Unit-2

LINUX NETWORKING: Introduction to Networking in Linux, Network basics & tools, File transfer protocol in Linux, Network file system , Domain Naming Services, Dynamic hosting configuration Protocol & Network information Services.

What is *Networking*?

A *network* consists of multiple machines (computers) that are connected together and share each other all kinds of information. This connection between the network can be developed through waves and signals or wires, depending on which is most convenient for work and the type of information that needs to be shared.

In the *network* multiple machines (host) are connected to the communication sub-net that allows the dialog between them. They can communicate in two basic ways:

- Through channels point to point (PPP)
- Through broadcast channels

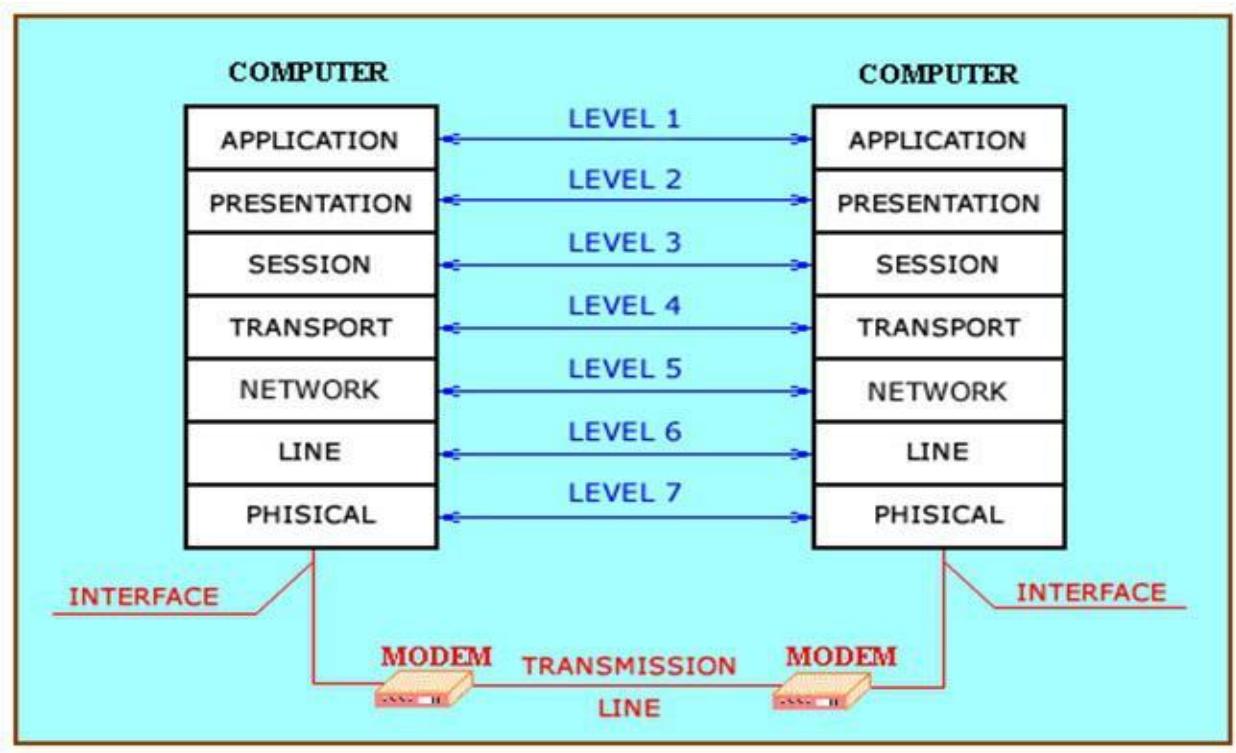
For communicating machines that aren't able to communicate by themselves, **routers** (intermediate machines) are used.

Moreover, the **protocols** are a set of rules (interfaces, algorithms, formats messages...) known by the entities exchanging data through the communications network.

The protocols used by the machines are organized in different **layers or levels**, in such a way that:

- Each layer offers services to a higher level
- Each layer is supported by services offered by a lower level

Each level in a machine "talks with" his twin in another. The rules governing this "conversation" form the protocol of that level.



Layer name	Protocols
Application layer	HTTP, DNS, SMTP, POP, ...
Transport layer	TCP, UDP
Network layer	IP, IPv6
Network access layer	PPP, PPPoE, Ethernet

When we talk about **Network Architecture**, we are talking about the set of levels and protocols of a computers network.

Linux networking

To go into the next chapters, you should have a basic knowledge of Linux/Unix. If not,we recommend you to read first a Unix introduction tutorial.

As you know, Linux itself is just a kernel. Linux can be configured as a networked workstation, a DNS server, a DHCP server, a web server, a mail server, a file and print server, database server, a firewall, a gateway router and many more. Linux is capable to be all that. In this section, you will learn the odds of **Linux as a network operating system or server system**, to be all that mention above.

TCP and packets

Modern networking applications require a sophisticated approach to carrying data from one machine to another. The solution that Unix systems, and subsequently many non−Unix systems, have adopted is known as TCP/IP.

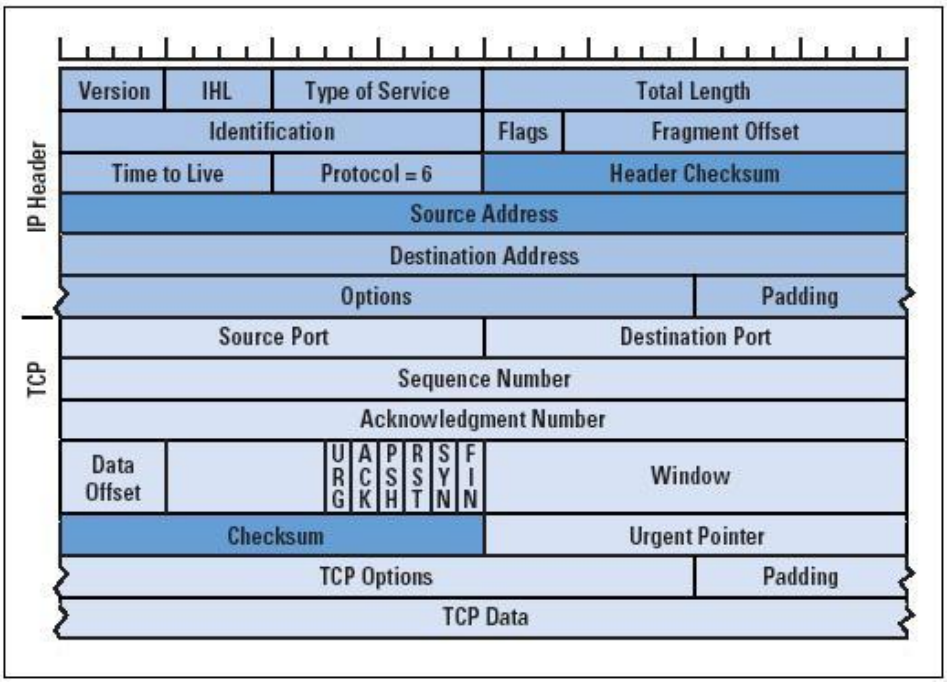
The **Transport Control Protocol (TCP)** and the **Internet Protocol (IP)** are the two most popular ways of communicating on the Internet. A lot of applications, such as your browser and E-mail program, are built on top of this protocol suite. (Remember: A protocol is system of digital rules for data exchange within or between computers).

When talking about TCP/IP networks you will hear the term datagram, which technically has a special meaning but is often used interchangeably with packet. Very simply put, IP provides a solution for sending packets of information from one machine to another, while TCP ensures that the packets are arranged in streams, so that packets from different applications don't get mixed up, and that the packets are sent and received in the correct order.

Here is a description of what a packet actually looks like. The start of each packet says where it's going, where it came from, the type of the packet, and other administrative details. This part is called the 'packet header'. The rest of the packet, containing the actual data being transmitted, is usually called the 'packet body'.

- Any IP packet begins with an 'IP header': at least 20 bytes long.
- If the protocol fields says this is a TCP packet, then a TCP header will immediately follow this IP header: the TCP header is also at least 20 bytes long.

Figure 1: TCP/IP Header Fields Altered by NATs (Outgoing Packet)



If you want to know more about TPC/IP protocols and the packets, you can visit this link.

Basics: First steps in networking

In this chapter you can find the very basics of networking in Linux:

- Basic commands

- Basic concepts

Basic commands

This is a resume containing some of the most used comands when networking.

ifconfig command

This command lets you configure network interface parameters or assingn an address to a network.

netstat command

With this command you can list network connections, view routing table and gain information about network interface.Definitely, netstat show network status.

Also, netstat -r command is widely used to show the routing tables.

route command

Linux route command manipulates the IP routing table. route is a utility used to manually manipulate the network routing.

ping command

Send ICMP ECHO_REQUEST packets to network hosts is what Linux ping command does.

telnet command

telnet command allows you to communicate with another host using the Telnet protocol. Probably telnet is one of those terms that most users are familiar with. If telnet is invoked without the host argument, it enters command mode, indicated by its prompt (``telnet>''). In this mode, it accepts and executes the commands.

ftp command

This program allows users to transfer files to and from a remote network site using the Internet standard File Transfer Protocol.

arp command

The arp utility displays and modifies the Internet-to-Ethernet address translation tables used by the address resolution protocol.

lsusb command

Is a utility for displaying information about USB buses in the system and the devices connected to them.

To make use of all the features of this program, you need to have a Linux kernel which supports the /proc/bus/usb interface (e.g., Linux kernel 2.3.15 or newer).

lsmod command

lsmod shows information about all loaded modules. The format is name, size, use count, list of referring modules. The information displayed is identical to that available from /proc/modules.

ip command

IP is the transport layer protocol used by the Internet protocol family. Options may be set at the IP level when using higher-level protocols that are based on IP (such as TCP and UDP). It may also be accessed through a``raw socket'' when developing new protocols, or special-purpose applica-tions. With this command you can display the IP address or the Ip route.

traceroute command

Displays the route packets take to network host. traceroute utilizes the IP protocol `time to live' field and attempts to elicit an ICMP TIME_EXCEEDED response from each gateway along the path to some host to determine the route one packet follows.

whois command

Specific domain name information can be queried using the whois command.This utility looks up records in the databases maintained by several Network Information Centers (NICs) and then displays internet domain name and network number directory service

sudo command

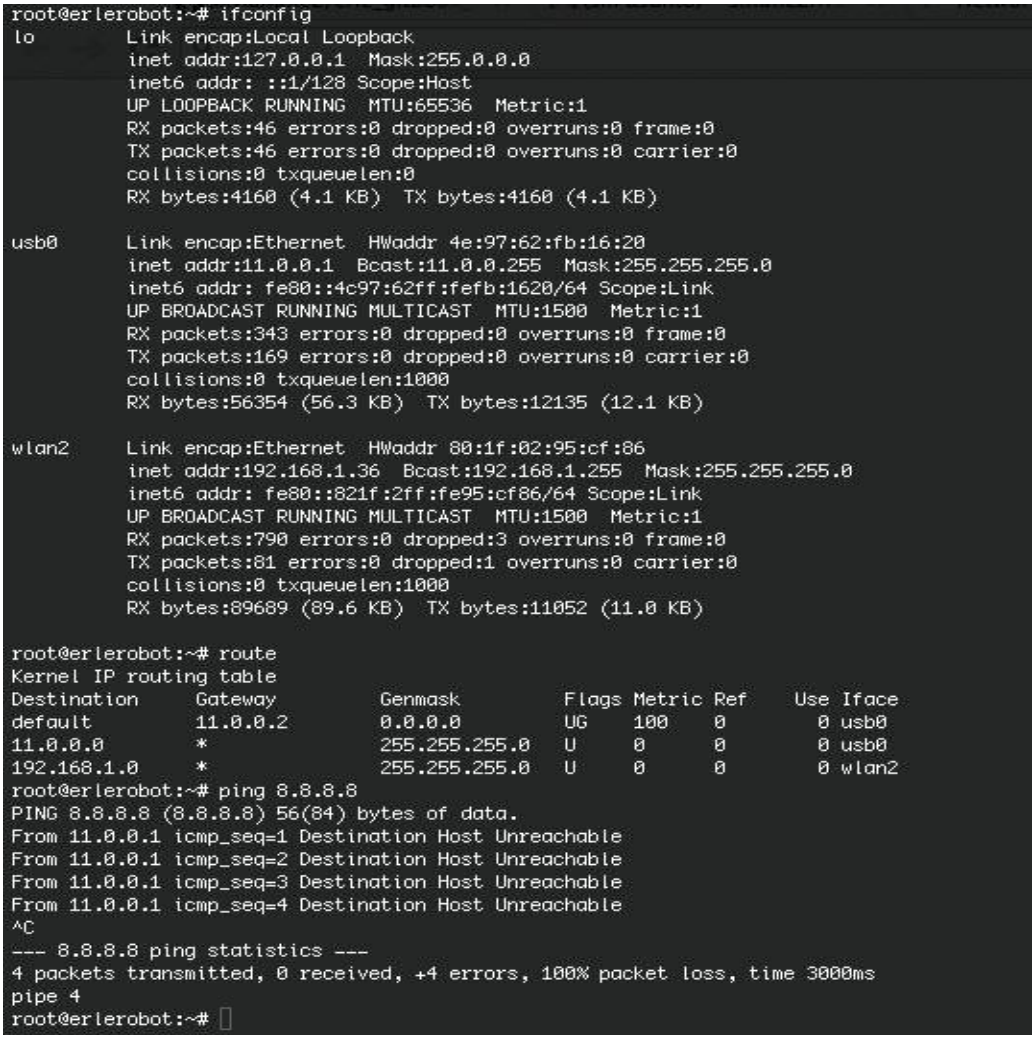
This command allows a permitted user to execute a command as the superuser or another user, as specified in the sudoers file.

If the invoking user is root or if the target user is the same as the invoking user, no password is required. Otherwise, sudo requires that users authenticate themselves with a password by default (NOTE: in the default configuration this is the user's password, not the root password).Once a user has been authenticated, a time stamp is updated and the user may then use sudo without a password for a short period of time (5 minutes unless overridden in sudoers).

Command	Meaning
ifconfig	configure network interface
netstat	show network status
route	manually manipulate the network routing
ping	send ICMP ECHO_REQUEST packets to network hosts
telnet	communicate with another host using the Telnet protocol
ftp	transfer files to and from a remote network site
arp	address resolution display and control
lsusb	displays info. about usb connections
lsmod	information about all loaded modules
ip -- show	display Ip address/route

traceroute	display packet's route
whois	domain name information
sudo	execute a command as another user

Here you can find some examples of the execution of these commands:



```
root@erlerobot:~# netstat -nr
Kernel IP routing table
Destination     Gateway         Genmask         Flags   MSS Window  irtt Iface
0.0.0.0         11.0.0.2        0.0.0.0         UG        0 0          0 usb0
11.0.0.0        0.0.0.0         255.255.255.0   U         0 0          0 usb0
192.168.1.0     0.0.0.0         255.255.255.0   U         0 0          0 wlan2
root@erlerobot:~#
root@erlerobot:~# lsusb
Bus 001 Device 002: ID 7392:7811 Edimax Technology Co., Ltd EW-7811Un 802.11n Wireless Adapte
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
root@erlerobot:~# lsmod
Module                  Size  Used by
bnep                    8941  2
rfcomm                 26161  0
bluetooth             155193  10 bnep,rfcomm
rfkill                 16483  2 bluetooth
8192cu                423094  0
g_ether                23528  0
libcomposite           14601  1 g_ether
root@erlerobot:~# ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN qlen 1000
    link/ether 00:18:30:f7:38:21 brd ff:ff:ff:ff:ff:ff
3: usb0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 4e:97:62:fb:16:20 brd ff:ff:ff:ff:ff:ff
    inet 11.0.0.1/24 brd 11.0.0.255 scope global usb0
    inet6 fe80::4c97:62ff:fefb:1620/64 scope link
       valid_lft forever preferred_lft forever
4: wlan2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP qlen 1000
    link/ether 80:1f:02:95:cf:86 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.36/24 brd 192.168.1.255 scope global wlan2
    inet6 fe80::821f:2ff:fe95:cf86/64 scope link
       valid_lft forever preferred_lft forever
root@erlerobot:~#
```

IP address

In this section you will find the elemental concepts related to the IP protocol and IP address.

Basic concepts

One of the first thing you should learn about networking is **IP protocol** and **IP addresses**.

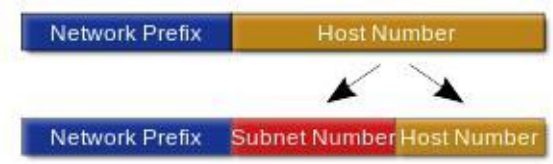
IP protocol is one of the protocols that make a networking possible. Remember that a protocol is a rules that govern communication between two systems. IP is a protocol at *Network Level* that follows a pattern:

- *not oriented to connection*: whenever there is data to send, a message is send to the destination without establishment phases.
- *datagram-based*: each message to a destination routed separately. The unit of data that is send by IP is called IP datagram.
- *untrusted*: messages may be lost, get duplicates, arrive out of order.

When talking about IP protocol, you should know the next subject which is IP address. IP address is a unique address assigned to one network computer. This is important because a network computer must know which computer it is communicating with such as in client talking to a server situation.Threrefore an IP address is assigned to each physic machine connected to the Internet.

IP addresses have 32 bytes and are divides into two parts:

- network identifier/network prefix: set of bytes that identify the network the machine is connected to. machine identifier/host prefix:unique set of bytes for each machine inside a network.



Example:

IP address: 212.128.4.4

Network identifier	**Machine identifier**
212.128.4	4

IP address is divided into five classes.Only the three first classes are assigned to machines (class A, class B and class C). In each class the range and the size of the identifiers is different:

Next is **subnet mask**. Every time we assign an IP address to a network computer, we must also assign a subnet mask. Ip address comes with different subnet mask depending on it's class. In each IP classes, the subnet mask defines network segment of that system. It says how much of the address is used for the network is defined by the subnet mask.Definitely, the subnet mask is used to specify the networks and the sub-networks used.

Default subnet mask:

A-255.0.0.0

B- 255.255.0.0

C-255.255.255.0

ifconfig

```
root@erlerobot:/# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:36 errors:0 dropped:0 overruns:0 frame:0
          TX packets:36 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:3074 (3.0 KB)  TX bytes:3074 (3.0 KB)

usb0      Link encap:Ethernet  HWaddr 9a:84:d7:d4:82:47
          inet addr:11.0.0.1  Bcast:11.0.0.255  Mask:255.255.255.0
          inet6 addr: fe80::9884:d7ff:fed4:8247/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:234 errors:0 dropped:0 overruns:0 frame:0
          TX packets:140 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:40190 (40.1 KB)  TX bytes:10750 (10.7 KB)

wlan2     Link encap:Ethernet  HWaddr 80:1f:02:95:cf:86
          inet addr:192.168.1.36  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::821f:2ff:fe95:cf86/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:508 errors:0 dropped:3 overruns:0 frame:0
          TX packets:65 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:58935 (58.9 KB)  TX bytes:10167 (10.1 KB)

root@erlerobot:/#
```

IPv4 vs IPv6

As we have seen, at first glance, an IP address is like a phone number or a street address. When you connect to the Internet, your device (computer, cell phone, tablet) is assigned with an IP address, as well as each site you visit has an IP address.

The addressing system that we have used since the Internet was born is called IPv4, and the new addressing scheme is called IPv6.

It is important to define the difference between this two addressing systems.

IPv4 address

To understand that the IPv4 address space is limited to 4.3 billion addresses, we can decompose an IPv4 address. An IPv4 address is a 32-bit number consisting of four octets (8-bit numbers) in a decimal notation, separated by periods. The bit can be either a 1 and a 0 (two possibilities), therefore the decimal notation would octet 2 raised to the 8th power of various options (256 of them, to be exact). Since we start counting from 0, the possible valuesof a byte in an IP address range from 0 to 255.

Examples of IPv4 addresses: 192.168.0.1, 66.228.118.51, 173.194.33.16

If an IPv4 address is made up of four sections with 256 possibilities in each section, to find the total number of IPv4 addresses, you should just multiply 256 *256* 256 * 256 to find results 4,294,967,296 addresses. To put it another way, we have 32 bits then 2 to the 32nd power will give the same result obtained.

IPv6 address

IPv6 was designed to support the growth of Internet in the future generations. As mentioned earlier, each device that connects to the Internet using an IP address that needs to be unique. Other existing or developing solutions consider the "share" the same IP address between different devices, which leads to complicated networks become fragile and at the same time are difficult to analyze to correct problems.

The minimum allocation unit is IPv6, CIDR notation using a / 64. This implies that each device connected to the Internet using IPv6 has available 2 to the 64th power (18,446,744,073,709,551,616) IP addresses.

IPv6 addresses are 128 bits based. Using the same math above, we have 2 to the 128th power to find the total of total IPv6 address, same as mentioned above. Since space in IPv6 is much more extensive than the IPv4 would be very difficult to define space with decimal notation ... would have 2 raised to the 32nd power in each section.

To allow the use of such a large number of IPv6 addresses easier, IPv6 is composed of eight 16-bit sections, separated by a colon (:). Since each section is 16 bits, there are 2 raised to the 16 variations (which are 65,536 different possibilities). Using decimal numbers 0 through 65,535, would have represented a rather long address, and to facilitate it is that IPv6 addresses are expressed in hexadecimal notation (16 different characters 0-9 and af).

Example of an IPv6 address: 2607: f0d0: 4545: 3: 200: f8ff: FE21: 67CF

which remains a long term but is more manageable to do with decimal alternatives.

Comparison between IPv4 and IPv6

	IPv4	IPv6
Standard since Developed by	1974 IETF	1998 IETF
Length in bits Amount of addresses	32 2^{32} = 4,294,967,296	128 2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456
Address format	Dotted decimal 192.168.100.1	Hexadecimal Notation: 2001:0DB8:0234:AB00:0123:4567:8901:ABCD
Dynamic addressing	DHCP	SLAAC / DHCPv6
IPSec	Optional	Mandatory
Header length	Variable	Fixed
Minimal packet size	576 bytes (fragmented)	1280 bytes
Header checksum	Yes	No
Header options	Yes	No (extensions)
Flow	No	Packet flow label

IPv4 and IPv6 are very similar in terms of functionality (but not in terms of mechanisms)

IPv6:Security::nl

Assigning an IP address

Computers may be assigned a static IP address or assigned one dynamically. Typically a server will require a static IP while a workstation will use DHCP (dynamic IP assignment). The Linux server requires a static IP so that those who wish to use its resources can find the system. It is more easily found if the IP address does not change and is static. This is not important for the Linux client workstation and thus it is easier to use an automated Dynamic Host Configuration Protocol (DHCP) for IP address assignment.

The sintaxis of the commadn used to assign a IP address is:

```
ifconfig interface [aftype] options | address ...
```

Static IP address assignment example:

```
ifconfig eth0 192.168.1.5 netmask 255.255.255.0 up
```

The ifconfig command does NOT store this information permanently.Upon reboot this information is lost.

After setting up a Linux IP address with ifconfig command, use Linux route command to set up static routes to specific hosts or networks. Linux route command is a tool where you can setup where to send which data. Basically you can use route command to show and manipulate routing table. This is an example of how to use route command in Linux. Issue route command without any option will print current routing table.

To add a new IP route via eth0 (first Ethernet card), issue route add command in this format:

```
route add -net <ip> netmask <ip> dev eth0
```

```
root@erlerobot:~# route add -net 192.168.1.0 netmask 255.255.255.0 dev eth0
```

You can also add a gateway of the network:

```
route add -net <ip> gw <ip> netmask <ip> dev eth0
```

```
root@erlerobot:~# route add -net 192.168.1.0 gw 192.168.1.1 netmask 255.255.255.0 dev eth0
```

Now, check the routing table again:

```
root@erlerobot:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         11.0.0.2        0.0.0.0         UG    100    0        0 usb0
11.0.0.0        *               255.255.255.0   U     0      0        0 usb0
192.168.1.0     192.168.1.1     255.255.255.0   UG    0      0        0 eth0
192.168.1.0     *               255.255.255.0   U     0      0        0 eth0
192.168.1.0     *               255.255.255.0   U     0      0        0 wlan2
192.168.1.0     *               255.255.255.0   U     0      0        0 eth0
root@erlerobot:~#
```

We can see all configurations we made is in the result above.

IP alias

New kernels support a feature that can completely replace the dummy interface and serve other useful functions. **IP Alias allows you to configure multiple IP addresses onto a physical device**. In the simplest case,you could replicate the function of the dummy interface by configuring the host address(or the host ID portion of an IP address), as an alias onto the loopback interface, represented as *lo* and completely avoid using the dummy interface. In more complex uses, you couldconfigure your host to look like many different hosts, each with its own IP address. This configuration is sometimes called *Virtual Hosting*.

To configure an alias for an interface, you must first ensure that your kernel has been compiled with support for IP Alias (check that you have a /proc/net/ip_alias file; if not, you will have to recompile your kernel). Configuration of an IP alias is virtually identical to configuring a real network device; you use a special name to indicate it's an alias that you want. For example:

```
ifconfig lo:0 172.16.1.1
```

This command would produce an alias for the loopback interface with the address 172.16.1.1. IP aliases are referred to by appending :n to the actual network device, in which n is an integer. In our example, the network device we are creating the alias on is lo, and we are creating an alias numbered zero for it. This way, a single physical device may support a number of aliases. Each alias may be treated as though it is a separate device, and as far as the kernel IP software is concerned, it will be; however, it will be sharing its hardware with another interface.

Ethernet

The most common type of LAN **hardware** is known as Ethernet. In its simplest form, it consists of a single cable with hosts attached to it through connectors, taps, or transceivers. Simple Ethernets are relatively inexpensive to install, which together with a net transfer rate of 10, 100, or even 1,000 Megabits per second,accounts for much of its popularity.

Ethernets come in three flavors: thick, thin, and twisted pair.

Ethernet works like a bus system, where a host may send packets (or frames) of up to 1,500 bytes to another host on the same Ethernet. A host is addressed by a six−byte address hardcoded into the firmware of its Ethernet network interface card (NIC). These addresses are usually written as a sequence of two−digit hex numbers separated by colons, as in aa:bb:cc:dd:ee:ff.

A frame sent by one station is seen by all attached stations, but only the destination host actually picks it up and processes it. If two stations try to send at the same time, a collision occurs. Collisions on an Ethernet are detected very quickly by the electronics of the interface cards and are resolved by the two stations aborting the send, each waiting a random interval and re−attempting the transmission.

ARP protocol

The ARP protocol allows to find out the Ethernet address of a machine knowing its IP address.

The arp utility displays and modifies the Internet-to-Ethernet address translation tables used by the address resolution protocol (arp(4)). With no flags, the program displays the current ARP entry for hostname.The host may be specified by name or by number, using Internet dot notation.

One of the most useful commands is:

```
arp -a
```

With this the program displays or deletes all of the current ARP entries.

Linux Network Devices

This chapter introduce the use and acccess to hardware drivers in Linux.

Linux Interfaces

The Linux kernel supports a number of hardware drivers for various types of equipment. This section gives a short overview of the driver families available and the interface names they use. There is a number of standard names for interfaces in Linux, which are listed here. Most drivers support more than one interface, in which case the interfaces are numbered, as in `eth0` and `eth1` :

Lo

This is the local loopback interface. It is used for testing purposes, as well as a couple of network applications. It works like a closed circuit in that any datagram written to it will immediately be returned to the host's networking layer.In other words,the loopback network device is an interface network always represents the virtual device itself regardless of the IP address that you may have assigned. Your IP is 127.0.0.1. There's always one loopback device present in the kernel, and there's little sense in having more.

eth0, eth1, &

These are the Ethernet card interfaces. They are used for most Ethernet cards, including many of the parallel port Ethernet cards.

tr0, tr1, &

These are the Token Ring card interfaces. They are used for most Token Ring cards, including non−IBM manufactured cards.

sl0, sl1, &

These are the SLIP interfaces. SLIP interfaces are associated with serial lines in the order in which they are allocated for SLIP.

ppp0, ppp1, &

These are the PPP interfaces. Just like SLIP interfaces, a PPP interface is associated with a serial line once it is converted to PPP mode.

plip0, plip1, &

These are the PLIP interfaces. PLIP transports IP datagrams over parallel lines. The interfaces are allocated by the PLIP driver at system boot time and are mapped onto parallel ports. In the 2.0.x

kernels there is a direct relationship between the device name and the I/O port of the parallel port, but in later kernels the device names are allocated sequentially, just as for SLIP and PPP devices.

ax0, ax1, &

These are the AX.25 interfaces. AX.25 is the primary protocol used by amateur radio operators. AX.25 interfaces are allocated and mapped in a similar fashion to SLIP devices. There are many other types of interfaces available for other network drivers. We've listed only the most common ones.

Accessing Serial Devices

Like all devices in a Unix system, serial ports are accessed through device special files, located in the /dev directory. Type this to list the content of dev directory:

```
cd /dev
ls
```

There are two varieties of device files related to serial drivers, and there is one device file of each type for each port. The device will behave slightly differently, depending on which of its device files we open. We'll cover the differences because it will help you understand some of the configurations and advice that you might see relating to serial devices, but in practice you need to use only one of these.

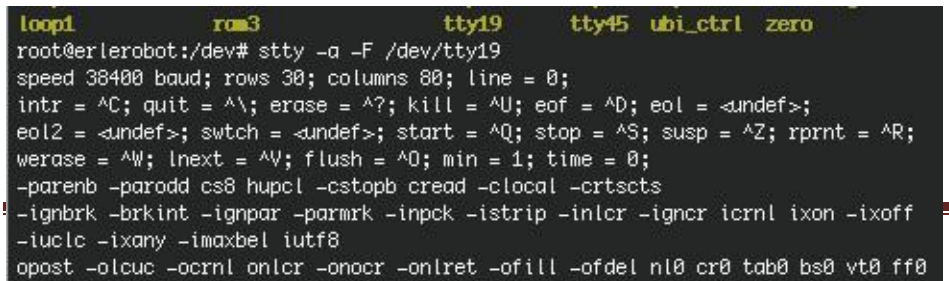
The most important of the two classes of serial device has a major number of 4, and its device special files are named **ttyS0** , **ttyS1** , etc. The second variety has a major number of 5, and was designed for use when dialing out (calling out) through a port; its device special files are called **cua0** , **cua1** , etc. In the Unix world, counting generally starts at zero, while laypeople tend to start at one. This creates a small amount of confusion for people because COM1: is represented by /dev/ttyS0 , COM2: by /dev/ttyS1 , etc.

The cua , or "callout," devices were created to solve the problem of avoiding conflicts on serial devices for modems that have to support both incoming and outgoing connections. Unfortunately, they've created their own problems and are now likely to be discontinued.

When dealing with devices stty command is very useful.The stty utility sets or reports on terminal characteristics for the device that is its standard input. If no options or operands are specified, it reports the settings of a subset of characteristics as well as additional ones if they differ from their default values. Otherwise it modifies the terminal state according to the specified arguments. Some combinations of arguments are mutually exclusive on some terminal types.

`stty command can be used to display the terminal configuration parameters of a tty device.
To display all of the active settings on a tty device, use:

```
stty −a −F /dev/ttyS1
```



DNS

In this chapter you will understand what a DNS is and how it works.

What is *DNS*?

Domain Name System or DNS is a hierarchical naming system for computers, services, or any resource connected to the Internet or a private network. This system associates various information with domain names assigned to each of the participants. Its most important function is to translate (resolve) intelligible names for people in binary identifiers associated with the devices connected to the network, all this in order to locating and addressing these devices worldwide.

The DNS server uses a distributed, hierarchical database that stores information associated with domain names in Internet networks. Although as the DNS database is able to associate different types of information on each name, the most common uses are mapping domain names to IP addresses and the location of the mail servers in each domain.

Hierarchy of domains

- Root domain or domain `.:
  - managed by ICANN (Internet Corporation for Assigned Names and Numbers).
  - The servers are root nameservers.
- First level domains (TLDs, Top Level Domains):
  - Generic tradicional domains:

    ```
    com, edu, gov, mil, org, net, int
    ```

  - Generic modern domains:

    ```
    aero, biz, coop, info, museum, name,
    pro, jobs, mobi, tel, travel, cat, asia
    ```

  - Domain for the DNS infrastructure:

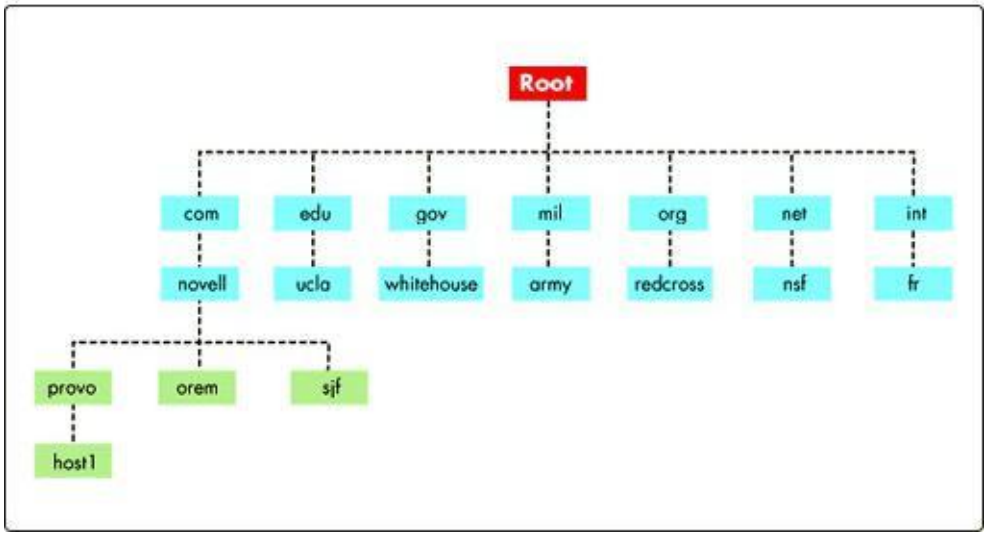
    ```
    arpa
    ```

  - Domains by ISO country code:

    ```
    uk, mx, ar, de, es, jp. . .
    ```

Second, third ... level domains.

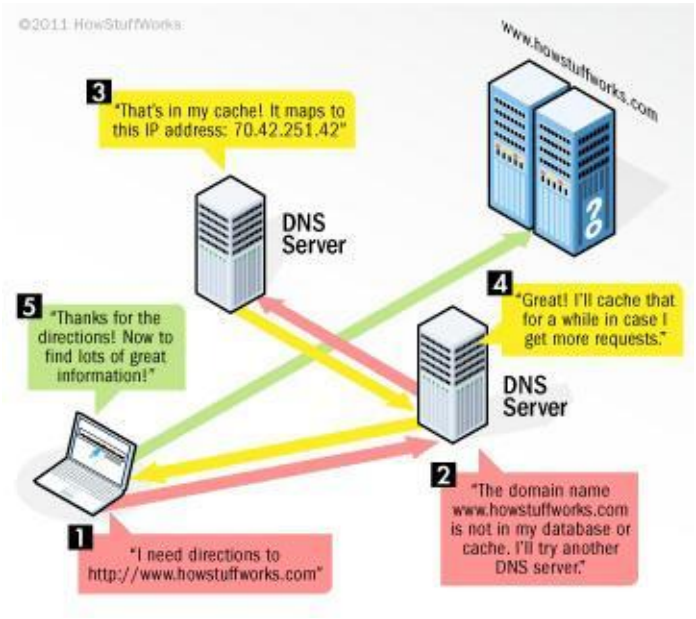
•


Root
com
edu
gov
mil
org
net
int
novell
ucla
whitehouse
army
redcross
nsf
fr
provo
orem
sjf
host1

How *DNS* works

DNS servers accept requests from programs and other name servers to convert domain names into IP addresses. When a request comes in, the DNS server can do one of four things with it: It can answer the request with an IP address because it already knows the IP address for the requested domain. It can contact another DNS server and try to find the IP address for the name requested. It may have to do this multiple times. It can say, "I don't know the IP address for the domain you requested, but here's the IP address for a DNS server that knows more than I do." It can return an error message because the requested domain name is invalid or does not exist.

How a DNS works in an image:



Note: In networking, when talking about caché we refer to data temporarily stored in anticipation of using them again and thus save computation time, search or download from the network.

As we have seen, DNS organizes hostnames in a domain hierarchy. A domain is a collection of sites that are related in some sense because they form a proper network (e.g., all machines on a campus, or all hosts on BITNET), because they all belong to a certain organization (e.g., the U.S. government), or because they're simply geographicallyclose. For instance, universities are commonly grouped in the edu domain, with each university or college using a separate subdomain, below which their hosts are subsumed.

> Groucho Marx University have the groucho.edu domain, while the LAN of the Mathematics department is assigned maths.groucho.edu. Hosts on the departmental network would have this domain name tacked onto their hostname, so erdos would be known as erdos.maths.groucho.edu. This is called the fully qualified domain name (FQDN), which uniquely identifies this host worldwide.

Organizing the namespace in a hierarchy of domain names nicely solves the problem of name uniqueness; with DNS, a hostname has to be unique only within its domain to give it a name different from all other hosts worldwide. Furthermore, fully qualified names are easy to remember. Taken by themselves, these are already very good reasons to split up a large domain into several subdomains.

DNS does even more for you than this. It also allows you to delegate authority over a subdomain to its administrators.

> For example, the maintainers at the Groucho Computing Center might create a subdomain for each department; we already encountered the math and physics subdomains above. When they find the network at the Physics department too large and chaotic to manage from outside (after all, physicists are known to be an unruly bunch of people), they may simply pass control of the physics.groucho.edu domain to the administrators of this network. These administrators are free to use whatever hostnames they like and assign them IP addresses from their network in whatever fashion they desire, without outside interference.

To this end, the namespace is split up into zones, each rooted at a domain. Note the subtle difference between a *zone* and a *domain*:

> The domain groucho.edu encompasses all hosts at Groucho Marx University, while the zone groucho.edu includes only the hosts that are managed by the Computing Center directly; those at the Mathematics department, for example. The hosts at the Physics department belong to a different zone,namely physics.groucho.edu.

Host

In this section you find the basic concepts of Host.

Host basics

A network host is a computer or other device connected to a computer network. A network host may offer information resources, services, and applications to users or other nodes on the network. A network host is a network node that is assigned a network layer host address.

The /etc /hostname file contains the computer name adopted when the operating system starts. If you use the command hostname you can see the name of your host computer.

```
root@erlerobot:~#
hostname   erlerobot
root@erlerobot:~#
```

The names of the machines can be with complete or qualification relating to the local domain.

The /etc/host.conf tells the older Linux standard library resolver functions which services to use, and in what order.In other words, host.conf indicates the order of the sources will use the address of operating system to obtain DNS resolutions requiring computer applications. There are two options:

- Look for them inside: /etc/hosts
- Search them outside: /etc/resolv.conf

Options in host.conf must appear on separate lines. Fields may be separated by white space (spaces or tabs). A hash sign
(#) introduces a comment that extends to the next newline. For example typing the option order etermines the order in which the resolving services are tried

The /etc/hosts is a simple mechanism of name resolution. Contains one record per line, consisting of a IP address, hostname and optionally a list of aliases for the hostname. The fields are separated by tabs or spaces and field with the @ IP should begin in the first column.The command host is a simple utility for performing DNS lookups. It is normally used to convert names to IP addresses and vice versa. When no arguments or options are given, host prints a short summary of its command line arguments and options.

The file /etc/resolv.conf contains the IP addresses of machines that can provide DNS services to our host. The statement points to DNS nameserver have the function that the host can use them to make their decisions.

Moreover, just as with IP addresses, sometimes You can also use a symbolic name for network numbers. For this purpose, the file /etc/hosts has a companion called /etc /networks, that associates names network with corresponding numbers and vice versa.

Network Configuration

Here you can find some ways of changing the configuration of your network.

Network configuration commands

ip

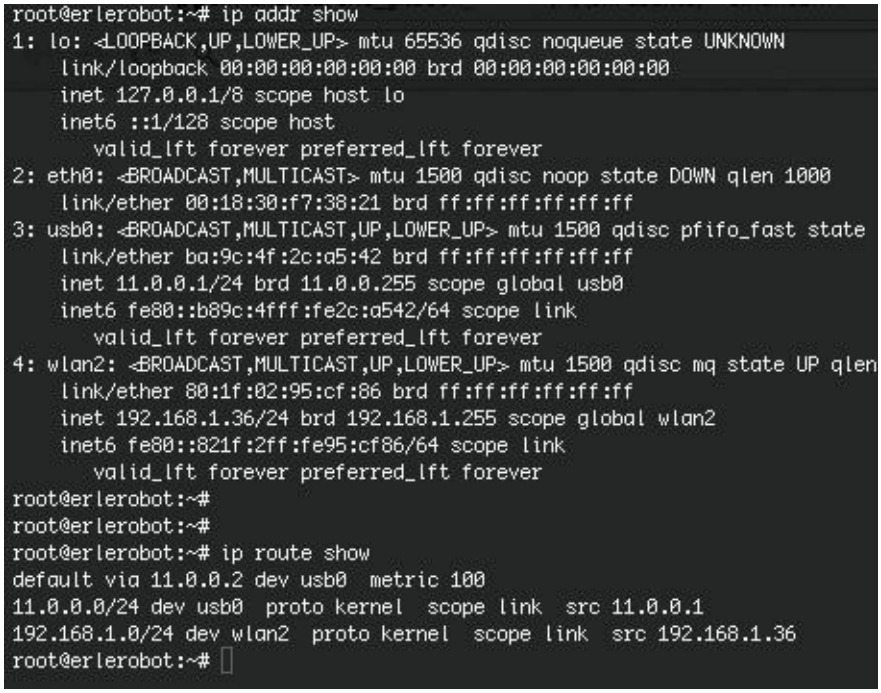
IP is the transport layer protocol used by the Internet protocol family. Options may be set at the IP level when using higher-level protocols that are based on IP (such as TCP and UDP).

```
ip addr show
```

Displays the IP address

```
ip route show
```

Displays the IP route



ifconfig

There are many more parameters to ifconfig than we have described so far. Its normal invocation is this:

```
ifconfig interface [address [parameters]]
```

interface is the interface name, and address is the IP address to be assigned to the interface. This may be either an IP address in dotted quad notation or a name that ifconfig will look up in /etc/hosts.

```
ifconfig
```

As we have seen this command displays the configuration information for all network interfaces of the system.

```
root@erlerobot:/proc/net# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:36 errors:0 dropped:0 overruns:0 frame:0
          TX packets:36 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:3074 (3.0 KB)  TX bytes:3074 (3.0 KB)

usb0      Link encap:Ethernet  HWaddr 9a:84:d7:d4:82:47
          inet addr:11.0.0.1  Bcast:11.0.0.255  Mask:255.255.255.0
          inet6 addr: fe80::9884:d7ff:fed4:8247/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:108 errors:0 dropped:0 overruns:0 frame:0
          TX packets:140 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:20982 (20.9 KB)  TX bytes:10750 (10.7 KB)

wlan2     Link encap:Ethernet  HWaddr 80:1f:02:95:cf:86
          inet addr:192.168.1.36  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::821f:2ff:fe95:cf86/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:188 errors:0 dropped:3 overruns:0 frame:0
          TX packets:45 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:24881 (24.8 KB)  TX bytes:8727 (8.7 KB)
```

ifconfig eth0 down

Disables the network interface eth0.

ifconfig eth0

Check the status of the eth0 interface.

```
root@erlerobot:/proc# ifconfig wlan2
wlan2     Link encap:Ethernet  HWaddr 80:1f:02:95:cf:86
          inet addr:192.168.1.36  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::821f:2ff:fe95:cf86/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:280 errors:0 dropped:3 overruns:0 frame:0
          TX packets:49 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:33679 (33.6 KB)  TX bytes:9015 (9.0 KB)
```

ifconfig interfase dirección-ip

Interfacing basic configuration.Asign IP address and activates it. The other parameters take values assigned by default.For example, the subnet mask takes the value corresponding to the type of network the Ip address belong to.Like that we have 255.255.0.0 for a vlass B address.

ifconfig eth0 100.200.26.1 netmask 255.255.255.0 broadcast 100.200.26.255

Sets the network interface from scratch.

In this link you can find other option when working with ifconfig.

route

The sintaxis is the following one:

```
route [-n] command [-net|-host] destination
```

In the sintaxis above, destination is the destination host or network, gateway is the next-hop intermediary via which packets should be routed. Routes to a particular host may be distinguished from those to a network by inter- preting the Internet address specified as the destination argument. The optional modifiers -net and -host force the destination to be interpreted as a network or a host, respectively.

The route command itselfs display the IP routing table of the system. Also allows to add or remove an entry in the routing table. This command allows you to set static routes when network routing.

```
root@erlerobot:/# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         11.0.0.2        0.0.0.0         UG    100    0        0 usb0
11.0.0.0        *               255.255.255.0   U     0      0        0 usb0
192.168.1.0     *               255.255.255.0   U     0      0        0 wlan2
```

```
option -net
```

Specifies that the specified target is a network.

```
option -host
```

Specifies that the specified target is a computer.

```
route -n
```

Prints the routing table full core if run without arguments (the-n option makes use dotted quad instead of hostnames).

```
route add –net 192.168.1.0 gw 192.168.1.2
```

Add a route to a network through a gateway.

```
route add- host 192.168.1.250 dev eth0
```

Adds a route to an particular machine via a local interfacing.

route add domain

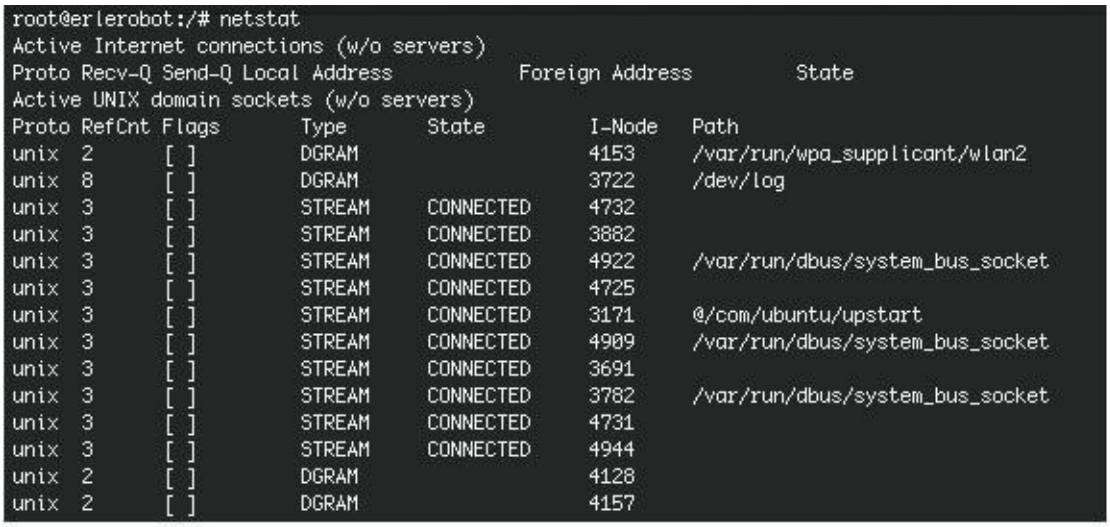
Adds a route to the routing table using the names defined in the file /etc /networks. Thus prevents write-net indicator because route knows that this is network

```
route add default gw host
```

Routing through the default gateway.

netstat

Depending on the selected option netstat command shows the networks interfaces, the PID associated to each interface...



```
root@erlerobot:/# netstat
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
Active UNIX domain sockets (w/o servers)
Proto RefCnt Flags       Type       State         I-Node   Path
unix  2      [ ]         DGRAM                    4153     /var/run/wpa_supplicant/wlan2
unix  8      [ ]         DGRAM                    3722     /dev/log
unix  3      [ ]         STREAM     CONNECTED     4732
unix  3      [ ]         STREAM     CONNECTED     3882
unix  3      [ ]         STREAM     CONNECTED     4922     /var/run/dbus/system_bus_socket
unix  3      [ ]         STREAM     CONNECTED     4725
unix  3      [ ]         STREAM     CONNECTED     3171     @/com/ubuntu/upstart
unix  3      [ ]         STREAM     CONNECTED     4909     /var/run/dbus/system_bus_socket
unix  3      [ ]         STREAM     CONNECTED     3691
unix  3      [ ]         STREAM     CONNECTED     3782     /var/run/dbus/system_bus_socket
unix  3      [ ]         STREAM     CONNECTED     4731
unix  3      [ ]         STREAM     CONNECTED     4944
unix  2      [ ]         DGRAM                    4128
unix  2      [ ]         DGRAM                    4157
```

```
netstat -c
```

Renews the information continually till you push ^C (ctrl + c).

```
netstat -i
```

Displays a list with all the network interfaces.

```
netstat -p
```

Shows a list with all the PID.

```
netstat -r
```

Displays the information of the routing table.

```
netstat -t
```

Shows the active connections of the TCP ports Muestra las conexiones activas a puertos TCP.

```
netstat -u
```

Displays active connections to UDP ports. If included "a" will also display the ports that are waiting for a connection (listening).

netstat-nr

Displays routing information.The -n shows network addresses as numbers and the -r shows the routing tables.

ping

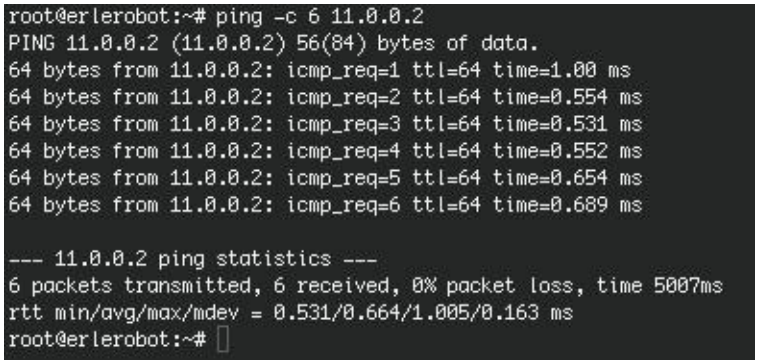
The sintaxis is the following one:

```
ping hostname
```

The ping command sends an ICMP echo request protocol to the specified hostname and shows the time to receive confirmation echo. The default sends messages indefinitely until the order is canceled by ^C .

```
ping -c n hostname
```

n messages will be sent. Al finalizar los mensajes especificados se muestra la estadística de los resultados.After sending the specified messages, statistical results are shown.



traceroute

The Internet is a large and complex aggregation of network hardware, connected together by gateways. Tracking the route one's packets follow (or finding the miscreant gateway that's discarding your packets) can be difficult. traceroute utilizes the IP protocol `time to live' field and attempts to elicit an ICMP TIME_EXCEEDED response from each gateway along the path to some host.

For example, you can check the route the packets follow to a network host using this command:

```
/usr/sbin/traceroute www.eunet.be
```

Network configuration files

In Linux we are able to configure the network by editing the configuration files.We can find this files in the etc directory and edit them using, for example *vi* text editor.(If they don't exist, you can create them and they will update their content automatically).

/etc/network/interfaces

Contains information required to configure the interfaces of host network at boot time. It also allows you to set static routes to other networks.

What you find if you go to networks directory and open interfaces, by typing:

```
vi interfaces
```

Is text editable file like this:

```
# interfaces(5) file used by ifup(8) and ifdown(8)

# loopback network interface
auto lo
iface lo inet loopback

# primary network interface
#auto eth0
#iface eth0 inet dhcp
#hwaddress ether DE:AD:BE:EF:CA:FE

# wireless network interface
#auto wlan0
#iface wlan0 inet dhcp
#   wpa-ssid "my_wifi_name"
#   wpa-key "my_wifi_name"

auto wlan2
iface wlan2 inet dhcp
    wpa-driver wext
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf

## wlan3 for access point
"interfaces" [readonly] 37L, 697C                    1,1           Top
```

/etc/hostname

Here is specified the name of the machine.

```
erlerobot
~
~
~
~
~
~
```

/etc/hosts

As we have seen in *5.1 Host Basics*, in the file /etc/hosts specify the IP along with the name of each machine you want to access by name. The /etc/hosts file always contains the localhost IP address, 127.0.0.1, which is used for interprocess communication(never remove this line).Sometimes contains addresses of additional hosts, which can be contacted without using an external naming service such as DNS (the Domain Name Server).

```
127.0.0.1 localhost
127.0.1.1 ubuntu-armhf

10.0.0.1 erle
11.0.0.1 erlerobot

~
~
~
```

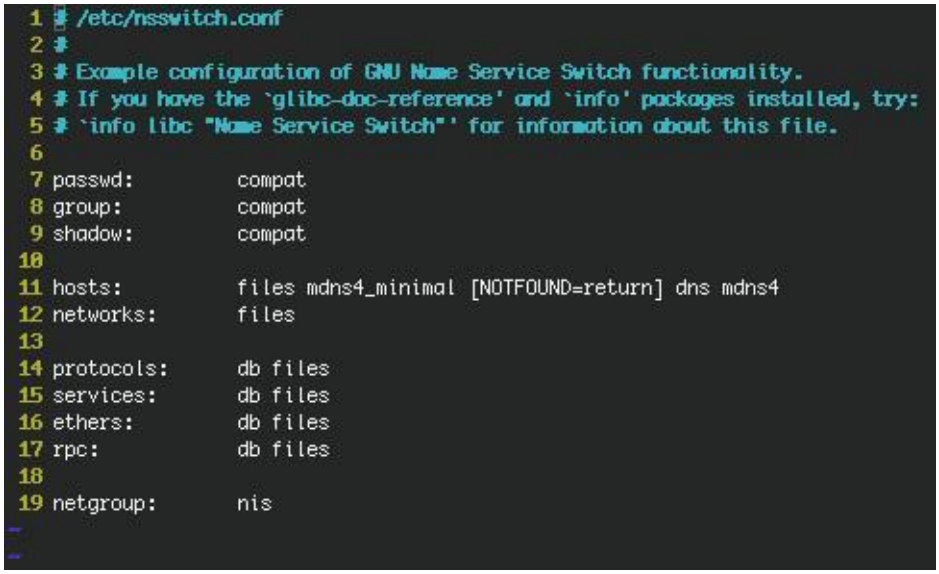
/etc/resolv.conf

In the file / etc / resolv.conf specify what servers use to resolve domain names.

```
nameserver 80.58.61.250
nameserver 80.58.61.254
~
~
~
~
~
```

/etc/nsswitch.conf

Defines the order in which to contact different name services.



```
# /etc/nsswitch.conf
#
# Example configuration of GNU Name Service Switch functionality.
# If you have the `glibc-doc-reference' and `info' packages installed, try:
# `info libc "Name Service Switch"' for information about this file.

passwd:         compat
group:          compat
shadow:         compat

hosts:          files mdns4_minimal [NOTFOUND=return] dns mdns4
networks:       files

protocols:      db files
services:       db files
ethers:         db files
rpc:            db files

netgroup:       nis
```

Internet/Intranet applications

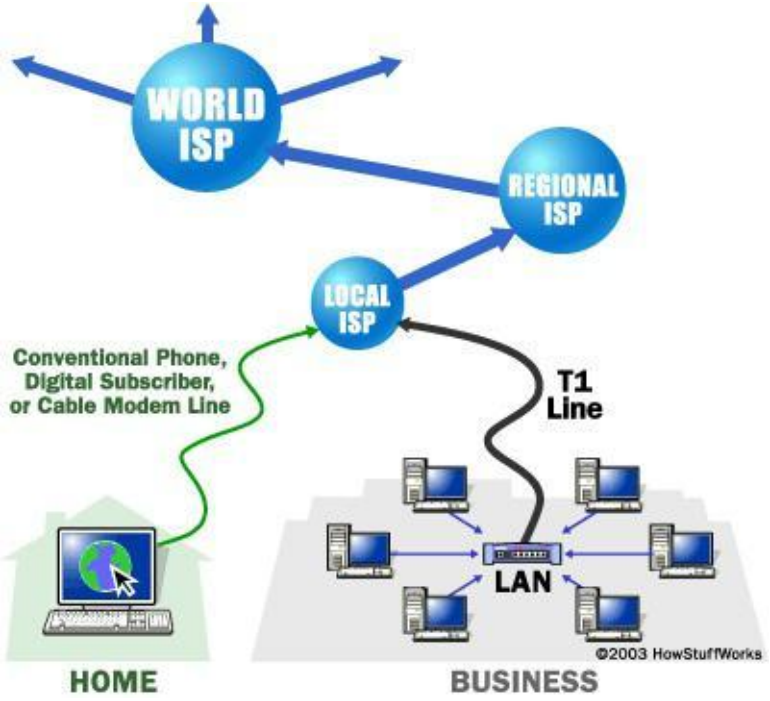
The Linux system is a great platform for offering networking services. In this section, we will try to give an overview of most

common network servers, applications and how Internet works.

Internet basics

So what is "the Internet"? The Internet is a gigantic collection of millions of computers, all linked together on a computer network.

One of the greatest things about the Internet is that nobody really owns it. It is a global collection of networks, both big and small. These networks connect together in many different ways to form the single entity that we know as the Internet. In fact, the very name comes from this idea of interconnected networks.



The network allows all of the computers to communicate with one another. A home computer may be linked to the Internet using a phone-line modem, DSL or cable modem that talks to an **Internet service provider (ISP)**. A computer in a business or university will usually have a **network interface card (NIC)** that directly connects it to a **local area network (LAN)** inside the business. The business can then connect its LAN to an ISP using a high-speed phone line like a **T1 line**. A T1 line can handle approximately 1.5 million bits per second, while a normal phone line using a modem can typically handle 30,000 to 50,000 bits per second. ISPs then connect to larger ISPs, and the largest ISPs maintain fiber-optic "backbones" for an entire nation or region. **Backbones** are typically fiber optic trunk lines. The trunk line has multiple fiber optic cables combined together to increase the capacity.Backbones around the world are connected through fiber-optic lines, undersea cables or satellite links (see An Atlas of Cyberspaces for some interesting backbone maps). In this way, every computer on the Internet is connected to every other computer on the Internet.

The Function of an Internet Router

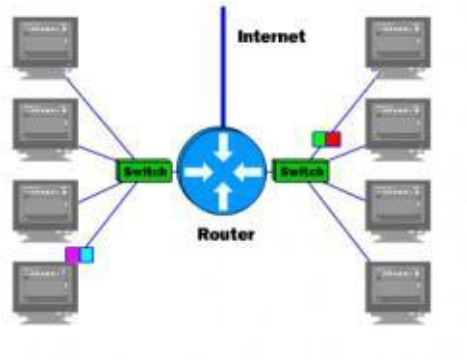
All the Internet networks rely on NAPs, backbones and routers to talk to each other.

A **router** is a device that forwards data packets between computer networks.The routers determine where to send information from one computer to another. Routers are specialized computers that send your messages and those of every other Internet user speeding to their destinations along thousands of pathways. A router has two separate, but related, jobs:

- It ensures that information doesn't go where it's not needed. This is crucial for keeping large volumes of data from clogging the connections of "innocent bystanders."
- It makes sure that information does make it to the intended destination.

In performing these two jobs,a router is extremely useful in dealing with two separate computer networks. It joins the two networks, passing information from one to the other. It also protects the networks from one another, preventing the traffic on one from unnecessarily spilling over to the other. Regardless of how many networks are attached, the basic operation and

function of the router remains the same. Since the Internet is one huge network made up of tens of thousands of smaller networks, its use of routers is an absolute necessity.



Clients and servers

In general, all of the machines on the Internet can be categorized as two types: servers and clients. Those machines that provide services (like Web servers or FTP servers) to other machines are **servers**. And the machines that are used to connect to those services are **clients**.

A server machine may provide one or more services on the Internet. For example, a server machine might have software running on it that allows it to act as a Web server, an e-mail server and an FTP server. Clients that come to a server machine do so with a specific intent, so clients direct their requests to a specific software server running on the overall server machine. For example, if you are running a Web browser on your machine, it will most likely want to talk to the Web server on the server machine. Your Telnet application will want to talk to the Telnet server, your e-mail application will talk to the e-mail server, and so on...

URL: Uniform Resource Locator

When you use the Web or send an e-mail message, you use a domain name to do it. For example, the Uniform Resource Locator (URL) "http://www.erlerobot.com" contains the domain name erlerobot.com. So does this e-mail address: example@erlerobot.com. Every time you use a domain name, you use the Internet's DNS servers to translate the human-readable domain name into the machine-readable IP address.

Top-level domain names, also called first-level domain names, include .COM, .ORG, .NET, .EDU and .GOV. Within every top-level domain there is a huge list of second-level domains. For example, in the .COM first-level domain there is: Yahoo and Microsoft. Every name in the .COM top-level domain must be unique. The left-most word, like www, is the host name. It specifies the name of a specific machine (with a specific IP address) in a domain. A given domain can, potentially, contain millions of host names as long as they are all unique within that domain.

Ports and HTTP

Any server machine makes its services available using numbered ports(one for each service that is available on the server). For example, if a server machine is running a Web server and a file transfer protocol (FTP) server, the Web server would typically be available on port 80, and the FTP server would be available on port 21. Clients connect to a service at a specific IP address and on a specific port number. Once a client has connected to a service on a particular port, it accesses the service using a specific protocol. Protocols are often text and simply describe how the client and server will have their conversation. Every Web server on the Internet conforms to the **hypertext transfer protocol (HTTP)**.

HTTP is an application protocol for distributed, collaborative, hypermedia information systems. Hypertext is structured text that uses logical links (hyperlinks) between nodes containing text. HTTP is the protocol to exchange or transfer hypertext.

Cookies

A cookie is a piece of text that a Web server can store on a user's hard disk. Cookies allow a Web site to store information on a user's machine and later retrieve it. The pieces of information are stored as name-value pairs.

Cookies evolved because they solve a big problem for the people who implement Web sites. In the broadest sense, a cookie allows a site to store state information on your machine. This information lets a Web site remember what state your browser is in. An ID is one simple piece of state information; if an ID exists on your machine, the site knows that you have visited before. The state is, "Your browser has visited the site at least one time," and the site knows your ID from that visit.

The World Wide Web (WWW)

The Internet has much to offer in terms of information on almost any subject matter imaginable and interaction with people and organizations from all over the world. Much of this access and interaction make use of the environment which is popularly known as the World Wide Web (WWW) or web. The WWW is an interlinked network of systems(web servers) offering multimedia services and information. A user can access these using what is known as web browser software, such as Mozilla or Chrome web browsers.

Servers

A server is a system (software and suitable computer hardware) that responds to requests across a computer network to provide, or help to provide, a network service. Servers can be run on a dedicated computer, which is also often referred to as "the server", but many networked computers are capable of hosting servers. In many cases, a computer can provide several services and have several servers running.

If you want to get into a bit more detail on the process of getting a Web page onto your computer screen, here are the basic steps that occurred behind the scenes:

The browser broke the URL into three parts:

- The protocol ("http")
- The server name ("www.erlerobot.com")
- The file name ("tutorials.htm")

The browser communicated with a name server to translate the server name "www.erlerobot.com" into an IP Address, which it uses to connect to the server machine. The browser then formed a connection to the server at that IP address on port 80. Following the HTTP protocol, the browser sent a GET request to the server, asking for the file "http://www.erlerobot.com/tutorials.htm".

The server then sent the HTML text for the Web page to the browser. (Cookies may also be sent from server to browser in the header for the page.) The browser read the HTML tags and formatted the page onto your screen.

Server types

Standalone server

Offering a service to users can be approached in two ways. A daemon or service can run in standalone mode, or it can be dependent on another service to be activated.

Network services that are heavily and/or continuously used, usually run in the standalone mode: they are independent program daemons that are always running. They are most likely started up at system boot time, and they wait for requests on the specific connection points or ports for which they are set up to listen. When a request comes, it is processed, and the listening continues until the next request. A web server is a typical example: you want it to be available 24 hours a day, and if it is too busy it should create more listening instances to serve simultaneous users.

An example of a standalone network service on your home computer might be the named (name daemon), a caching name server. Standalone services have their own processes running, you can check any time using ps :

```
root@erlerobot:~# ps auxw | grep named
```

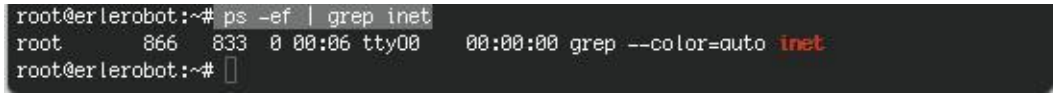
However, there are some services that you can use on your PC, even if there is no server process running for that services. Examples could be the FTP service, the secure copy service or the finger service. Those services have the Internet Daemon (inetd) listening in their place.

(x)inetd

On your home PC, things are usually a bit calmer. You may have a small network, for instance, and you may have to transfer files from one PC to another from time to time, using FTP or Samba. In those cases, starting all the services which you only need occasionally and having them run all the time would be a waste of resources. So in smaller setups, you will find the necessary daemons dependent on a central program, that listen on all the ports of the services for which it is responsible.

This super-server, the Internet services daemon, is started up at system initialization time. There are two common implementations: inetd and xinetd (the extended Internet services daemon). One or the other is usually running on every Linux system:

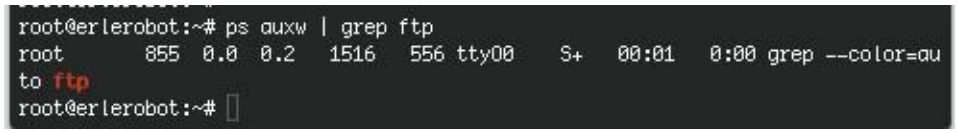
ps -ef | grep inet



The services for which the Internet daemon is responsible, are listed in its configuration file, /etc/inetd.conf, for inetd, and in the directory /etc/xinetd.d for xinetd. Commonly managed services include file share and print services, SSH, FTP, telnet, the Samba configuration daemon, talk and time services.

As soon as a connection request is received, the central server will start an instance of the required server. Thus, in the example below, when user bob starts an FTP session to the local host, an FTP daemon is running as long as the session is active:

```
ps auxw |
grep ftp
```



Of course, the same happens when you open connections to remote hosts: either a daemon answers directly, or a remote

(x)inetd starts the service you need and stops it when you quit.

Web

The Apache Web Server

Apache is by far the most popular web server, used on more than half of all Internet web servers. Most Linux distributions include Apache. Apache's advantages include its modular design, SSL support, stability and speed. Given the appropriate hardware and configuration it can support the highest loads.

On Linux systems, the server configuration is usually done in the /etc/httpd directory. The most important configuration file is httpd.conf; it is rather self-explanatory. Should you need help, you can find it in the httpd man page or on the Apache website.

Web browsers

A number of web browsers, both free and commercial, exist for the Linux platform. Netscape Navigator as the only decent option has long been a thing of the past, as Mozilla/Firefox or Google Chrome offer a competitive alternative running on many other operating systems, like MS Windows and MacOS X as well.

Amaya is the W3C browser. Opera is a commercial browser, compact and fast. Many desktop managers offer web browsing features in their file manager, like nautilus.

Among the popular text based browsers are lynx and links. You may need to define proxy servers in your shell, by setting the appropriate variables. Text browsers are fast and handy when no graphical environment is available, such as when used in scripts.

Proxy servers

What is a proxy server?

A proxy server is a server (a computer system or an application) that acts as an intermediary for requests from clients seeking resources from other servers. A client connects to the proxy server, requesting some service, such as a file, connection, web page, or other resource available from a different server and the proxy server evaluates the request as a way to simplify and control its complexity.

Proxy configuration

If you have the proxy server name and port, it should be rather obvious to feed that information into your browser. However, many (command line) applications depend on the variables http_proxy and ftp_proxy for correct functioning. For your convenience, you might want to add a line like the following to your ~/.bashrc.

You can edit it with *vi* text editor by typing:

```
vi ~/.bashrc
```

Then add

```
export http_proxy=http://username:password@proxy_server_name:port_number
```

For instance:

```
export http_proxy=http://willy:Appelsi3ntj3@proxy:80
```

If you do not need to give a username and password, simply leave out everything before the "@" sign, this sign included.

- For more info about proxy serves you can read: http://www.brennan.id.au/11-Squid_Web_Proxy.html
- Here you can find answers to common questions about proxy serves:http://www.cyberciti.biz/faq/linux-unix-set-proxy-environment-variable/

Mail

Electronic mail transport has been one of the most prominent uses of networking since the first networks were devised.

Servers

Sendmail is the standard mail server program or Mail Transport Agent for UNIX platforms. It is robust, scalable, and when properly configured with appropriate hardware, handles thousands of users without blinking. More information about how to configure Sendmail is included with the sendmail and sendmail-cf packages.For more information use man sendmail and man aliases.

Qmail is another mail server, gaining popularity because it claims to be more secure than Sendmail. While Sendmail is a monolithic program, Qmail consists of smaller interacting program parts that can be better secured. Postfix is another mail server which is gaining popularity.

These servers handle mailing lists, filtering, virus scanning and much more. Free and commercial scanners are available for use with Linux. Examples of mailing list software are Mailman, Listserv, Majordomo and EZmlm. See the web page of your favorite virus scanner for information on Linux client and server support. Amavis and Spamassassin are free implementations of a virus scanner and a spam scanner.

Remote mail servers

The most popular protocols to access mail remotely are POP3 and IMAP4. IMAP and POP both allow offline operation, remote access to new mail and they both rely on an SMTP server to send mail.

While POP is a simple protocol, easy to implement and supported by almost any mail client, IMAP is to be preferred because:

- It can manipulate persistent message status flags.
- It can store as well as fetch mail messages.
- It can access and manage multiple mailboxes.
- It supports concurrent updates and shared mailboxes.
- It is also suitable for accessing Usenet messages and other documents.

IMAP works both on-line and off-line.

it is optimized for on-line performance, especially over low-speed links.

Mail user-agents

There are plenty of both text and graphical E-mail clients, we'll just name a few of the common ones. Pick your favorite.

The UNIX mail command has been around for years, even before networking existed. It is a simple interface to send messages and small files to other users, who can then save the message, redirect it, reply to it etcetera.

While it is not commonly used as a client anymore, the mail program is still useful, for example to mail the output of a command to somebody.

- Sending mail:

```
mail   example@erlerobot
< doc.txt
```

```
mail -s “Hello Erle” example@erlerobot.com
```

```
echo “This will go into the body of the mail.” | mail -s “Hello Erle” example@erlerobot.com
```

- Reading Mail:

In normal usage mail is given no arguments and checks your mail out of the post office, then prints out a one line header of each message found.The current message is initially the first message (numbered 1) and can be printed using the `print command (which can be abbreviated p). You can move among the messages much as you move between lines in ed(1), with thecommands + and - moving backwards and forwards, and simple numbers.

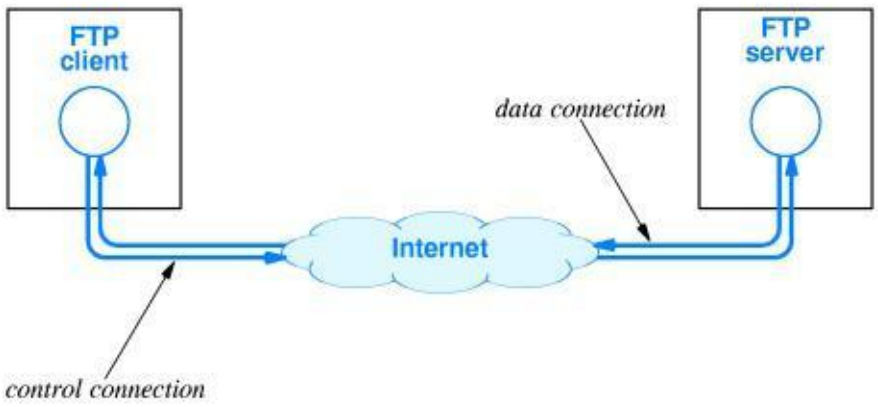
For those users who prefer a graphical interface to their mail (and a tennis elbow or a mouse arm), there are hundreds of options. The most popular for new users are Mozilla Mail/Thunderbird, which has easy anti-spam configuring options, and Evolution, the MS Outlook clone. Kmail is popular among KDE users.

For more info and mail installation/configuration, you can visit: http://www.ajpdsoft.com/modules.php?name=News&file=article&sid=506#instalarmailx

FTP

FTP (File Transfer Protocol) is used to transfer files between two computers over a network and Internet. FTP can transfer files between any computers that have an Internet connection, and also works between computers using totally different operating systems.

FTP requires a client (FTP program) installed on your PC to connect to your host, or server. Once you are logged in, you are presented with a directory. If files already exist on your host you can select the download to option and pull files off the FTP server to a specified directory on your computer. If you select the upload option, you must also select your PC directory that contains the files you wish to upload. The files are then copied from one location to the other. It's like copying files from one directory or folder on your PC, except that one of the folders could be on the East coast and the other folder on the West cost.



Transferring files from a client computer to a server computer is called "uploading" and transferring from a server to a client is "downloading".

FTP servers

On a Linux system, an FTP server is typically run from xinetd, using the WU-ftpd server, although the FTP server may be configured as a stand-alone server on systems with heavy FTP traffic. See the exercises.

Other FTP servers include among others vsftpd, Ncftpd and Proftpd.

Most Linux distributions contain the anonftp package, which sets up an anonymous FTP server tree and accompanying configuration files.

FTP clients

Most Linux distributions include ncftp, an improved version of the common UNIX `ftp command, which you may also know from the Windows command line. The ncftp program offers extra features such as a nicer and more comprehensible user interface, file name completion, append and resume functions, bookmarking, session management and more.

> *Warning FTP is insecure!*

Don't use the File Transfer Protocol for non-anonymous login unless you know what you are doing. Your user name and password might be captured by malevolent fellow network users. Use secure FTP instead; the sftp program comes with the Secure SHell suite, see Section

To install and configure ftp in your Linux pc visit: https://help.ubuntu.com/10.04/serverguide/ftp-server.html

FTP examples

Use the following syntax to connect to transfer files to and from a remote network ftp site:

```
ftp ftp.example.com
ftp 1.2.3.4
ftp user@ftp.example.com
```

FTP command options:

```
ftp
```

Type the ls command at ftp> prompt for listing current file:

```
ftp> ls
```

To change directory on the remote machine use cd command:

```
ftp> cd dirName
```

To copy one file at a time from the remote ftp server to the local system use get command:

```
get fileName
get fileName newFileName
```

In this example, download file resume.pdf in the current remote directory to (or on top of) a file with the same name, resume.pdf, in your current local directory:

```
ftp> get resume.pdf
```

In this example, copies file data.tar.gz in the current remote directory to (or on top of) a file named backup.tar.gz in your current local directory:

```
ftp> get data.tar.gz backup.tar.gz
```

To change directory on your local system, enter:

```
ftp> lcd /path/to/new/dir
ftp> lcd /tmp
```

Print local directory:

```
ftp> lpwd
```

To delete a file in the current remote directory use delete command:

```
ftp> delete fileName
ftp> delete output.jpg
```

To copy one file at a time from the local systems to the remote ftp server, enter:

```
ftp> put fileName
```

Type quit or bye, enter:

```
ftp> quit
```

or

```
ftp> bye
```

For more examples visit this website

Authentication services

Traditional

Traditionally, users are authenticated locally, using the information stored in /etc/passwd and /etc/shadow on each system. But even when using a network service for authenticating, the local files will always be present to configure system accounts for administrative use, such as the root account, the daemon accounts and often accounts for additional programs and purposes.

These files are often the first candidates for being examined by hackers, so make sure the permissions and ownerships are strictly set as should be:

```
root@erlerobot:~#  ls -l /etc/passwd /etc/shadow
```

```
-rw-       roo       125 M     201  /etc/pass
r--    r--1 t    root  6    ay 22 4    wd
-rw-       roo shad      M     201  /etc/shad
r-----     1 t    ow    800 ay 22 4    ow
```

PAM

Linux can use PAM, the Pluggable Authentication Module, a flexible method of UNIX authentication. Advantages of PAM:

A common authentication scheme that can be used with a wide variety of applications.

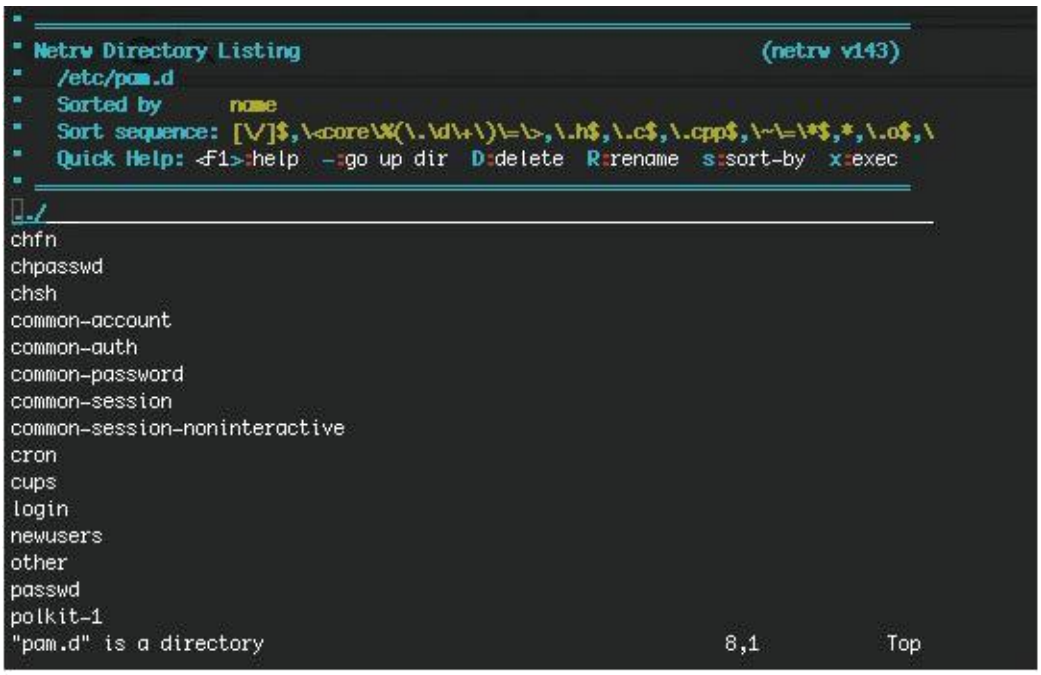
PAM can be implemented with various applications without having to recompile the applications to specifically support PAM.

Great flexibility and control over authentication for the administrator and application developer.

Application developers do not need to develop their program to use a particular authentication scheme. Instead, they can focus purely on the details of their program.

The directory /etc/pam.d contains the PAM configuration files (used to be /etc/pam.conf). Each application or service has its own file. You can edit o show the content of this files by typing:

```
vi pam.d
```



vi pam.conf

Each line in the file has four elements:

Module:

- auth: provides the actual authentication (perhaps asking for and checking a password) and sets credentials, such as group membership or Kerberos tickets.
- account: checks to make sure that access is allowed for the user (the account has not expired, the user is allowed to log in at this time of day, and so on).

- password: used to set passwords.
- session: used after a user has been authenticated. This module performs additional tasks which are needed to allow access (for example, mounting the user's home directory or making their mailbox available).

The order in which modules are stacked, so that multiple modules can be used, is very important.

- Control Flags: tell PAM which actions to take upon failure or success. Values can be required, requisite, sufficient or optional.
- Module Path: path to the pluggable module to be used, usually in /lib/security.
- Arguments: information for the modules.

Shadow password files are automatically detected by PAM.

More information can be found in the pam man pages or at the Linux-PAM project homepage.

LDAP

The Lightweight Directory Access Protocol is a client-server system for accessing global or local directory services over a network. On Linux, the OpenLDAP implementation is used. It includes slapd, a stand-alone server; slurpd, a stand-alone LDAP replication server; libraries implementing the LDAP protocol and a series of utilities, tools and sample clients.

LDAP directory service is based on a client-server model. One or more LDAP servers contain the data making up the LDAP directory tree or LDAP backend database. An LDAP client connects to an LDAP server and asks it a question. The server responds with the answer, or with a pointer to where the client can get more information (typically, another LDAP server). No matter what LDAP server a client connects to, it sees the same view of the directory; a name presented to one LDAP server references the same entry it would at another LDAP server. This is an important feature of a global directory service, like LDAP.

The main benefit of using LDAP is the consolidation of certain types of information within your organization. For example, all of the different lists of users within your organization can be merged into one LDAP directory. This directory can be queried by any LDAP-enabled applications that need this information. It can also be accessed by users who need directory information.

Since LDAP is an open and configurable protocol, it can be used to store almost any type of information relating to a particular organizational structure. Common examples are mail address lookups, central authentication in combination with PAM, telephone directories and machine configuration databases.

See your system specific information and the man pages for related commands such as ldapmodify (LDAP modify entry and LDAP add entry tools) and ldapsearch (LDAP search tool) for details.

- More information can be found in the LDAP Linux HOWTO, in ths webpage you will also find installing and configuting steps.
- Also this website should be insteresting, for managing the LDAP from the command line.

Remote execution of applications

In this chapter we will talk about remote execution of applocations.There are a couple of different ways to execute commands or run programs on a remote machine and have the output, be it text or graphics, sent to your workstation.

Rsh, rlogin and telnet

The rlogin and rsh commands for remote login and remote execution of commands are inherited from UNIX. While seldom used because they are blatantly insecure, they still come with almost every Linux distribution for backward compatibility with UNIX programs.

Telnet, on the other hand, is still commonly used, often by system and network administrators. Telnet is one of the most powerful tools for remote access to files and remote administration, allowing connections from anywhere on the Internet. Combined with an X server, remote graphical applications can be displayed locally. There is no difference between working on the local machine and using the remote machine.

Because the entire connection is unencrypted, allowing telnet connections involves taking high security risks. For normal remote execution of programs, Secure SHell or ssh is advised. We will discuss the secure method later in this section.

However, telnet is still used in many cases. For more information use man telnet, and for installing them visit this website http://www.cyberciti.biz/faq/how-do-i-turn-on-telnet-service-on-for-a-linuxfreebsd-system/

The X Window System

The X Window System was developed at MIT in the late 1980s, rapidly becoming the industry standard windowing system for Unix graphics workstations. The software is freely available, very versatile, and is suitable for a wide range of hardware platforms. Any X environment consists of two distinct parts, the X server and one or more X clients. It is important to realise the distinction between the server and the client. The server controls the display directly and is responsible for all input/output via the keyboard, mouse or display. The clients, on the other hand, do not access the screen directly - they communicate with the server, which handles all input and output. It is the clients which do the "real" computing work - running applications or whatever. The clients communicate with the server, causing the server to open one or more windows to handle input and output for that client.

In short, the X Window System allows a user to log in into a remote machine, execute a process (for example, open a web browser) and have the output displayed on his own machine. Because the process is actually being executed on the remote system, very little CPU power is needed in the local one. Indeed, computers exist whose primary purpose is to act as pure X servers. Such systems are called X terminals.

- Here you can find more information about the X window System.
- A free port of the X Window System exists for Linux and can be found at: http://www.xfree86.org/

Telnet and X

If you would want to use telnet to display graphical applications running on a remote machine, you first need to give the remote machine access to your display (to your X server) using the xhost command.

By typing a command similar to the one below in a terminal window on your local machine:

```
xhost +remote.machine.com
```

After that, connect to the remote host and tell it to display graphics on the local machine by setting the environment variable
DISPLAY:

```
export DISPLAY="local.host.com:0.0"
```

After completing this step, any application started in this terminal window will be displayed on your local desktop, using remote resources for computing, but your local graphical resources (your X server) for displaying the application.

This procedure assumes that you have some sort of X server (XFree86, X.org, Exceed, Cygwin) already set up on the machine where you want to display images. The architecture and operating system of the client machine are not important as long as they allow you to run an X server on it.

Mind that displaying a terminal window from the remote machine is also considered to be a display of an image.

SSH suite

SSH (Secure SHell) is a protocol which facilitates secure communications between two systems using a client / server architecture that allows users to connect to a remote host.

Most UNIX and Linux systems now run Secure SHell in order to leave out the security risks that came with Telnet. Most Linux systems will run a version of OpenSSH, an Open Source implementation of the SSH protocol, providing secure encrypted communications between untrusted hosts over an untrusted network. In the standard setup X connections are automatically forwarded, but arbitrary TCP/IP ports may also be forwarded using a secure channel.

The SSH client connects and logs into the specified host name. The user must provide his identity to the remote machine as specified in the sshd_config file, which can usually be found in /etc/ssh. The configuration file is rather self-explanatory and by defaults enables most common features. Should you need help, you can find it in the sshd man pages.

When the user's identity has been accepted by the server, the server either executes the given command, or logs into the machine and gives the user a normal shell on the remote machine. All communication with the remote command or shell will be automatically encrypted.

The session terminates when the command or shell on the remote machine exits and all X11 and TCP/IP connections have been closed.

When connecting to a host for the first time, using any of the programs that are included in the SSH collection, you need to establish the authenticity of that host and acknowledge that you want to connect:

```
ssh 11.0.0.2
```

If you just want to check something on a remote machine and then get your prompt back on the local host, you can give the commands that you want to execute remotely as arguments to ssh:

```
ssh 11.0.0.2 who
```

```
root@erlerobot:~# ssh 11.0.0.2 who
ssh: connect to host 11.0.0.2 port 22: No route to host
```

The command `uname` prints operating system name:

```
root@erlerobot:~# uname -n
erlerobot
```

X11 and TCP forwarding

X11 forwarding is when you use SSH to forward X windows to your local machine. If the X11 Forwarding entry is set to yes on the target machine and the user is using X applications, the DISPLAY environment variable is set, the connection to the X11 display is automatically forwarded to the remote side in such a way that any X11 programs started from the shell will go through the encrypted channel, and the connection to the real X server will be made from the local machine. The user should not manually set DISPLAY. Forwarding of X11 connections can be configured on the command line or in the sshd configuration file.

The X server

This procedure assumes that you have a running X server on the client where you want to display the application from the

remote host. The client may be of different architecture and operating system than the remote host, as long as it can run an X server, such as Cygwin (which implements an X.org server for MS Windows clients and others) or Exceed, it should be possible to set up a remote connection with any Linux or UNIX machine.

For more information about this topics you canv visit: https://wiki.archlinux.org/index.php/Secure_Shell

Server authentication

The ssh client/server system automatically maintains and checks a database containing identifications for all hosts it has ever been used with. Host keys are stored in $HOME/.ssh/known_hosts in the user's home directory. Additionally, the file /etc/ssh/ssh_known_hosts is automatically checked for known hosts. Any new hosts are automatically added to the user's file. If a host's identification ever changes, ssh warns about this and disables password authentication to prevent a Trojan horse from getting the user's password. Another purpose of this mechanism is to prevent man-in-the-middle attacks which could otherwise be used to circumvent the encryption. In environments where high security is needed, sshd can even be configured to prevent logins to machines whose host keys have changed or are unknown.

Secure remote copying

The SSH suite provides scp scp uses ssh for data transfer, uses the same authentication command. same security as and provides the copies files between hosts on a network.For ssh.In other words, scp example:

```
scp <file> root@Ip:<destination directory>
```

```
scp prueba.txt root@11.0.0.2:/var/tmp/
```

scp can only be used for transferring files, and it is non-interactive (i.e., everything has to be specified on the command line). sftp is more elaborate, and allows interactive commands to do things like creating directories, deleting directories and files (all subject to system permissions, of course), etc.

```
sftp 11.0.0.2
sftp> cd /var/tmp
sftp> get Sch*
```

```
sftp> bye
```

This are complecated commands, you can learn more here.

Authentication keys

The ssh-keygen command generates, manages and converts authentication keys for ssh. It can create RSA keys for use by SSH protocol version 1 and RSA or DSA keys for use by SSH protocol version 2.

Normally each user wishing to use SSH with RSA or DSA authentication runs this once to create the authentication key in $HOME/.ssh/identity, id_dsa or id_rsa. Additionally, the system administrator may use this to generate host keys for the system.

Normally this program generates the key and asks for a file in which to store the private key. The public key is stored in a file with the same name but .pub appended. The program also asks for a passphrase. The passphrase may be empty to indicate no passphrase (host keys must have an empty passphrase), or it may be a string of arbitrary length.

There is no way to recover a lost passphrase. If the passphrase is lost or forgotten, a new key must be generated and copied to the corresponding public keys.

```
root@erlerobot:~# ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa): /root/.ssh/id_rsa
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
ff:b1:7b:39:71:33:82:91:fa:ea:d4:96:0a:4f:c1:58 root@erlerobot
The key's randomart image is:
+--[ RSA 2048]----+
|                 |
|                 |
|        E  .     |
|       +  o      |
|       .So. o    |
|         oo....o.|
|       . oo+. .+o|
|        = oo o+  |
|         .=. +o . |
+-----------------+
root@erlerobot:~#
```

Extra concepts

VNC

VNC or Virtual Network Computing is in fact a remote display system which allows viewing a desktop environment not only on the local machine on which it is running, but from anywhere on the Internet and from a wide variety of machines and architectures, including MS Windows and several UNIX distributions. You could, for example, run MS Word on a Windows NT machine and display the output on your Linux desktop. VNC provides servers as well as clients, so the opposite also works and it may thus be used to display Linux programs on Windows clients. VNC is probably the easiest way to have X connections on a PC. The following features make VNC different from a normal X server or commercial implementations:

No state is stored at the viewer side: you can leave your desk and resume from another machine, continuing where you left. When you are running a PC X server, and the PC crashes or is restarted, all remote applications that you were running will die. With VNC, they keep on running.

For more info visit the VCN wesite

The rdesktop protocol

In order to ease management of MS Windows hosts, recent Linux distributions support the Remote Desktop Protocol (RDP), which is implemented in the rdesktop client. rdesktop is an open source client for Windows Remote Desktop Services, capable of natively speaking Remote Desktop Protocol (RDP) in order to present the user's Windows desktop. The protocol is used in a number of Microsoft products, including Windows NT Terminal Server, Windows 2000 Server, Windows XP and Windows 2003 Server.

The project's homepage is at http://www.rdesktop.org/.

Cygwin

Cygwin is a large collection of GNU and Open Source tools which provide functionality similar to a Linux distribution on Windows. Apart from providing UNIX command line tools and graphical applications, it can also be used to display a Linux desktop on an MS Windows machine, using remote X.

You can read more in the official webpage:https://www.cygwin.com/

Security

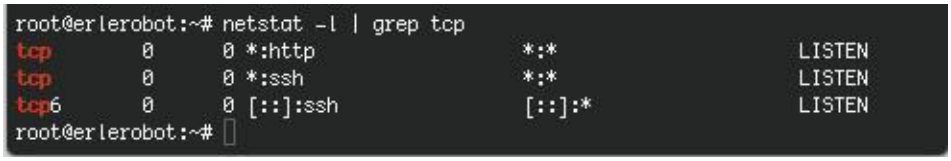
In the ever-changing world of global data communications, inexpensive Internet connections, and fast-paced software development, security is becoming more and more of an issue. Security is now a basic requirement because global computing is inherently insecure. In this chapter we will matter about Linux security.

Secure services and security tips

The goal is to run as few services as possible. If the number of ports that are open for the outside world are kept to a minimum, this is all the better to keep an overview. If services can't be turned off for the local network, try to at least disable them for outside connections.

A rule of thumb is that if you don't recognize a particular service, you probably won't need it anyway. Also keep in mind that some services are not really meant to be used over the Internet. Don't rely on what should be running, check which services are listening on what TCP ports using the netstat command:

```
netstat -l | grep tcp
```



Security Tips:

- xec, rlogin and rsh, and telnet just to be on the safe side.
- X11 on server machines.
- No lp if no printer is physically attached.
- No MS Windows hosts in the network, no Samba required.
- Don't allow FTP unless an FTP server is required.
- Don't allow NFS and NIS over the Internet, disable all related services on a stand-alone installation.
- Don't run an MTA if you're not actually on a mail server.
- Do not allow root logins. UNIX developers came up with the su over two decades ago for extra security.
- Direct root access is always dangerous and susceptible to human errors, be it by allowing root login or by using the su - command. Rather than using su, it is even better to use sudo to only execute the command that you need extra permissions for, and to return afterwards to your own environment.

- Note: sudo allows a permitted user to execute a command as the superuser or another user, as specified in the sudoers file.

- Take passwords seriously. Use shadow passwords. Change your passwords regularly.

- Try to always use SSH or SSL. Avoid telnet, FTP and E-mail clients and other client programs which send unencrypted passwords over the network. Security is not only about securing your computer, it is also about securing your passwords.

- Limit resources using quota and/or ulimit.

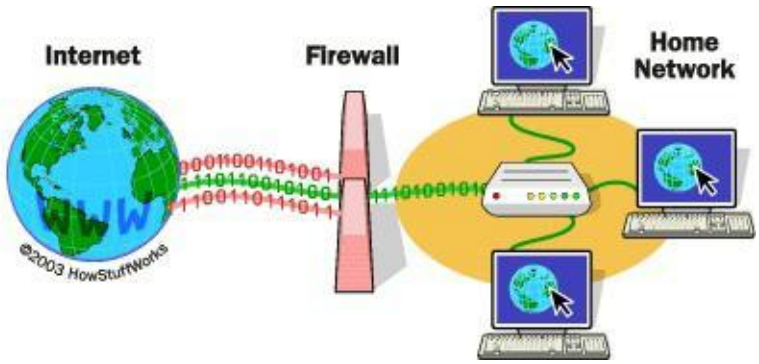
- The mail for root should be delivered to, or at least read by, an actual person.

Firewall

Firewalls are a means of controlling what information is allowed into and out of your local network.In other words, a firewall is a secure and trusted machine that sits between a private network and a public network.

Typically the firewall host is connected to the Internet and your local LAN, and the only access from your LAN to the Internet is through the firewall. This way the firewall can control what passes back and forth from the Internet and your LAN.

Firewalls can be constructed in quite a variety of ways. The most sophisticated arrangement involves a number of separate machines and is known as a perimeter network. Two machines act as "filters" called chokes to allow only certain types of network traffic to pass, and between these chokes reside network servers such as a mail gateway or a World Wide Web proxy server. This configuration can be very safe and easily allows quite a great range of control over who can connect both from the inside to the outside, and from the outside to the inside



The Linux kernel provides a range of built−in features that allow it to function quite nicely as an IP firewall.The network implementation includes code to do IP filtering in a number of different ways, and provides a mechanism to quite accurately configure what sort of rules you'd like to put in place.

IP Filtering

IP filtering is simply a mechanism that decides which types of IP datagrams will be processed normally and which will be discarded. By discarded we mean that the datagram is deleted and completely ignored, as if it had never been received. You can apply many different sorts of criteria to determine which datagrams you wish to filter; some examples of these are:

- Protocol type: TCP, UDP, ICMP, etc.
- Socket number (for TCP/UPD).
- Datagram type: SYN/ACK, data, ICMP Echo Request, etc.
- Datagram source address: where it came from.
- Datagram destination address: where it is going to.

It is important to understand at this point that IP filtering is a network layer facility. This means it doesn't understand anything about the application using the network connections, only about the connections themselves. For example, you may deny users access to your internal network on the default telnet port, but if you rely on IP filtering alone, you can't stop them from using the telnet program with a port that you do allow to pass trhough your firewall. You can prevent this sort of problem by using proxy servers for each service that you allow across your firewall. The proxy servers understand the application they were designed to proxy and can therefore prevent abuses, such as using the telnet program to get past a firewall by using the World Wide Web port.

If you want to read more visit the chapter about IP filtering here.

Iptables

Iptables Firewall is a tool that is almost always available in the Linux kernel (for kernel 2.4 and 2.6).His administration is in command line as root.

Here you can find a short introduction to Iptables.

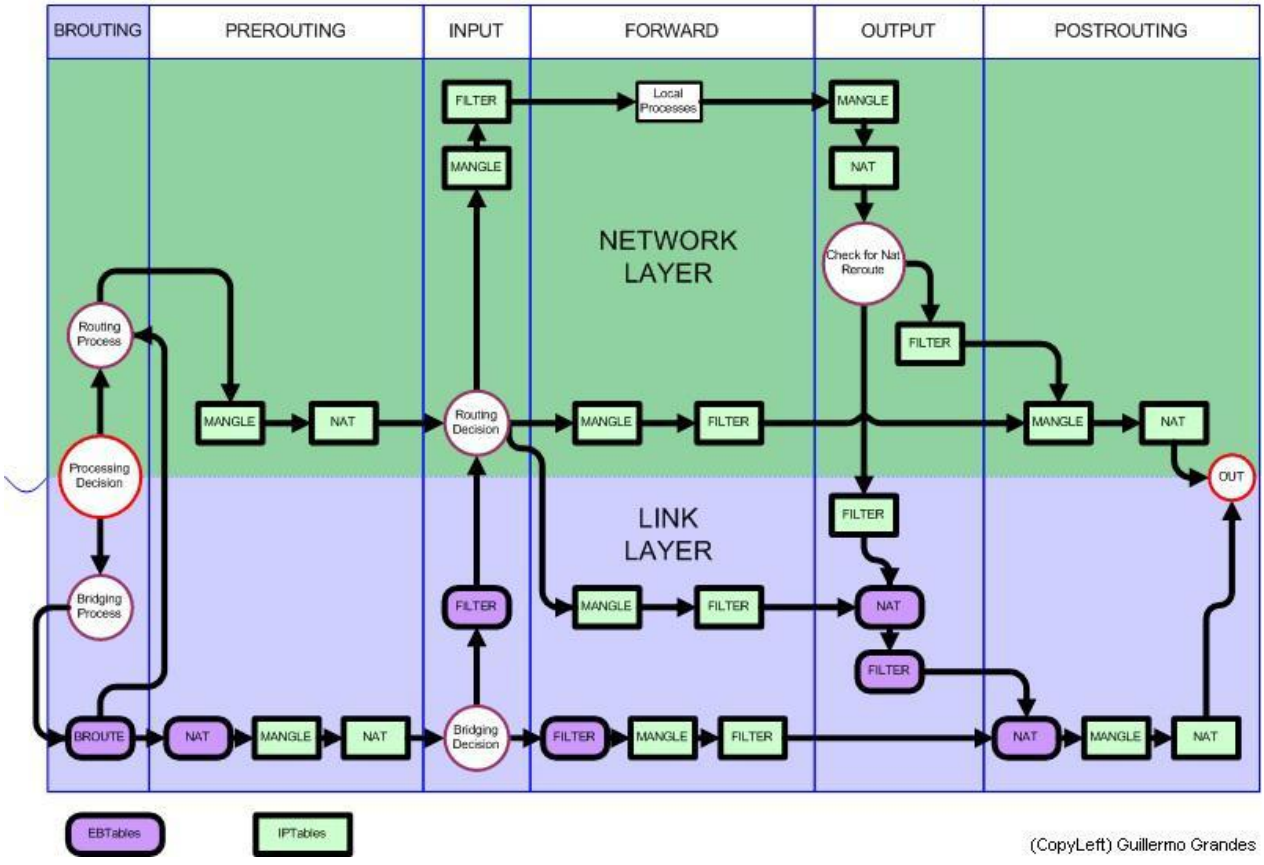
Introduction to IPtables

Iptables is a powerful **firewall integrated into the Linux kernel** itself and part of the netfilter project (consisting of IPtables, ip6tables, ebtables, arptables and ipset). This firewall is fully configurable:

- command line without installing anything on the computer.
- through a Graphical User Interface(there are already several circulating on the network).

iptables is a firewall tool that allows not only filter packets, but also perform network address translation (NAT) for IPv4 or maintain log records. In other words, iptables is the name of the user space tool by which administrators can define policies that filter the traffic flowing through the network.

Iptables starts with the system and remains active all the time, adapting and applying to all network traffic rules which have been previously configured.



Types of tables

There are three types of tables in iptables :

MANGLE tables:

The mangle tables, are responsible for the modification of packets, such as TTL or TOS for example, at the time you specify. It is normally used so far we will not stop in this section. Just tell that to the Kernel 2.4.17 consisted of 2 strings:

- PREROUTING to modify incoming packets before routing it to the next level Iptables.
- OUTPUT for altering locally generated packets before routing them.

Since kernel 2.4.18, three new brands were introduced in MANGLE tables:

- INPUT to modify incoming packets.

- FORWARD to alter packets that are then routed through Iptables.
- POSTROUTING to change packages that are ready to go.

NAT table:

The NAT (network address translation or network address translation) tables will be consulted when a packet creates a new connection. Allow share a public IP address among many computers, it is essential in many situations by the shortage of IPv4 addresses. Also allow you to add rules that modify the IP addresses of the packets. It contains two main types of rules, SNAT (or IP masquerading) to change the source address and DNAT (or Port Forwarding) for addresses. Amendment contains three chains:

- PREROUTING to modify packets as soon get on your PC.
- OUTPUT for altering locally generated packets before routing them.
- POSTROUTING to update packages that are ready to leave the team.

Filtering tables:

Filtering tables are used by default for the handling of data packets. It is responsible for filtering packages such as the string that is set for each of them to a destination or another, or block. All packets pass through this table, which contains three built-in chains:

- INPUT with which all packets destined for this system traver sing this chain (and this is called sometimes LOCAL_INPUT),
- OUTPUT for all packages created by this system pass through this chain (which is also known as the LOCAL_OUTPUT).
- FORWARD (REDIRECTION) with all the packages just go through this system to be routed to its destination walking this chain .

Every network packet received by or sent from a Linux system is subject to at least one table. However, a packet may be subjected to multiple rules within each table before emerging at the end of the chain. The structure and purpose of these rules may vary, but usually seek to identify a packet coming from or going to a particular IP address or set of addresses, when using a particular protocol and network service. Regardless of their destination, when packets match a particular rule in one of the tables, are given a goal (target) or share them.

Every chain has a default policy of ACCEPT , DROP , REJECT , or QUEUE. If any of these rules in the chain apply to the packet, then the packet is treated according to the default policy.

Types Targets

These policies are also known as Targets for the above brands and the most common are:

Target ACCEPT

A once the package complies with all the conditions you have specified, if we use the option-j ACCEPT it will be accepted and not travel more rules in the current chain and any other of the same table. This is important because they clarify the package can be removed in another table.

Target DROP

A once the package complies with all the conditions you have specified, if we use the option-j DROP it will be blocked and will not be processed in any other chain or table. This can have the drawback leave dead sockets and in many cases should use the REJECT target.

Target REJECT

This module has the same effect as 'DROP', except that the sender is sent an ICMP error message "port unreachable"

Target
QUEUE

Is used to process packets arriving at a given process, whether accompanied or not addressed to him.

Orders and parameters

Most common orders are:

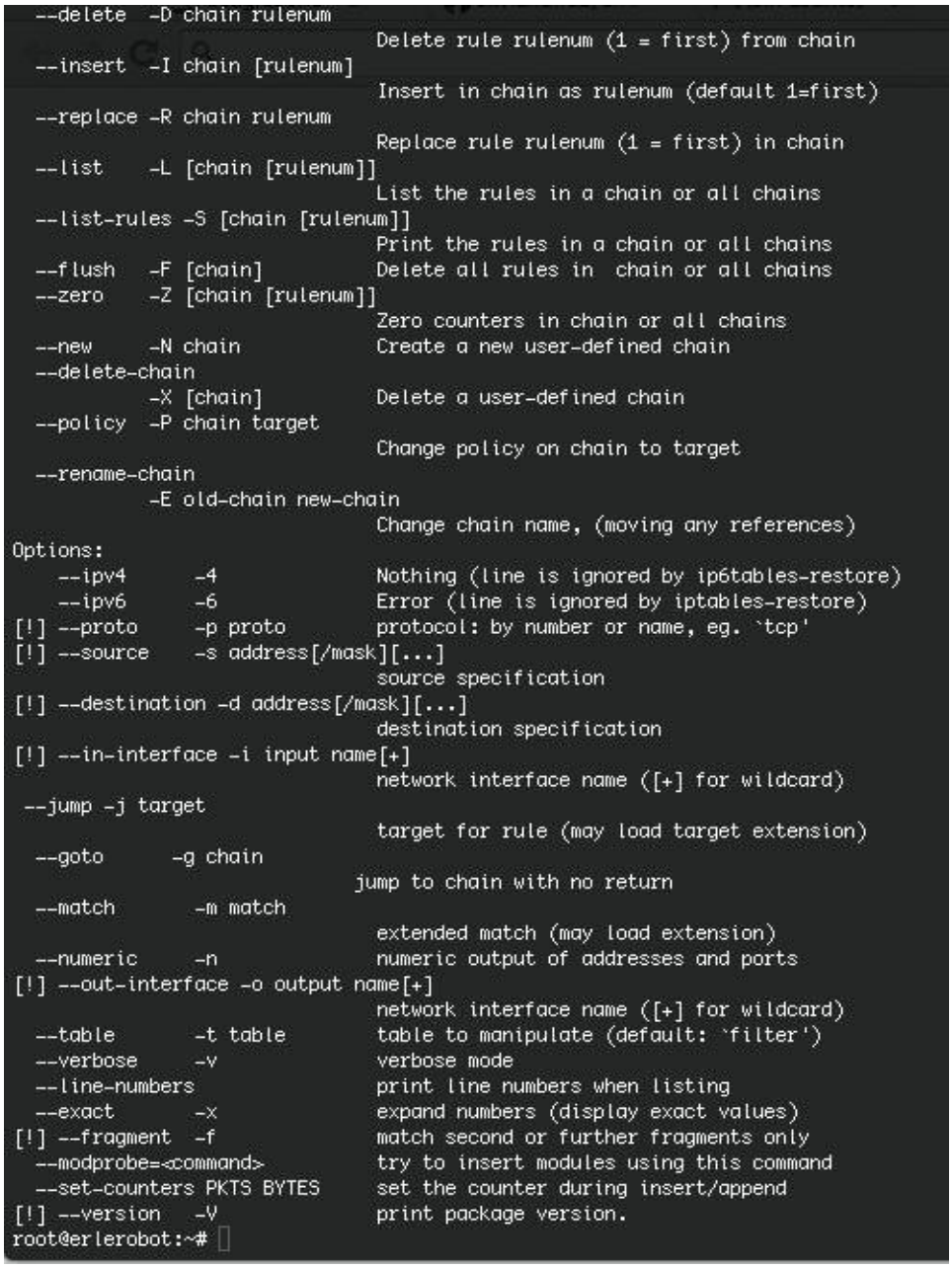
Order	Meaning
Iptables-F	flush (erase, emptying) of all rules.
IPtables-L	list of rules that are being implemented.
Iptables-A	add rule.
Iptables-D	delete a rule .

Most used parameters are:

Parameter	Meaning
-p [protocol]	protocol to which the packet belongs.
-s [source]	source address of the packet, can be a hostname, a normal IP address or a network address (mask, so address / mask).
-d [destination]	Like the above, it can be a host name, network address, or unique IP address.
-i [interface- entry]	Specify the interface on which the packet is received.
-o [output- interface]	interface by which to send the packet.
[!]-F:	Specifies that the rule refers to second and further fragments of a fragmented packet. If preempts!, Refers only to the first package, or unfragmented packets.
-j [target]	Allows you to choose the target to which to send the packet, ie, the action to perform with him.

For more, you can try typing:

```
iptables --help
```



First you may have in to account that if you get this when you use the command line above, you don't need to type -t

`filter` in the following commands:

```
--table -t table table to manipulate (default: `filter')
```

To list or consult our firewall rules:

```
iptables -t filter -L
```

When calling one of the chains, we do this:

```
iptables -t <table> -Action <string>
```

The table is filter, the action can be A,-I,-P or-D (plus other more specific), With respect to the chain, we have the choice

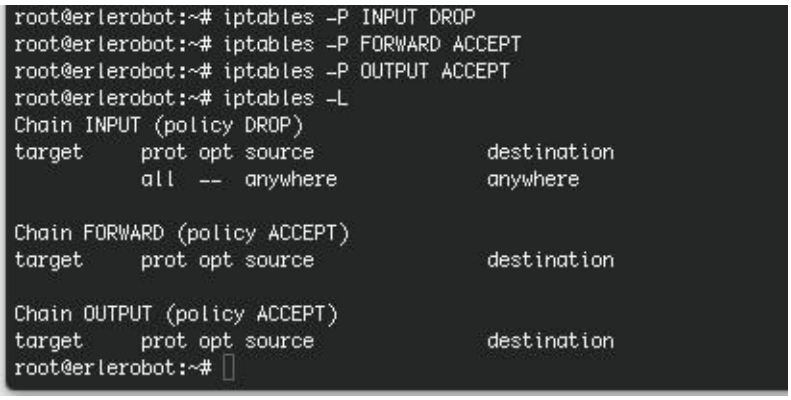
between -INPUT, -OUTPUT ,- FORDWARD .

example:

```
iptables -t filter -A INPUT
```

To create a basic firewall that blocks incoming connections only, first we build the policies of the three chains of the filter table:

```
iptables -t filter -P INPUT DROP
iptables -t filter -P FORWARD ACCEPT
iptables -t filter -P OUTPUT ACCEPT
```



Now for an example of a rule that accepts connections to port 80 of the system:

```
iptables -A INPUT -i eth0-s 0.0.0.0 / 0-p TCP - dport www-j ACCEPT
```

And here the description of each component of the above command:

- iptables: Iptables command to (do not forget that the rules are a
- Shell script) A: append option to add the rule
- INPUT: package status (to enter is
- INPUT) i eth0: eth0 network interface
- s 0.0.0.0 / 0: address access (either in this
- case) p TCP: port type
- dport: destination port
- j ACCEPT: packet destination (although it is accepted here could be DROP, LOG, REJECT, ..)

For more info you can visit this two websites:

- Iptables man page(http://ipset.netfilter.org/iptables.man.html)

Network file systems

A *network file system* is a network abstraction over a file system that allows a remote client to access it over a network in a similar way to a local file system. Although not the first such system, NFS has grown and evolved into the most powerful and widely used network file system in UNIX®. NFS permits sharing of a common file system among a multitude of users and provides the benefit of centralizing data to minimize needed storage.

A short history of NFS

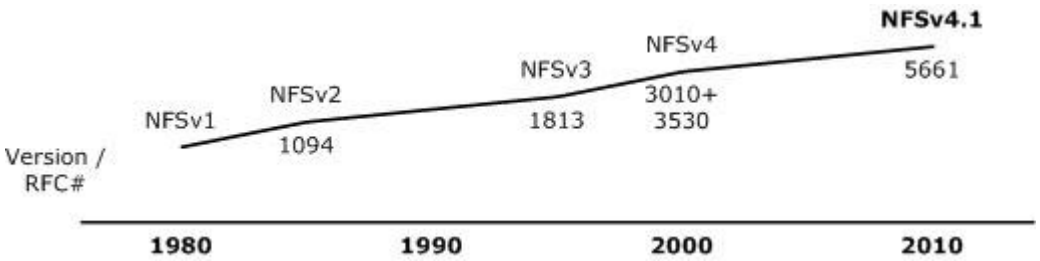
The first network file system—called File Access Listener—was developed in 1976 by Digital Equipment Corporation (DEC). An implementation of the Data Access Protocol (DAP), it was part of the DECnet suite of protocols. Like TCP/IP, DEC published protocol specifications for its networking protocols, which included the DAP.

NFS was the first modern network file system (built over the IP protocol). It began as an experimental file system developed in-house at Sun Microsystems in the early 1980s. Given the popularity of the approach, the NFS protocol was documented as a Request for Comments (RFC) specification and evolved into what is known as NFSv2. As a standard, NFS grew quickly because of its ability to interoperate with other clients and servers.

The standard continued to evolve into NFSv3, defined by RFC 1813. This iteration of the protocol was much more scalable than previous versions, supporting large files (larger than 2GB), asynchronous writes, and TCP as the transport protocol, paving the way for file systems over wide area networks. In 2000, RFC 3010 (revised by RFC 3530) brought NFS into the enterprise setting. Sun introduced NFSv4 with strong security along with a stateful protocol (prior versions of NFS were stateless). Today, NFS exists as version 4.1 (as defined by RFC 5661), which adds protocol support for parallel access across distributed servers (called the *pNFS extension*).

The timeline of NFS, including the specific RFCs that document its behavior, is shown in Figure 1.

Figure 1. Timeline of NFS protocols

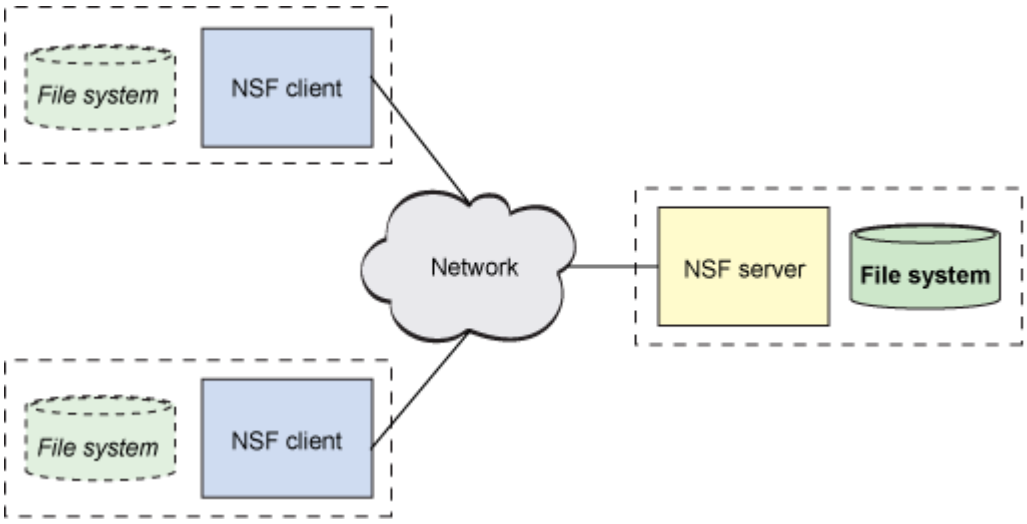


Amazingly, NFS has been under development for almost 30 years. It represents an extremely stable (and portable) networked file system that's scalable, high performing, and enterprise quality. As network speeds increase and latencies decrease, NFS continues to be an attractive option for serving a file system over a network. Even in local network settings, virtualization drives storage into the network to support more mobile virtual machines. NFS even supports the latest computing models to optimize virtualized infrastructures.

The NFS architecture

NFS follows the client-server model of computing (see Figure 2). The server implements the shared file system and storage to which clients attach. The clients implement the user interface to the shared file system, mounted within the client's local file space.

Figure 2. The client-server architecture of NFS



Within Linux®, the virtual file system switch (VFS) provides the means to support multiple file systems concurrently on a host (such as International Organization for Standardization [ISO] 9660 on a CD-ROM and ext3fs on the local hard disk). The VFS determines which storage a request is intended for, then which file system must be used to satisfy the request. For this reason, NFS is a pluggable file system just like any other. The only difference with NFS is that input/output (I/O) requests may not be satisfied locally, instead having to traverse the network for completion.

Once a request is found to be destined for NFS, VFS passes it to the NFS instance within the kernel. NFS interprets the I/O request and translates it into an NFS procedure (OPEN, ACCESS, CREATE, READ, CLOSE,REMOVE, and so on). These procedures, which are documented within the particular NFS RFC, specify the behaviors within the NFS protocol. Once a procedure is selected from the I/O request, it is performed within the remote procedure call (RPC) layer. As the name implies, RPC provides the means to perform procedure calls between systems. It marshals the NFS request and accompanying arguments together, manages

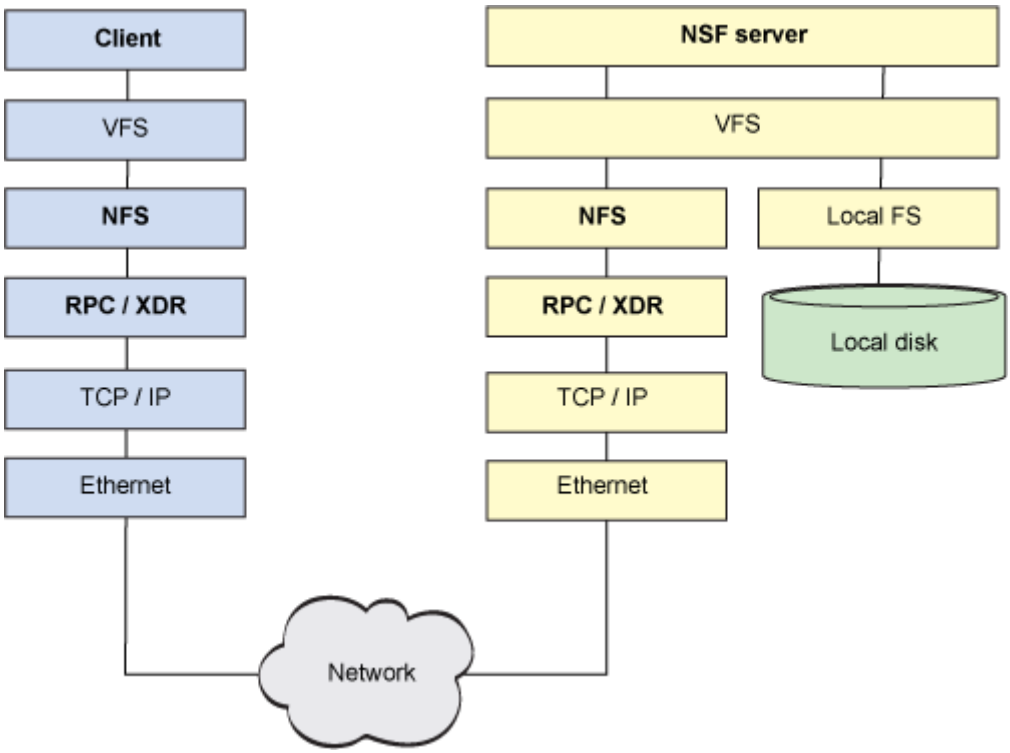
sending them to the appropriate remote peer, and then manages and tracks the response, providing it to the appropriate requester.

Further, RPC includes an important interoperability layer called *external data representation* (XDR), which ensures that all NFS participants speak the same language when it comes to data types. When a given architecture performs a request, the data type representation may differ from the target host that satisfies the request. XDR takes care of converting types to the common representation (XDR) so that all architectures can interoperate and share file systems. XDR specifies the bit format for types such as floatand the byte ordering for types such as fixed and variable-length arrays. Although XDR is best known for its use in NFS, it's a useful specification whenever you're dealing with multiple architectures in a common application setting.

Once XDR has translated the data into the common representation, the request is transferred over the network given a transport layer protocol. Early NFS used the Universal Datagram Protocol (UDP), but today TCP is commonly used for greater reliability.

At the server, NFS operates in a similar fashion. The request flows up the network stack, through RPC/XDR (to translate the data types to the server's architecture), and to the NFS server. The NFS server is responsible for satisfying the request. The request is passed up to the NFS daemon, which identifies the target file system tree needed for the request, and VFS is again used to get to that file system in local storage. This entire process is shown in Figure 3. Note here that the local file system at the server is a typical Linux file system (such as ext4fs). As such, NFS is not a file system in the traditional sense but instead a protocol for accessing file systems remotely.

Figure 3. The client and server NFS stack



For higher-latency networks, NFSv4 implements what's called the *compound procedure*. This procedure essentially permits multiple RPC calls to be embedded within a single request to minimize the transfer tax of the request over the network. It also implements a callback scheme for responses.

The NFS protocol

From the client's perspective, the first operation to occur within NFS is called a *mount*. Mount represents the mounting of a remote file system into the local file system space. This process begins as a call to mount(a Linux system call), which is routed through the VFS to the NFS component. After establishing the port number for the mount (via the get_port request RPC call to the remote server), the client performs an RPCmount request. This request occurs between the client and a special daemon responsible for the mountprotocol (rpc.mountd). This daemon checks the client request against the server's list of currently exported file systems; if the requested file system exists and the client has access, an RPC mount reply establishes the file handle for the file system. The client side stores the remote mount information with the local mount point and establishes the ability to perform I/O requests. This protocol represents a potential security issue; therefore, NFSv4 replaces this ancillary mount protocol with internal RPC calls for managing the mount point.

To read a file, the file must first be opened. There's no OPEN procedure within RPC; instead, the client simply checks to see if the directory and file exist within the mounted file system. The client begins with a GETATTRRPC request for the directory, which results in a response with the attributes of the directory or an indication that the directory does not exist. Next, the

client issues a LOOKUP RPC request to see if the requested file exists. If so, a GETATTR RPC request is issued for the requested file that returns the attributes for the file. Based upon successful GETATTRs and LOOKUPs, the client creates a file handle that is provided to the user for future requests.

With the file identified in the remote file system, the client can issue READ RPC requests. The READ consists of the file handle, state, offset, and count for the read. The client uses the state to determine whether the operation can be performed (that is, whether the file is locked). The offset indicates where to begin reading, and the count identifies the number of bytes to read. The server may or may not return the number of bytes requested but identifies the number of bytes returned (along with the data) within the READ RPC reply.

Innovation in NFS

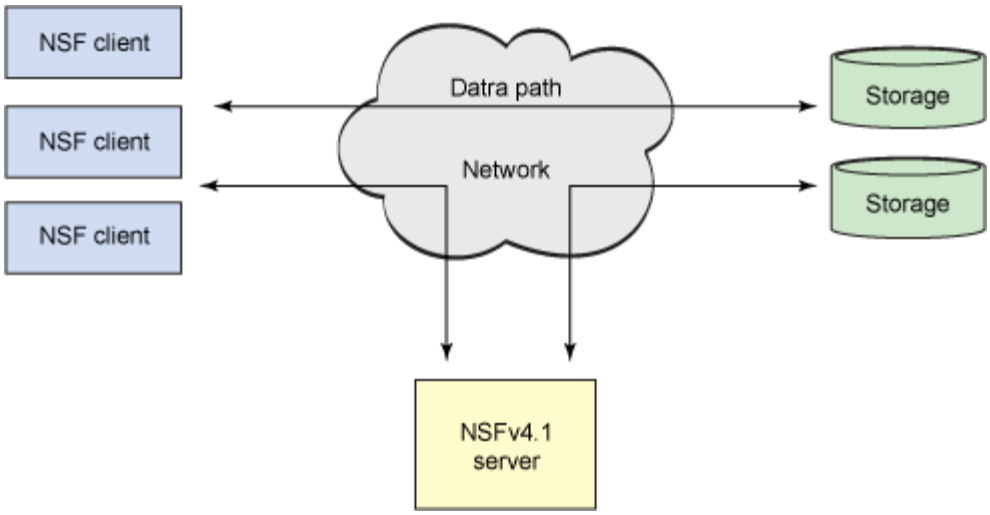
The last two versions of NFS (4 and 4.1) are among the most interesting and important for NFS. Let's look at some of the most important aspects of NFS's evolution.

Prior to NFSv4, there existed a number of ancillary protocols for mounting, locks, and other elements in file management. NFSv4 simplifies this process to one protocol and removes support for UDP as a transport protocol. NFSv4 also integrates support for UNIX and Windows®-based file access semantics, extending NFS for native integration into other operating systems.

NFSv4.1 introduces the concept of parallel NFS (pNFS) for higher scaling and higher performance. To support greater scaling, NFSv4.1 implements a split data/metadata architecture with striping in a manner similar to clustered file systems. As shown in Figure 4, pNFS breaks the ecosystem down into three parts: the client, the server, and storage. You can see that two paths exist: one for the data and one for control. pNFS splits the layout of the data from the data itself, permitting the dual-path architecture. When a client wants to access a file, the server responds with the layout. The layout describes the mapping of the file to the storage devices. When the client has the layout, it can directly access the storage without having to work through the server (which permits greater scaling and performance). When the client is finished with the file, it commits the data (changes) and the layout. If needed, the server can request the layout back from the client.

pNFS implements a number of new protocol operations to support this behavior. LayoutGet andLayoutReturn get and release the layout from the server, respectively, while LayoutCommit commits the data from the client to the storage so that it's available to other users. The server recalls the layout from a client using LayoutRecall. The layout is spread across some number of storage devices to enable parallel access and higher performance.

Figure 4. NFSv4.1's pNFS architecture



Both the data and metadata are stored in the storage area. The clients may perform direct I/O given receipt of the layout, and the NFSv4.1 server handles metadata management and storage. Although this behavior isn't necessarily new, pNFS adds the ability to support multiple access methods for the storage. Today, pNFS supports the use of block-based protocols (Fibre Channel), object-based protocols, and NFS itself (even in a non-pNFS form).

Work continues on NFS, with the requirements for NFSv2 being published in September 2010. Some of the new advancements address the changing world of storage in virtualization environments. For example, duplication of data is very likely in hypervisor environments (many operating systems read/writing and caching the same data). For this reason, it's desirable for the storage system as a whole to understand where duplication occurs. This would preserve cache space at the client and capacity at the storage end. NFSv4.2 proposes a block map of shared blocks to deal with this problem. Because storage systems have begun to integrate processing capabilities in the back end, server-side copy is introduced to offload the interior storage network of data copy when it can be done efficiently at the storage back end itself. Other innovations are appearing, as well, including sub-file caching for flash memory and client-side hints for I/O (potentially using mapadvise as the path).

Alternatives to NFS

Although NFS is the most popular network file system on UNIX and Linux systems, it's certainly not the only choice. On Windows® systems, Server Message Block [SMB], also known as *CIFS*) is the most widely used option (though Windows also supports NFS, as Linux supports SMB).

One of the latest distributed file systems, which is also supported in Linux, is Ceph. Ceph was designed from the ground up as a fault-tolerant distributed file system with Portable Operating System Interface for UNIX (POSIX) compatibility. Other examples include OpenAFS, an open source version of the Andrew distributed file system (from Carnegie Mellon and IBM),

GlusterFS, which focuses on a general-purpose distributed file system for scalable storage, and Lustre, which is a massively parallel distributed file system focusing on cluster computing. All are open source software solutions for distributed storage.

DHCP(Dynamic Host Configuration Protocol)

The Dynamic Host Configuration Protocol (DHCP) is a standardized network protocol used on Internet Protocol (IP) networks for dynamically distributing network configuration parameters, such as IP addresses for interfaces and services. With DHCP, computers request IP addresses and networking parameters automatically from a DHCP server, reducing the need for a network administrator or a user to configure these settings manually.

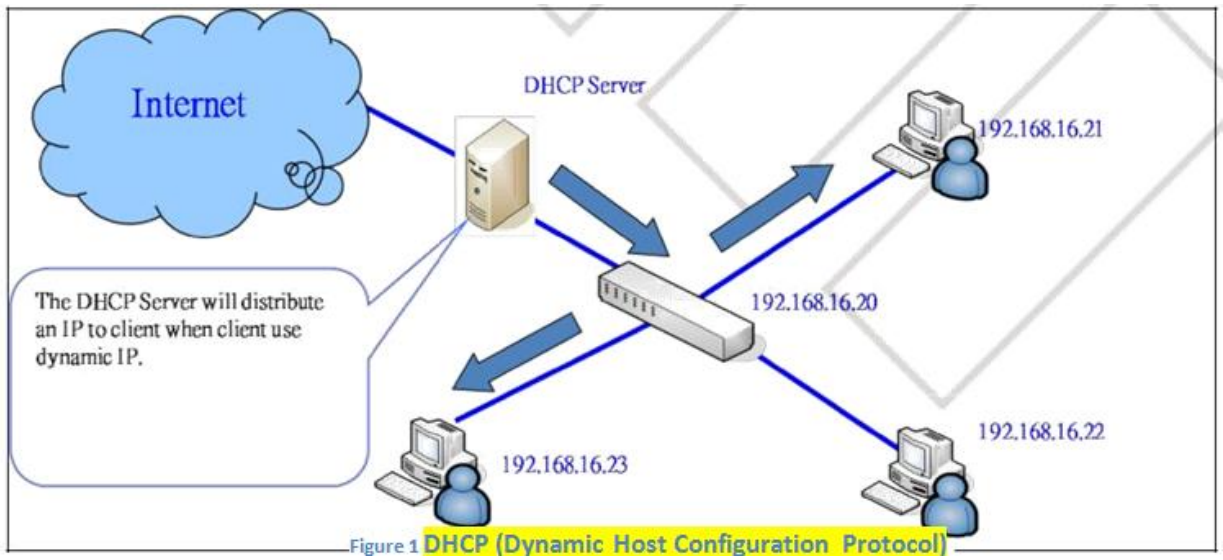


Figure 1 DHCP (Dynamic Host Configuration Protocol)

Depending on implementation, the DHCP server may have three methods of allocating IP-addresses:

1. **Dynamic Allocation:** A network administrator reserves a range of IP addresses for DHCP, and each client computer on the LAN is configured to request an IP address from the DHCP server during network initialization. The request-and-grant process uses a lease concept with a controllable time period, allowing the DHCP server to reclaim (and then reallocate) IP addresses that are not renewed.

2. **Automatic Allocation:** The DHCP server permanently assigns an IP address to a requesting client from the range defined by the administrator. This is like dynamic allocation, but the DHCP server keeps a table of past IP address assignments, so that it can preferentially assign to a client the same IP address that the client previously had.

3. **Static Allocation:** The DHCP server allocates an IP address based on a preconfigured mapping to each client's MAC address. This feature is variously called static DHCP assignment by DD-WRT, fixed-address by the dhcpd documentation, address reservation by Netgear, DHCP reservation or static DHCP by Cisco and Linksys, and IP address reservation or MAC/IP address binding by various other router manufacturers.

DHCP is used for Internet Protocol version 4 (IPv4), as well as IPv6. While both versions serve the same purpose, the details of the protocol for IPv4 and IPv6 are sufficiently different that they may be considered separate protocols. For IPv6 operation, devices may alternatively use stateless address auto configuration. IPv4 hosts may also use link-local addressing to achieve operation restricted to the local network link.

DHCP is a collection of software that implements all aspects of the DHCP (Dynamic Host Configuration Protocol) suite. It includes:

1 **DHCP Server**, which receives clients' requests and replies to them.

2 **DHCP Client**, which can be bundled with the operating system of a client computer or other IP capable device and which sends configuration requests to the server. Most devices and operating systems already have DHCP clients included.

3 **DHCP Relay Agent**, which passes DHCP requests from one LAN to another so that there need not be a DHCP server on every LAN.

The DHCP server, client and relay agent are provided both as reference implementations of the protocol and as working, fully-featured sample implementations.

History?

In 1984, the Reverse Address Resolution Protocol (RARP), defined in RFC 903, was introduced to allow simple devices such as diskless workstations to dynamically obtain a suitable IP address. However, because it acted at the data link layer it made implementation difficult on many server platforms, and also required that a server be present on each individual network link. Soon afterwards it was superseded by the "Bootstrap Protocol" (BOOTP) defined in RFC 951. This introduced the concept of a relay agent, which allowed the forwarding of BOOTP packets across networks, allowing one central BOOTP server to serve hosts on many IP subnets.

DHCP is based on BOOTP but can dynamically allocate IP addresses from a pool and reclaim them when they are no longer in use. It can also be used to deliver a wide range of extra configuration parameters to IP clients, including platform-specific parameters. It was first defined in RFC 1531 in October 1993; but due to errors in the editorial process was almost immediately reissued as RFC 1541.

Four years later the DHCPINFORM message type and other small changes were added by RFC 2131; which as of 2014 remains the standard for IPv4 networks.

DHCPv6 was initially described by RFC 3315 in 2003, but this has been updated by many subsequent RFCs. RFC 3633 added a DHCPv6 mechanism for prefix delegation, and stateless address auto configuration was added by RFC 3736.

Why use DHCP?

Every device on a TCP/IP-based network must have a unique unicast IP address to access the network and its resources. Without DHCP, IP addresses for new computers or computers that are moved from one subnet to another must be configured manually; IP addresses for computers that are removed from the network must be manually reclaimed.

With DHCP, this entire process is automated and managed centrally. The DHCP server maintains a pool of IP addresses and leases an address to any DHCP-enabled client when it starts up on the network. Because the IP addresses are dynamic (leased) rather than static (permanently assigned), addresses no longer in use are automatically returned to the pool for reallocation.

How DHCP works?

Before understanding the process of IP address assignment, it is important to know some key technical terms that are used in context of the DHCP server.

- **DHCP Address Pool**

DHCP address pool is a virtual container that contains all the IP addresses that have been configured in the DHCP range to make available to the client computers. As soon as any IP address from the address pool is assigned to a client computer, the address is temporarily removed from the pool.

- **DHCP Lease**

When the DHCP server assigns an IP address to a DHCP client computer, the address is assigned for specific time duration. The time duration for which an IP address is assigned to a DHCP client computer by the DHCP server is technically called the DHCP lease. When the DHCP lease expires, the IP address is revoked from the DHCP client computer and is sent back to the DHCP address pool.

- **IP Assign Operation (DORA)**

The DHCP protocol employs a connectionless service model, using the User Datagram Protocol (UDP). It is implemented with two UDP port numbers for its operations which are the same as for the BOOTP protocol. UDP port number 67 is the destination port of a server, and UDP port number 68 is used by the client.

DHCP operations fall into four phases: server discovery, IP lease offer, IP request, and IP lease acknowledgment. These stages are often abbreviated as DORA for discovery, offer, request, and acknowledgment.

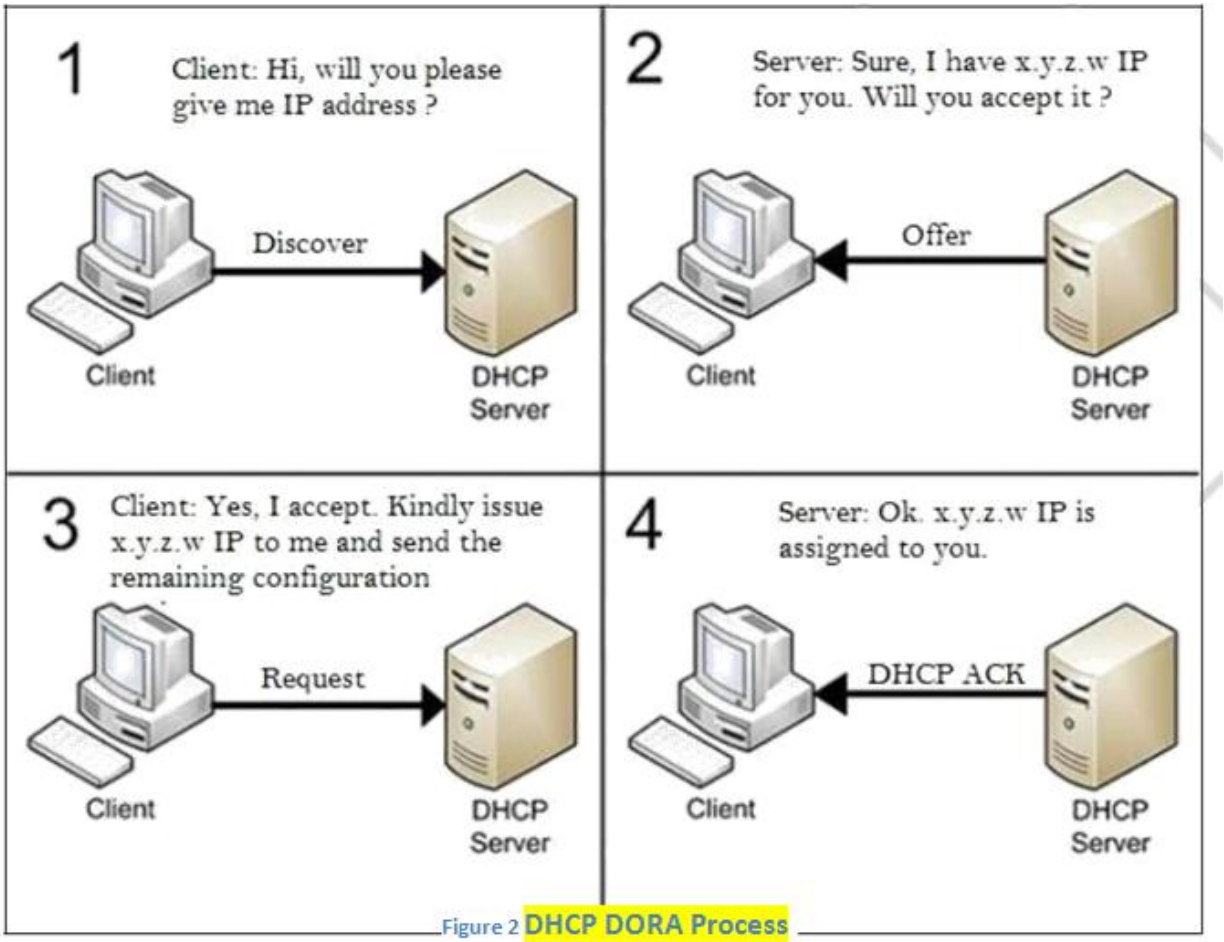


Figure 2 DHCP DORA Process

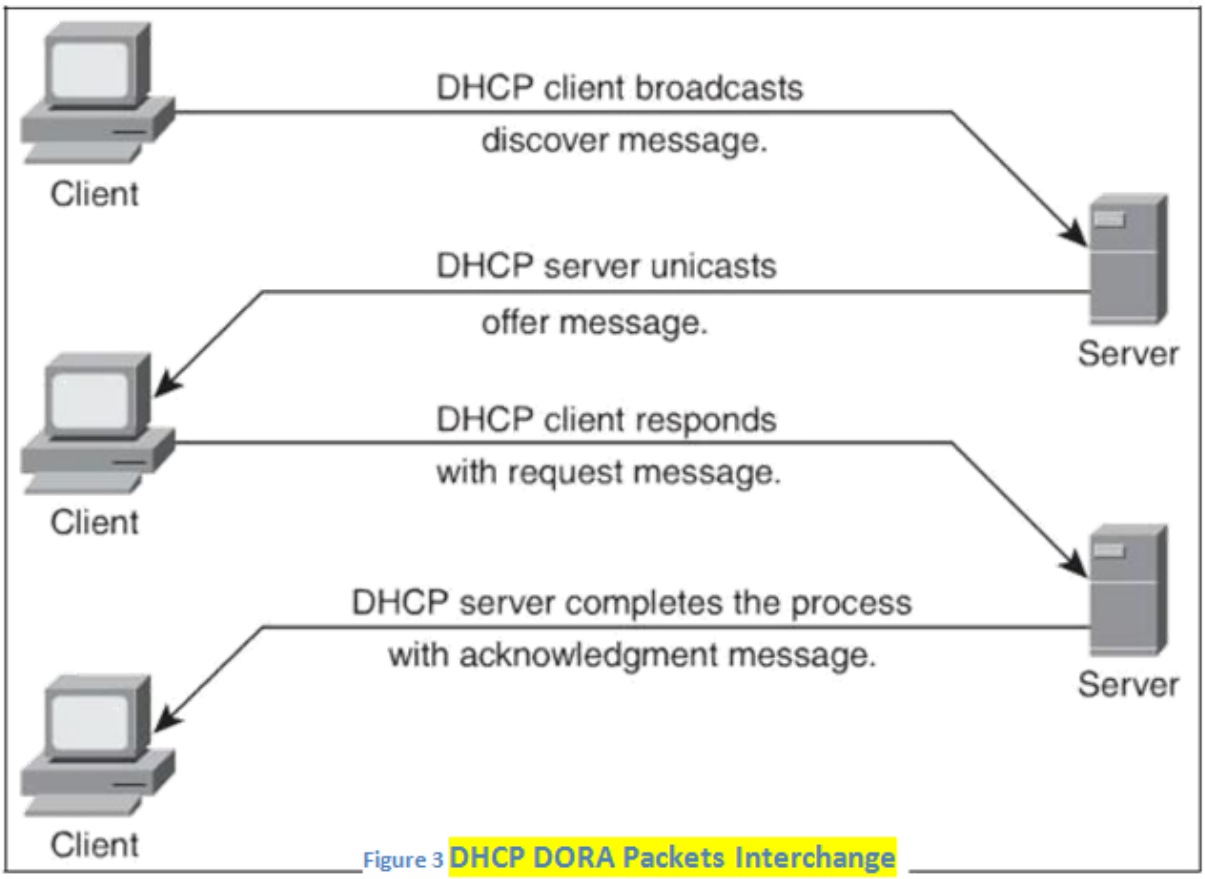


Figure 3 DHCP DORA Packets Interchange

1. **DHCP Discovery**

D in the term DORA stands for the DHCP Discover packet. The DHCP Discover packet is broadcasted by the DHCP client computer in order to find the available DHCP server(s) in the network. Since the DHCP client computer sends the DHCP Discover packet as a broadcast, all the DHCP servers that are present in the network receive the packet and respond accordingly.

UDP Src=0.0.0.0 sPort=68 Dest=255.255.255.255 dPort=67			
OP	HTYPE	HLEN	HOPS
0x01	0x01	0x06	0x00
XID			
0x3903F326			
SECS		FLAGS	
0x0000		0x0000	
CIADDR (Client IP address)			
0x00000000			
YIADDR (Your IP address)			
0x00000000			
SIADDR (Server IP address)			
0x00000000			
GIADDR (Gateway IP address)			
0x00000000			
CHADDR (Client hardware address)			
0x00053C04			
0x8D590000			
0x00000000			
0x00000000			
192 octets of 0s. or overflow space for additional options. BOOTP legacy			
Magic cookie			
0x63825363			
DHCP Options			
DHCP option 53: DHCP Discover			
DHCP option 50: 192.168.1.100 requested			
DHCP option 55: Parameter Request List:			
Request Subnet Mask (1), Router (3), Domain Name (15), Domain Name Server (6)			

Figure 4 DHCPDISCOVER Message

2. DHCP Offer

O in the term DORA stands for the DHCP Offer packet. The DHCP Offer is a unicast packet that is sent by the DHCP server who receives the DHCP Discover packet from the DHCP client computer. The DHCP Offer packet contains the available IP address that the DHCP server offers to the client computer.

The server determines the configuration based on the client's hardware address as specified in the CHADDR (client hardware address) field. Here the server, 192.168.1.1, specifies the client's IP address in the YIADDR (your IP address) field.

Figure 5 DHCPOFFER Message

3. DHCP Request

R in the term DORA stands for the DHCP Request packet. In response to the DHCP offer, the client replies with a DHCP request, broadcast to the server, requesting the offered address. A client can receive DHCP offers from multiple servers, but it will accept only one DHCP offer. Based on required server identification option in the request and broadcast messaging, servers are informed whose offer the client has accepted. When other DHCP servers receive this message, they withdraw any offers that they might have made to the client and return the offered address to the pool of available addresses.

UDP Src=0.0.0.0 sPort=68 Dest=255.255.255.255 dPort=67			
OP	**HTYPE**	**HLEN**	**HOPS**
0x01	0x01	0x06	0x00
XID			
0x3903F326			
SECS		**FLAGS**	
0x0000		0x0000	
CIADDR (Client IP address)			
0x00000000			
YIADDR (Your IP address)			
0x00000000			
SIADDR (Server IP address)			
0xC0A80101			
GIADDR (Gateway IP address)			
0x00000000			
CHADDR (Client hardware address)			
0x00053C04			
0x8D590000			
0x00000000			
0x00000000			
192 octets of 0s. BOOTP legacy			
Magic cookie			
0x63825363			
DHCP Options			
DHCP option 53: DHCP Request			
DHCP option 50: 192.168.1.100 requested			
DHCP option 54: 192.168.1.1 DHCP server.			

Figure 6 DHCPREQUEST Message

4. DHCP Acknowledgement

A in the term DORA stands for the DHCP Acknowledge packet. When the DHCP server receives the DHCPREQUEST message from the client, the configuration process enters its final phase. The acknowledgement phase involves sending a DHCPACK packet to the client. This packet includes the lease duration and any other configuration information that the client might have requested. At this point, the IP configuration process is completed.

UDP Src=192.168.1.1 sPort=67 Dest=255.255.255.255 dPort=68			
OP	HTYPE	HLEN	HOPS
0x02	0x01	0x06	0x00
XID			
0x3903F326			
SECS			FLAGS
0x0000		0x0000	
CIADDR (Client IP address)			
0x00000000			
YIADDR (Your IP address)			
0xC0A80164			
SIADDR (Server IP address)			
0xC0A80101			
GIADDR (Gateway IP address switched by relay)			
0x00000000			
CHADDR (Client hardware address)			
0x00053C04			
0x8D590000			
0x00000000			
0x00000000			
192 octets of 0s. BOOTP legacy			
Magic cookie			
0x63825363			
DHCP Options			
DHCP option 53: DHCP ACK			
DHCP option 1: 255.255.255.0 subnet mask			
DHCP option 3: 192.168.1.1 router			
DHCP option 51: 86400s (1 day) IP address lease time			
DHCP option 54: 192.168.1.1 DHCP server			
DHCP option 6: DNS servers 9.7.10.15, 9.7.10.16, 9.7.10.18			

Figure 7 DHCPACK Message

The protocol expects the DHCP client to configure its network interface with the negotiated parameters.

After the client obtains an IP address, it should probe the newly received address (e.g. with ARP Address Resolution Protocol) to prevent address conflicts caused by overlapping address pools of DHCP servers.

- **DHCP Relaying**

In small networks, where only one IP subnet is being managed, DHCP clients communicate directly with DHCP servers. However, DHCP servers can also provide IP addresses for multiple subnets. In this case, a DHCP client that has not yet acquired an IP address cannot communicate directly with the DHCP server using IP routing, because it does not have a routable IP address, nor does it know the IP address of a router.

In order to allow DHCP clients on subnets not directly served by DHCP servers to communicate with DHCP servers, DHCP relay agents can be installed on these subnets. The DHCP client broadcasts on the local link; the relay agent receives the broadcast and transmits it to one or more DHCP servers using unicast. The relay agent stores its own IP address in the GIADDR field of the DHCP packet. The DHCP server uses the GIADDR to determine the subnet on which the relay agent received the broadcast, and allocates an IP address on that subnet. When the DHCP server replies to the client, it sends the reply to the GIADDR address, again using unicast. The relay agent then retransmits the response on the local network.

Advantages of DHCP

Its capability to automatically allocate IP addresses to clients booting on the TCP/IP network for the first time.

9. Using DHCP reduces the labour involved in managing the network.

10. Because the DHCP server automatically dispenses IP addresses and other configuration information, the process of connecting a new computer to the network is much simpler.

11. DHCP is very flexible and allows the network administrator to set up the server one time to serve many thousands of clients.

Disadvantages of DHCP

1. When client make query to DHCP server (DHCP Discover) it is UDP query it consume more bandwidth. When DHCP server is unavailable client unable to access enterprises network.

2. Your machine name does not change when you get a new IP address.
3. Unauthorized DHCP servers providing false information to clients.

4. Unauthorized clients gaining access to resources.

5. Resource exhaustion attacks from malicious DHCP clients.

DHCP Security Issues?

Not only does DHCP run over IP and UDP, which are inherently insecure, the DHCP protocol itself have in fact no security provisions whatsoever. This is a fairly serious issue in modern networks, because of the sheer power of DHCP: the protocol deals with critical configuration information.

There are two different classes of potential security problems related to DHCP:

1. **Unauthorized DHCP Servers:** If a malicious person plants a “rogue” DHCP server, it is possible that this device could respond to client requests and supply them with spurious configuration information. This could be used to make clients unusable on the network, or worse, set them up for further abuse later on. For example, a hacker could

exploit a bogus DHCP server to direct a DHCP client to use a router under the hacker's control, rather than the one the client is supposed to use.

2. **Unauthorized DHCP Clients:** A client could be set up that masquerades as a legitimate DHCP client and thereby obtain configuration information intended for that client; this could then be used to compromise the network later on. Alternately, a "bad guy" could use software to generate lots of bogus DHCP client requests to use up all the IP addresses in a DHCP server's pool. More simply, this could be used by a thief to steal an IP address from an organization for his own use.

Adding Security to DHCP

These are obviously serious concerns. The normal recommended solutions to these risks generally involve providing security at lower layers. For example, one of the most important techniques for preventing unauthorized servers and clients is careful control over physical access to the network: layer one security. Security techniques implemented at layer two may also be of use, for example, in the case of wireless LANs. Since DHCP runs over UDP and IP, one could use IPSec at layer three to provide authentication.

DHCP Authentication

To try to address some of the more specific security concerns within DHCP itself, in June 2001 the IETF published RFC 3118, Authentication for DHCP Messages. This standard describes an enhancement that replaces the normal DHCP messages with authenticated ones. Clients and servers check the authentication information and reject messages that come from invalid sources. The technology involves the use of a new DHCP option type, the Authentication option, and operating changes to several of the leasing processes to use this option.

Unfortunately, 2001 was pretty late in the DHCP game, and there are millions of DHCP clients and servers around that don't support this new standard. Both client and server must be programmed to use authentication for this method to have value. A DHCP server that supports authentication could use it for clients that support the feature and skip it for those that do not. However, the fact that this option is not universal means that it is not widely deployed, and most networks must rely on more conventional security measures.

Network Information Service

This chapter provides an overview of the Network Information Service (NIS).

NIS is a distributed naming service. It is a mechanism for identifying and locating network objects and resources. It provides a uniform storage and retrieval method for network-wide information in a transport-protocol and media-independent fashion.

This chapter covers the following topics:

- **NIS Introduction**
- **NIS Machine Types**
- **NIS Elements**
- **NIS Binding**

NIS Introduction

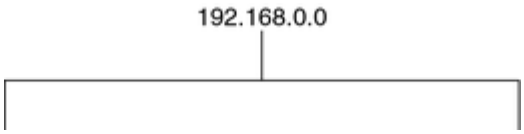
By running NIS, the system administrator can distribute administrative databases, called **maps**, among a variety of servers (**master** and **slaves**). The administrator can update those databases from a centralized location in an automatic and reliable fashion to ensure that all clients share the same naming service information in a consistent manner throughout the network.

NIS was developed independently of DNS and has a slightly different focus. Whereas DNS focuses on making communication simpler by using machine names instead of numerical IP addresses, NIS focuses on making network administration more manageable by providing centralized control over a variety of network information. NIS stores information not only about machine names and addresses, but also about users, the network itself, and network services. This collection of network **information** is referred to as the NIS **namespace**.

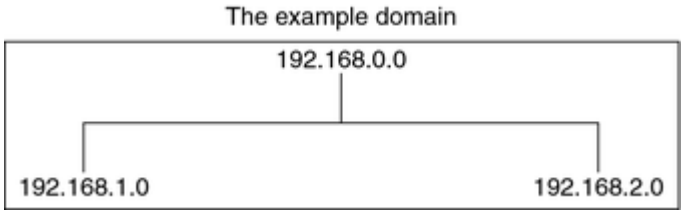
NIS Architecture

NIS uses a client-server arrangement. NIS servers provide services to NIS clients. The principal server is called a **master** server, and for reliability, it can have several backup servers or**slave** servers. Both master and slave servers use the NIS information retrieval software, and both store NIS maps.

NIS uses domains to arrange the machines, users, and networks in its namespace. However, it does not use a domain hierarchy. An NIS namespace is flat.



Thus, this physical network would be arranged into one NIS domain.



An NIS domain cannot be connected directly to the Internet using just NIS. However, organizations that want to use NIS and also be connected to the Internet can combine NIS with DNS. You can use NIS to manage all local information and use DNS for Internet host lookup. NIS also provides a forwarding service that forwards host lookups to DNS if the information cannot be found in an NIS map. The Oracle Solaris system also allows you to set up the name service switch service so that hosts lookup requests can be directed in the following ways: .

- To access only DNS
- To access DNS, but if a host is not found in DNS, then access NIS
- To access NIS, but if a host is not found by NIS, then access DNS

NIS Machine Types

There are three types of NIS machines.

- Master server
- Slave servers
- Clients of NIS servers

Any machine can be an NIS client, but only machines with disks should be NIS servers, either master or slave. Servers are also clients, typically of themselves.

NIS Servers

NIS servers come in two varieties, master and slave. The machine designated as master server contains the set of maps that the system administrator creates and updates as necessary. Each

NIS domain must have one, and only one, master server, which can propagate NIS updates with the least performance degradation.

You can designate additional NIS servers in the domain as slave servers. A slave server has a complete copy of the master set of NIS maps. Whenever the master server maps are updated, the updates are propagated among the slave servers. Slave servers can handle any overflow of requests from the master server, minimizing "server unavailable" errors.

Normally, the system administrator designates one master server for all NIS maps. However, because each individual NIS map has the machine name of the master server encoded within it, you could designate different servers to act as master and slave servers for different maps. To minimize confusion, designate a single server as the master for all the maps you create within a single domain. The examples in this chapter assume that one server is the master for all maps in the domain.

NIS Clients

NIS clients run processes that request data from maps on the servers. Clients do not make a distinction between master and slave servers, since all NIS servers should have the same information.

NIS Elements

The NIS naming service is composed of the following elements:

- Domains (see The NIS Domain)
- Daemons (see NIS Daemons)
- Commands (see NIS Commands)
- Maps (see NIS Maps)

The NIS Domain

An NIS **domain** is a collection of hosts which share a common set of NIS maps. Each domain has a domain name, and each machine sharing the common set of maps belongs to that domain.

NIS domains and DNS domains are not necessarily the same. In some environments, NIS domains are defined based on enterprise-wide network subnet administrative layouts. DNS

names and domains are defined by internet DNS naming standards and hierarchies. The two naming domain naming systems might be or might not be configured to match up identically. The domain name for the two services are controlled separately and might be configured differently.

Any host can belong to a given domain, as long as there is a server for that domain's maps in the same network or subnet. NIS domain lookups use remote procedure calls (RPCs). Therefore, NIS requires that all the clients and all the server machines that provide direct services to those clients must exist on the same accessible subnet. It is not uncommon to have each administrative subnet managed as a separate NIS domain (distinct from an enterprise-wide DNS domain) but using common databases managed from a common master machine. The NIS domain name and all the shared NIS configuration information is managed by the svc:/network/nis/domain SMF service.

NIS Daemons

The NIS service is provided by the daemons shown in the following table. The NIS service is managed by SMF. Administrative actions on this service, such as enabling, disabling, or restarting, can be performed by using the svcadm command. For an overview of SMF, refer to Chapter 6, Managing Services (Overview), in *Oracle Solaris Administration: Common Tasks*. Also refer to the svcadm(1M) and svcs(1) man pages for more details.

Table 5-1 NIS Daemons

Daemon	Function
nscd	A client service that provides a cache for most name service requests, which is managed by the svc:/system/name-service/cacheservice
rpc.yppasswdd	The NIS password update daemon managed by the svc:/network/nis/passwd service

---

Note - The rpc.yppasswdd daemon considers all shells that begin with an r to be restricted. For example, if you are in /bin/rksh, you are not allowed to change from that shell to another shell. If you have a shell that begins with r but is not intended to be restricted as such, refer to Chapter 8, NIS Troubleshooting for the workaround.

---

rpc.ypupdated A daemon that modifies other maps such as publickey and is managed by the svc:/network/nis/update service

ypbind The binding process managed by the svc:/network/nis/client service

ypserv The server process managed by the svc:/network/nis/server service

ypxfrd A high-speed map transfer daemon managed by the svc:/network/nis/xfr service

NIS Commands

The NIS service is supported by several commands, which are described in the following table.

Table 5-2 NIS Command Summary

Command	Description
make	Updates NIS maps by reading /var/yp/Makefile (when the command is run in the /var/yp directory). You can use make to update all maps based on the input files or to update individual maps. The ypmake(1M) man page describes the functionality of make for NIS.
makedbm	Takes an input file and converts it into dbm.dir and dbm.pag files. NIS uses valid dbm files as maps. You can also use makedbm -u to disassemble a map so that you can see the key-value pairs that comprise it.
ypcat	Displays the contents of an NIS map.
ypinit	Automatically creates maps for an NIS server from the input files. It is also used to construct the initial /var/yp/binding/*domain*/ypserversfile on the clients. Use ypinit to set up the master NIS server and the slave NIS servers for the first time.
ypmatch	Prints the value for one or more specified keys in an NIS map. You cannot specify which version of the NIS server map you are seeing.
yppoll	Shows which version of an NIS map is running on a server that you specify. It also lists the master server for the map.
yppush	Copies a new version of an NIS map from the NIS master server to its slaves. You run the yppush command on the master NIS server.
ypset	Instructs a ypbind process to bind to a named NIS server. This command is not for casual use, and its use is discouraged because of security implications. See the ypset(1M) and ypbind(1M) man pages for information about the ypset and ypsetme options to the ypbind process.
ypwhich	Shows which NIS server a client is using at the moment for NIS services. If

invoked with the -m *mapname* option, this command shows which NIS server is master of each map. If only -m is used, the command displays the names of all the available maps and their respective master servers.

ypxfr Pulls an NIS map from a remote server to the local /var/yp/*domain* directory by using NIS itself as the transport medium. You can run ypxfrinteractively or periodically from a crontab file. It is also called by ypserv to initiate a transfer.

NIS Maps

The information in NIS maps is stored in ndbm format. The ypfiles(4) and ndbm(3C) man pages explain the format of the map file.

NIS maps extend access to UNIX /etc data and other configuration files, such as passwd, shadow and group so that the same data can be shared between a network of systems. Sharing these files simplifies administrative updates and management of those data files. NIS is deployable with minimal effort. However, larger enterprises, especially those with security requirements should consider using LDAP naming services instead. On a network running NIS, the NIS master server for each NIS domain maintains a set of NIS maps for other machines in the domain to query. NIS slave servers also maintain duplicates of the master server's maps. NIS client machines can obtain namespace information from either master or slave servers.

NIS maps are essentially two-column tables. One column is the **key** and the other column is information related to the key. NIS finds information for a client by searching through the keys. Some information is stored in several maps because each map uses a different key. For example, the names and addresses of machines are stored in two maps: hosts.byname andhosts.byaddr. When a server has a machine's name and needs to find its address, it looks in the hosts.byname map. When it has the address and needs to find the name, it looks in thehosts.byaddr map.

An NIS Makefile is stored in the /var/yp directory of machines designated as an NIS server at installation time. Running make in that directory causes makedbm to create or modify the default NIS maps from the input files.

Note - Always create maps on the master server, as maps created on a slave will not automatically be pushed to the master server.

Default NIS Maps

A default set of NIS maps are provided in the Oracle Solaris system. You might want to use all these maps or only some of them. NIS can also use whatever maps you create or add when you install other software products.

Default maps for an NIS domain are located in each server's /var/yp/*domain–name* directory. For example, the maps that belong to the domain test.com are located in each server's/var/yp/test.com directory.

The following table describes the default NIS maps and lists the appropriate source file name for each map.

Table 5-3 NIS Map Descriptions

Map Name	Corresponding Source File	Description
audit_user	audit_user	Contains user auditing preselection data.
auth_attr	auth_attr	Contains authorization names and descriptions.
bootparams	bootparams	Contains path names of files that clients need during boot: root, swap, possibly others.
ethers.byaddr	ethers	Contains machine names and Ethernet addresses. The Ethernet address is the key in the map.
ethers.byname	ethers	Same as ethers.byaddr, except the key is machine name instead of the Ethernet address.
exec_attr	exec_attr	Contains profile execution attributes.
group.bygid	group	Contains group security information with group ID as key.
group.byname	group	Contains group security information with group name as key.
hosts.byaddr	hosts	Contains machine name, and IP address, with IP address as key.
hosts.byname	hosts	Contains machine name and IP address, with machine (host) name as key.

mail.aliases	aliases	Contains aliases and mail addresses, with aliases as key.
mail.byaddr	aliases	Contains mail address and alias, with mail address as key.
netgroup.byhost	netgroup	Contains group name, user name and machine name.
netgroup.byuser	netgroup	Same as netgroup.byhost, except that key is user name.
netgroup	netgroup	Same as netgroup.byhost, except that key is group name.
netid.byname	passwd, hosts group	Used for UNIX-style authentication. Contains machine name and mail address (including domain name). If there is a netid file available it is consulted in addition to the data available through the other files.
publickey.byname	publickey	Contains the public key database used by secure RPC.
netmasks.byaddr	netmasks	Contains network mask to be used with IP submitting, with the address as key.
networks.byaddr	networks	Contains names of networks known to your system and their IP addresses, with the address as key.
networks.byname	networks	Same as networks.byaddr, except key is name of network.
passwd.adjunct.byname	passwd and shadow	Contains auditing information and the hidden password information for C2 clients.
passwd.byname	passwd and shadow	Contains password information with user name as key.
passwd.byuid	passwd and shadow	Same as passwd.byname, except that key is user ID.
prof_attr	prof_attr	Contains attributes for execution profiles.
protocols.byname	protocols	Contains network protocols known to your network.
protocols.bynumber	protocols	Same as protocols.byname, except that key is

		protocol number.
rpc.bynumber	rpc	Contains program number and name of RPCs known to your system. Key is RPC program number.
services.byname	services	Lists Internet services known to your network. Key is port or protocol.
services.byservice	services	Lists Internet services known to your network. Key is service name.
user_attr	user_attr	Contains extended attributes for users and roles.
ypservers	N/A	Lists NIS servers known to your network.

The ageing.byname mapping contains information that is used by the yppasswdd daemon to read and write password aging information to the directory information tree (DIT) when the NIS-to-LDAP transition is implemented. If password aging is not being used, then it can be commented out of the mapping file. For more information about the NIS-to-LDAP transition, seeChapter 15, Transitioning From NIS to LDAP (Tasks).

Using NIS Maps

NIS makes updating network databases much simpler than with the /etc files system. You no longer have to change the administrative /etc files on every machine each time you modify the network environment.

However, NIS provides no additional security than that provided by the /etc files. If additional security is needed, such as restricting access to the network databases, sending the results of searches over the network by using SSL, or using more advanced features such as Kerberos secured searches, then LDAP naming services should be used instead.

For example, when you add a new user to a network running NIS, you only have to update the input file in the master server and run the makecommand. This command automatically updates the passwd.byname and passwd.byuid maps. These maps are then transferred to the slave servers and are available to all of the domain's client machines and their programs. When a client machine or application requests information by using the user name or UID, the NIS server refers to the passwd.byname or passwd.byuid map, as appropriate, and sends the requested information to the client.

You can use the ypcat command to display the values in a map. The ypcat basic format is the following.

```
% ypcat mapname
```

where *mapname* is the name of the map you want to examine or its **nickname**. If a map is composed only of keys, as in the case of ypservers, use ypcat -k. Otherwise, ypcat prints blank lines. The ypcat(1) man page describes more options for ypcat.

You can use the ypwhich command to determine which server is the master of a particular map. Type the following.

```
% ypwhich -m mapname
```

where *mapname* is the name or the nickname of the map whose master you want to find. ypwhich responds by displaying the name of the master server. For complete information, refer to theypwhich(1) man page.

NIS Map Nicknames

Nicknames are aliases for full map names. To obtain a list of available map nicknames, such as passwd for passwd.byname, type ypcat -x or ypwhich -x.

Nicknames are stored in the /var/yp/nicknames file, which contains a map nickname followed by the fully specified name for the map, separated by a space. This list can be added to or modified. Currently, there is a limit of 500 nicknames.