.3.3:
```

Note - The line above actually appears on one line, instead of being broken into two.

Solution: Use `dhtadm` to change any incorrect addresses.

Problem

You are using NIS+ and the server is not running in NIS+ compatibility mode. NIS+ tables do not have read rights for the *Nobody* category, so NIS clients cannot access the information stored there.

Verification: Run the command:

```
nisls -l org_dir
```

to show permissions of `.r---rmcdrmcdr---`

Check whether the `Y` option is set for the `rpc.nisd` daemon. For example:

```
ps -deaf | grep nis
```

Solution:

1. **Log in to the NIS+ server as root.**
2. **Enter the command:**

```
/usr/lib/nis/nisserver -r -Y -d domainname
```

Problem

An incorrect default router prevents the client from reaching a server on another network.

Verification: Make sure the router symbol definition in the `dhcptab` table is actually a router.

Solution: Use `dhtadm` to correct the route symbol in the table.

Problem

You are running NIS+ but DNS forwarding is not turned on for NIS clients.

Verification: Use the command:

```
ps -ef | grep rpc.nisd
```

A `–B` option means that NIS is running with DNS forwarding turned on. For example:

```
/usr/sbin/rpc.nisd -B
```

Solution: Start the NIS+ server in NIS compatibility mode with DNS forwarding enabled. For example:

```
/usr/sbin/rpc.nisd -YB
```

Diagnose Name Service Configuration Problems

Use the information below to fix errors in the configuration of the NIS name services that prevent the client from accessing a server during boot.

Problem

An incorrect default router prevents the client from reaching a server on another network.

Verification: Make sure the router symbol definition in the `dhcptab` table is actually a router. If there are problems with the default router, make corrections with server-based tools.

Solution: Use `dhtadm` to correct the route symbol in the table.

Problem

No name service is configured for the client in the `dhcptab` table. For clients, the name service must be DNS, NIS, or NIS+, and appropriate parameters must be provided to each client.

Verification: Check the network-specific macro relating to the client's configuration.

1. **Log in to the server and type the command:**

```
dhtadm -P
```

2. **Look for an entry that matches your client's network.**

   Solution: Use `dhtadm` to correct the client's macro for the name service:

   If this is the first client on the network:

1. **Use `dhtadm` to correct the entries.**

2. Then type:

```
/etc/init.d/dhcp stop,
/etc/rc3.d/S34dhcp start
```

on the server and reboot the client.

Note - The server does not dictate the name service choice to the client. The server only provides the relevant information. The client chooses its name service.

Macro Change Not Propagated to Client

You have changed one or more macros for a client with `dhtadm`, but the changes are not evident on your machine. For example, you changed the client's router, but the client is still using the old router.

Use the information below to solve the problem of changed client macros not showing up on the DHCP server.

Problem

The DHCP server was not reinitialized to read your changes to the `dhcptab` table. This must be done every time you change a macro definition.

Solution: Use the *rescan* option-set with `dhcpconfig`, or:

Reinitialize the DHCP server:

1. Log in to the DHCP server as root.

2. Enter:

```
/etc/init.d/dhcp stop
```

3. Restart the DHCP daemon by entering:

```
/etc/init.d/dhcp start
```

APPENDIX **A**

PCNFSpro Appendix

Troubleshooting

The following series of troubleshooting techniques are specific to PCNFSpro running as the Windows client. To get further information about PCNFSpro and the Windows client, consult the *SolarNet PC-Admin Admininstrator's Guide.*

Reboot the PC

This is a good first step if the PC is unable to connect to a server, or displays error messages as it contacts the server. Rebooting the machine resets network hardware and software. If the problem is caused by a temporary license that has expired, rebooting renews the license for 30 minutes.

For the Windows client, delete the file:

`c:\pcnfspro\dhcp\`*`interface`*`.bin`

Replace *interface* with the name of the actual interface in use, for example: `c:\pcnfspro\dhcp\pk0.bin`.

Running in Debug Mode

Running in DHCP debug mode reveals much of the ongoing dialog between the client and the server. This dialog provides useful clues for solving network problems.

▼ To Run a Windows Client in Debug Mode

1. **Kill the DHCP server and restart it in debug mode.**
2. **Enable the Network Event Log in the Services applet of the Configuration tool.**
3. **Close the Configuration Tool.**
4. **Start the Network Event Log directly from the program group.**
5. **Select the Display menu and highlight all priority levels.**
6. **Choose Save. After you do this,** `nfswdhcp.exe` **logs to the Network Event Log.**
7. **Exit and restart Windows.**

Client Fails to Connect With DHCP/BOOTP Server

If you have installed or added a new client, but the machine fails to connect to the server and displays an error message, check the machine's cable and adapter. If the adapter has a diagnostic program, run it to identify possible problems.

Start the Configuration application in the PCNFSpro directory. Choose Services and enable the Start Network Event Log. You can also start the Network Event Log directly from its icon. After it starts, choose Display and then Configure. Select all priority levels, down to Debug. Choose Save to save the configuration. Network Event Log entries similar to:

`DHCP: Attempting to configure interface using DHCP`

indicate that the machine has broadcast for a configuration. Server replies should follow.

Next, kill the `in.dhcpd` daemon on the server and run the server in diagnostic mode by entering **`in.dhcp -d`**.

After receiving output, check that there is a DHCP server or relay agent on the machine's subnet. While booting the client, run:

`snoop udp port 67` or **`udp port 68`**

on a server on the same subnet as the machine. See if a system responds. Windows client `snoop` output looks like this:

```
OLD-BROADCAST -> BROADCAST UDP D=67 S=68 LEN=311
glrr -> BROADCAST UDP D=68 S=67 LEN=490
```

The client name is not shown for the Windows client. The DHCP activity is reflected by the presence of BROADCAST.

Applications Run Out of Conventional Memory

The `CONFIG.SYS` file (by default) does not try to load the Windows client adapter drivers (packet driver, NDIS, or ODI) into upper memory. This can lead to applications reporting "not enough conventional memory" or a similar message when they start.

If you are running DOS 5.x or greater, change `CONFIG.SYS` lines from:

`DEVICE=C:\PCNFSPRO\`*filename*

to

`DEVICEHIGH=C:\PCNFSPRO\`*filename*

and `NFSWAUTO.BAT` lines that load TSRs from

tsrname

to

LH *tsrname*

Mounting Home Directories

The software default of mounting home directories on Drive H conflicts with the use of H by the MS-DOS 6.2 DoubleSpace utility. To resolve this conflict, remap the drive used by the DoubleSpace utility (`dblspace h: /host=`*new_drive*) or change your site login script to mount home directories on a different drive. The site login script is `/opt/SUNWpcnet/1.5/site/pcnfspro/login.snc`.

If you change the site login script, you must also change the HOME environment variable to a new drive.

Use of Ping

If a machine cannot mount a remote file with the `net use` command, verify that the pathname to the file system you want to access has been entered correctly. Then use the Ping application.

If a user is copying files to or from a network drive and the process stops before it is completed, use the Ping application.

If a machine has been receiving a license and cannot receive a license when it is turned on or rebooted, and instead receives error messages, use the Ping application.

SNC Script

The software distributes access to applications and other network services when a machine starts up or when a new user logs on. This interprets the directives in the `store\login.snc` file. `%SNDRIVE%` expands to `/opt/SUNWpcnet/1.5/site/pcnfspro`, the site SNC script directory for the Windows client. This script is not accessible to users because it is protected by UNIX permissions.

The directory `/opt/SUNWpcnet/1.5/site/pcnfspro` contains the default client scripts (SNC scripts) used at boot, login and logout time to control resources on the machines. The directories are mounted temporarily and then dismounted after the scripts are run. On the Windows client, SNC commands are responsible for establishing users' unique relationships to the network.

The Windows client's Configuration program processes the boot script (by default named `boot.snc`) in the SNC script directory `/opt/SUNWpcnet/1.5/site/pcnfspro`. The names of the script and the SNC script directory can be different for each network.

The Windows client's Configuration program is a comprehensive graphical tool used to view and change a wide variety of configuration parameters. The program enables you to change and customize any Windows client's default configuration, and to save the customized configuration. Among the parameters that you control by way of the Configuration program are TCP/IP, the Local Area Network (LAN) user name, NFS, the printer client, NetBIOS, and SNMP. You can also standardize and control the level of configuration that the Windows client's Configuration program makes available to users at your site. See the Configuration program's on-line help for details about using the program.

The site SNC script directory is expanded when you add an INCLUDE directive for a new group `login.snc` script. It is also expanded when you add an INCLUDE directive in the `store\logout.snc` file.

The script directory is used to create a directory with the UNIX login name for each user who has an individualized view of applications on the network. Then it is used

to create and copy the user-specific `login.snc` and `logout.snc` scripts into each directory. The commands are:

`cd/opt/SUNWpcnet/1.5/site/pcnfspro`

`mkdir` *user1user2 user3 user4 user5user6user7*

In this example, all users except *user8*, *user9*, *user10*, and *user11* use applications that they either do not share with other users or that they share with some, but not all users.

Three default SNC scripts are provided for each type of client in the SNC script directory `/opt/SUNWpcnet/1.5/site/pcnfspro`. They are:

- `boot.snc` - The site boot script used by the Windows client's Configuration program and Login/Logout application.
- `login.snc` - The site login script used by the Windows client's Login/Logout application.
- `logout.snc` - The site logout script used by the Windows client's Login/Logout application.

The default site `logout.snc` script cleans up after the site `login.snc` script. You can copy the site `logout.snc` script, rename it, and modify it to correspond to your login scripts. You should name all logout scripts `logout.snc` to parallel the login scripts. Place the logout scripts in user and group-specific directories you create under the SNC script directory `/opt/SUNWpcnet/1.5/site/pcnfspro`.

DHCP Databases

Each NIS+ domain has one `dhcptab` table, which defines the configuration parameters to be returned to DHCP (or BOOTP) clients. The `/opt/SUNWpcnet/1.5/site/pcnfspro` script directory is one of the entries used in defining user views and distributing applications.

License Upgrade

Checking to see that license upgrade files were created requires certain procedures for the Windows clients. First run `C:\pcnfspro\upgrade`. After checking the license upgrade file and its contents, rerun the `install` program. Then:

1. **Rename** `C:\windows\pcnfswin.ini`**.**

2. **Run the** `C:\pcnfspro\binnfswpupg` **program.**

3. **Finally, restore the renamed** `pcnfswin.ini` **file to its original name of** `pcnfswin.ini`**.**

After following the other steps to be sure the upgraded license file is present and is operating correctly, delete the old DHCP configuration files and reboot the machine. Delete the file in the directory `C:\pcnfspro\dhcp` corresponding to your interface.

Loss of Hostname and IP Address

Similar procedures must be followed if the machine has lost its original hostname and IP address. First start the Control Panel application and choose the Network icon. View the current hostname and IP address, as well as other pertinent information. Perform the procedure that creates an entry to the `dhcp_table`. Then run `C:\pcnfspro\dhcp` and follow the steps above.

Next, copy the upgrade file to the upgrade directory in the installation directory on the server. Check to see that the `snaddpcs` script was executed. Then delete old DHCP configuration files and reboot the screen. Do this by deleting the file in the directory `C:\pcnfspro\dhcp` corresponding to your interface.

Distributing Applications

The software distributes access to applications and other network services when a machine starts up or when a new user logs on. For the Windows client, these applications and services are provided to each user by the Login application, which starts automatically when Windows is started.

The Windows-based DHCP application initiates DHCP, receives an IP address and related network information for the machine, configures the machine's stack and services, then begins processing client (SNC) scripts that mount file systems and set search paths for shared resources, groups, individual users, and individual machines.

Logging In and Out

For the Windows client, logging into and out of the network is done by clicking on the Login/Logout application icon and filling in the resulting Windows dialog box. When a user fills in the dialog box with the user name and password, and clicks OK or presses Enter, the Windows client's site `logon.snc` script is launched by the following `INCLUDE` directive in the client's site boot script:

```
INCLUDE %SNDRIVE%\PCNFSPRO\LOGIN.SNC
```

This script mounts directories, sets certain environment variables, and provides other services for the user who is already logged in, regardless of which machine the person is using to log in. It establishes the login procedure that all users in the network follow.

When the Windows client uses the same Windows-based dialog box to log out, the client's site `logout.snc` script is processed. This script undoes what the `login.snc` script did. The Logout application unmounts file systems and printers, and resets the machine's environment variables to their original, pre-login values.

The Windows client's Login/Logout application provides detailed information about the user's network settings, and enables you to change the settings. Among the settings are version and license numbers, the user name and ID, the group ID, NIS and DNS domains, the subnet mask, MAC addresses (which identify an Ethernet communications adapter), the time zone, the last drive, and names and IP addresses of available servers.

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