

Networking

Zilogic Systems

1. Terminology

Computer Network	Group of interconnected computers.
Protocol	Refers to a set of rules for communicating. Two programs/computers that follow the same rules are able to exchange information, even if they don't run the same operating system and are not made by the same company.
Network Stack	A network stack is made of several layers. A layer implements one or more protocols. Each layer provides services to the layer above it and uses the services of the layer below it.
TCP/IP Stack	Physical Layer - Link Layer - Network Layer - Transport Layer - Application Layer

2. Networking Basics

2.1. Link Layer and Physical Layer

The physical layer specifies how data bits are to be transmitted and received.

- Specifies signalling levels (Electrical)
- Specifies connectors, cables (Mechanical)
- Specifies communication frequency, signal strength, bandwidth (Radio)

The link layer enables data to be transmitted between two nodes of the same network. Some of the services provided by the link layer are listed below.

- Framing
- Addressing
- Flow Control
- Error Control
- Multiple Access

Examples: Ethernet, UART, FDDI, CAN, Token Ring, ADSL

Figure 1. Between two computers

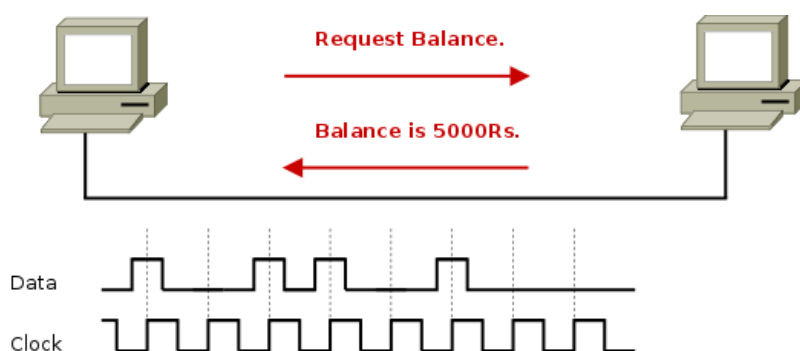


Figure 2. Between multiple computers - the problem

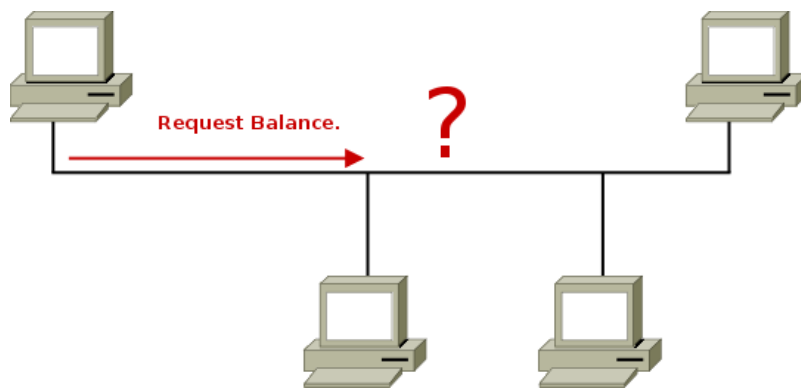


Figure 3. Communicating with using dest. address

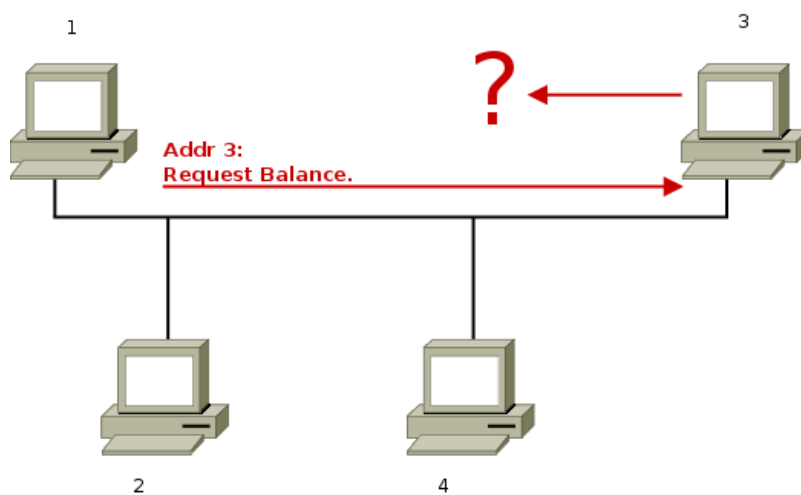
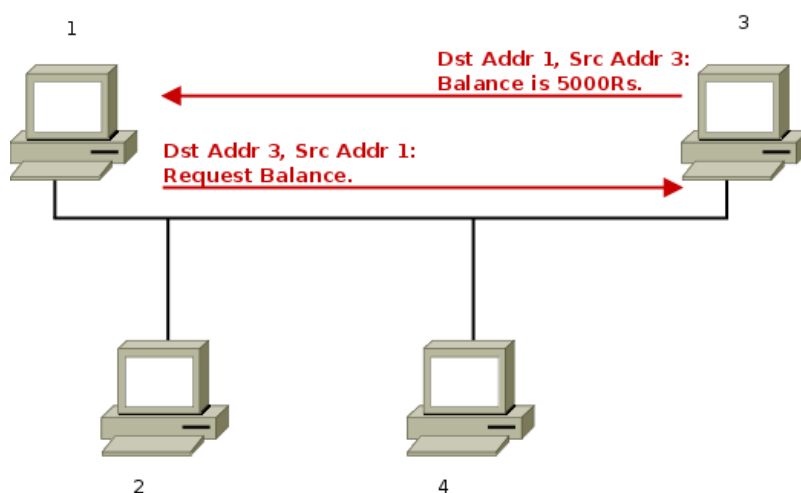


Figure 4. Communicating with source and destination address



2.2. Network Layer

- Network layer is provided by the Internet Protocol (IP).
- The term internet stands for inter-network. That is IP allows data to be exchanged between nodes on two different networks. Even different types of networks.

- Since each link layer protocol has its own addressing scheme, it is not possible to uniquely identify a destination with its MAC address. More over the MAC address is not hierarchical.
- IP layer uses its own address for each system, called the IP address. All systems part of the IP network will have a unique address. The IP address is also hierarchical.
- The IP address is a 32 bit number, and usually represented using a dotted-decimal notation. Example: 10.1.1.3
- The IP address uniquely identifies a system, and also specifies to which network it belongs. The IP address has two parts: host part and network part. All systems in the same network, have same network part. The network part is identified by a netmask.
- For example, the IP address is 10.1.1.3/24. The 24 indicates that the first 24 bits is the network part. The network is said to have an network address 10.1.1.0. All systems in the network will addresses like 10.1.1.1, 10.1.1.2, 10.1.1.3, ..., 10.1.1.254.
- The address 10.1.1.255 is called the broadcast address. Data packets sent to this address will be received by all systems in the network.
- So by looking at the IP address it is possible to tell, in which network the node is located. And hence the IP addressing scheme is said to be hierarchical.
- Two networks are connected using a node called a gateway. The gateway has two network interfaces, one in each network. The gateway has two IP addresses, one in each network.

2.3. Transport Layer

- A server is a program that offers a service, typically through a request-response method.
- A client is a program that sends requests to the server to avail the service.
- Example 1: A database server, will store/retrieve records from a database file, on request from the client.
- Example 2: A web server, serves web pages on request from a web client, typically a web browser.

Figure 5. Between two processes in two different computers - the problem

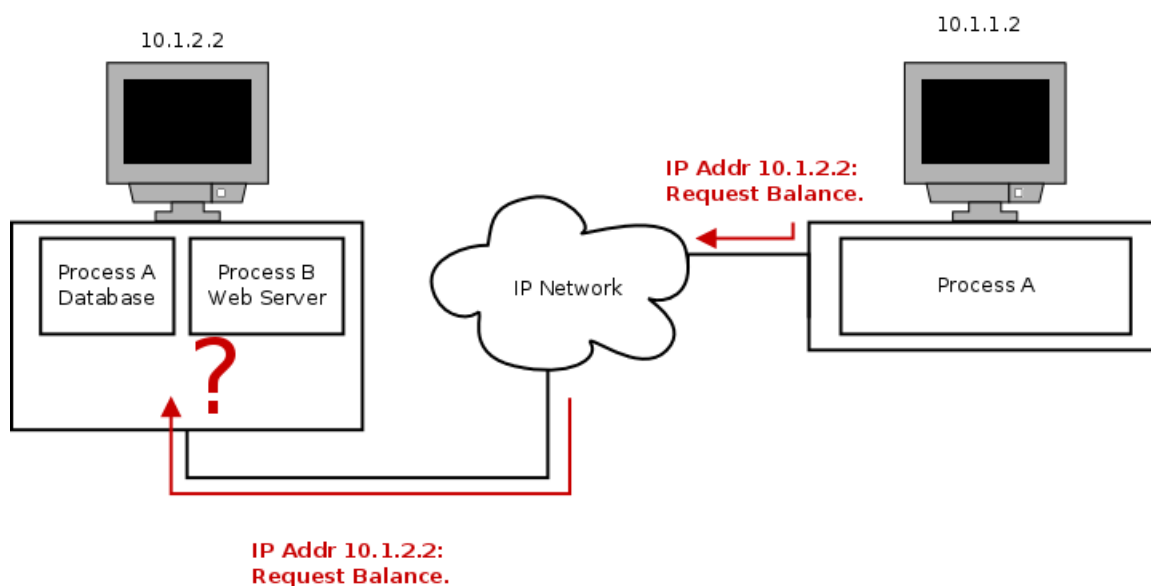
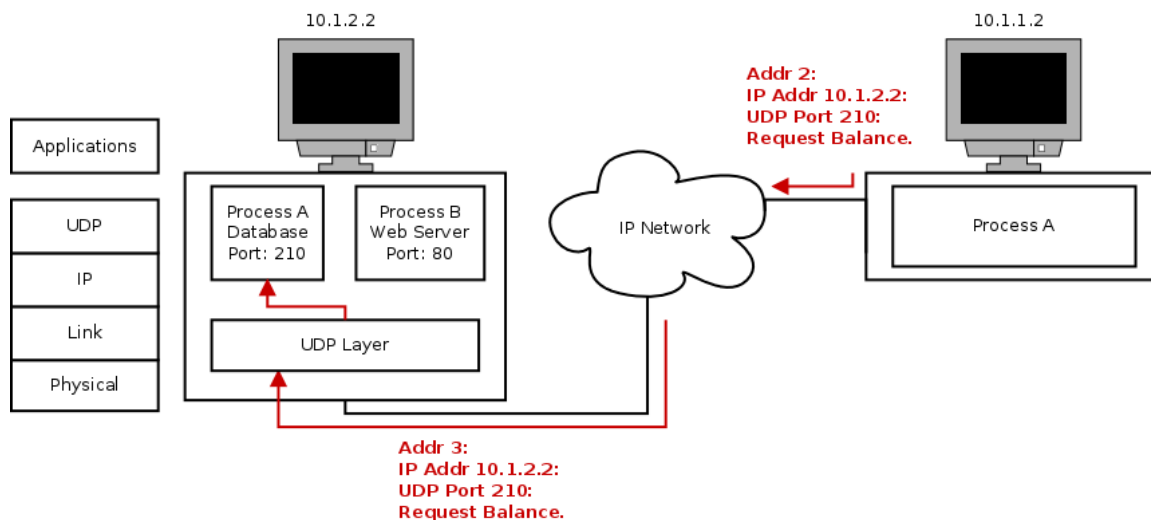


Figure 6. Between two processes in two different computers - the solution

3. Standard Port Numbers

- A server listens on a predefined port no. so that clients can always contact then on that port no.
- For example web servers always listen on port no. 80.

4. Linux Networking Tools

4.1. Domain Name System

For all practical purposes, it can be assumed that if your system is given the IP address of a Domain Name Server, your system will be able to resolve hostnames to IP addresses.

4.1.1. File Transfer Using HTTP Protocol

- Websites and hence Web browsers use the HTTP protocol to transfer data.
- Apart from web browser there are command line tools like `wget` to download files from a website.
- `wget` is capable of managing large transfers, recursive download of web sites and mirroring of FTP sites.

4.1.1.1. Download A Web Page

- To download the page alone.

```
$ wget http://www.zilogic.com/index.html
```

- To download the page and the elements need to display the page like images, style sheets, etc.

```
$ wget -p -k http://www.zilogic.com/index.html
```

- `-p` specifies that page requisites are to be downloaded
- `-k` specifies that the references to the elements in the HTML pages are to be converted for local viewing

4.1.1.2. Resuming Downloads

- `-c` option continues a previously stopped download

4.1.2. File Transfer Using SCP

4.1.2.1. Basic Usage

- Usage is similar to `cp`, except that the user and hostname has to be specified in case of a remote system.
- The user will be prompted for the password for remote systems.
- Transferring a single file from remote system to local system

```
$ scp vijaykumar@shark:~/test.txt /tmp
```

- Transferring a single file from local system to remote system

```
$ scp /tmp/test.txt vijaykumar@shark:~/
```

- Use `-r` to transfer a directory.

4.2. Remote Login

- It is possible to get a access to the shell interface of a remote system, if the system runs a telnet server or SSH server.
- Telnet is less secure since does not encrypt data (including passwords) sent to the remote server.
- SSH stands for Secure SHell. It uses
 - encryption to ensure the confidentiality of the data
 - public-key cryptography to authenticate the remote system

4.2.1. Telnet

4.2.1.1. Basic Telnet Usage

- Simplest usage of telnet

```
telnet myhost
```

- You will be prompted for user name and password, and will be dropped in a shell.
- Quitting the shell will terminate the telnet session.

4.2.1.2. Advanced Usage

- Invoking `telnet` without hostname or typing `Ctrl+]` within `telnet` will switch to `telnet` command interface.
- Available commands
 - `open <server>`, connect to remote server
 - `quit`, terminates telnet

4.2.1.3. Debugging Servers with Telnet

- The telnet program can be used to connect to specific ports on a server and write data to those ports.
- Example POP session is shown below, where the user connects to a POP server and retrieves an email.

```
vijaykumar@toad:~$ telnet mail.zilogic.com 110 ⓘ
```

```
Trying 69.56.173.213...
Connected to mail.zilogic.com.
Escape character is '^]'.
+OK Hello there.
USER vijaykumar ❷
+OK Password required.
PASS xxx ❸
+OK logged in.
LIST ❹
+OK POP3 clients that break here, they violate STD53.
1 54424
2 14587
.
RETR 1 ❺
Return-Path: <vijaykumar@bravegnu.org>
Date: Mon, 8 Oct 2007 12:08:18 +0530 (IST)
Subject: A test mail
From: "Vijay Kumar" <vijaykumar@bravegnu.org>
To: deepak@zillogic.com
Cc: sales@zillogic.com

This is the body of the test mail.

Regards,
Vijay

.
QUIT
+OK Bye-bye.
Connection closed by foreign host.
vijaykumar@toad:~$
```

- ❶ `telnet` is invoked with host name and POP3 port no.
- ❷❸ POP3 messages to authenticate the user.
- ❹ Message to list the messages in the mail box.
- ❺ Message to retrieve the contents of the first mail. (The mail contents have been trimmed for readability.)

4.2.2. Secure Shell

4.2.2.1. Basic Usage

- To connect to a remote system using secure shell

```
$ ssh vijaykumar@shark
```

- You will be prompted for password, and will be dropped in a shell.
- Logging out will cause ssh to terminate.

4.2.2.2. Advanced Usage

- To execute a command in the remote system

```
$ ssh vijaykumar@shark ls
```

- To enable programs X11 programs started from the shell to use the local display, the `-X` option can be used. An example invocation is shown below.

```
vijaykumar@toad:~$ ssh -X vijaykumar@shark
vijaykumar@shark's password:
Last login: Mon Mar  3 14:36:28 2008 from 172.16.253.251
vijaykumar@shark:~$ firefox
```

4.3. Configuration Tools

4.3.1. Getting the Interfaces

To get list of available interfaces in the system the following command can be used. Since `ifconfig` is a command generally used by the administrator, it is present in `/sbin`. Since `/sbin` is usually not present in the `$PATH` of a normal user, `ifconfig` should be invoked as `/sbin/ifconfig`.

```
$ /sbin/ifconfig -a -s
```

4.3.2. Getting the IP Address

To obtain the IP address assigned to a particular interface the following command can be used.

```
$ /sbin/ifconfig eth0
```

4.3.3. Setting the IP Address Statically

To statically set the IP address the following command can be used.

```
# /sbin/ifconfig eth0 172.16.254.251
```

4.3.4. Configuring the Default Gateway

To set the default gateway, the `route` command can be used as show below. If no other routing table entry matches the destination IP, then the packet is sent to the default route.

```
# /sbin/route add default gw 17.16.0.1
```

4.3.5. Configuring the DNS Server

The IP address of the DNS server is specified in `/etc/resolv.conf`. The format for `/etc/resolv.conf` is shown below.

```
# File /etc/resolv.conf
nameserver <ipaddress>
```

4.3.6. Setting the Parameters using DHCP

The IP address for interface, can be assigned dynamically (using DHCP) using the following command. Note that a DHCP server has to be present on the network for this command to work.

```
# /sbin/dhclient eth0
```

4.4. Debugging Tools

4.4.1. Checking if a System is Reachable

To check if a system is reachable, the `ping` command can be used.

```
$ ping www.zilogic.com
```

4.4.2. Finding the Route to a System

The `traceroute` command can be used to identify the intermediate routers that connect two nodes.

```
$ traceroute www.zilogic.com
```

5. Further Reading

- Introduction to Linux: Networking: http://www.tldp.org/LDP/intro-linux/html/chap_10.html
- Network Configuration: <https://wiki.debian.org/NetworkConfiguration>
- Linux: Rute User's Tutorial and Exposition: Using Internet Services - <http://rute.2038bug.com/node15.html.gz>