The grading pattern.

Attendance:		05%
Assignments:		20%
Mid-Term:		15%
End-Term:	LAB Test:	15%
	End-Sem:	45%

Credits and Course Format:

Grading Pattern = 1
Credits = 4
2 Classes/week, 1hr/Class,
2 Labs/Week, 2hr/Lab,

Motivation

Computer network programming enables computers to share data with each other via inter-process communication. Operating system kernel plays an important role in managing the basic requirements of networking. One of such operating system is Unix. Unix is an open source operating system that is the most versatile and coustomizable operating system available. Moreover the netwoshing function that are essential for network communication is already built in to its kernel. Hence, programmer prefer Unix as the main system for running servers.

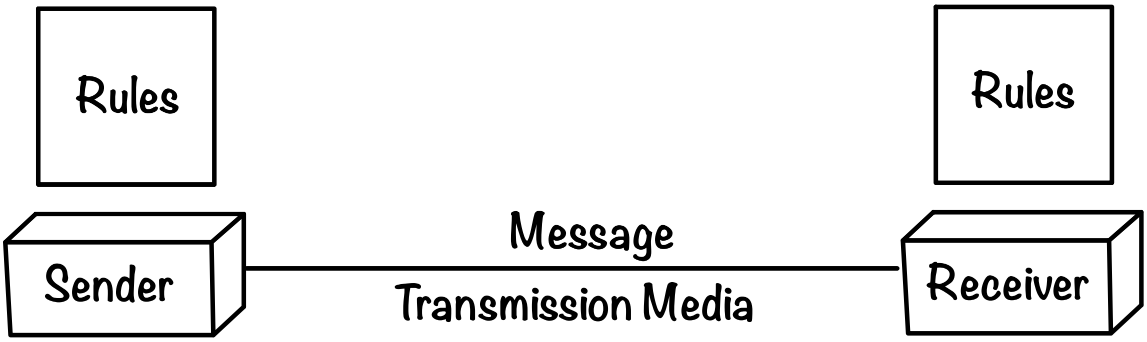
Hence, this course focuses on understanding the basic concepts of Unix operating system that will help us to design efficient server and client applications.

First, this course talks about the basics of networking and network protocols. Then it dives in to C programming concepts for designing server and clients on Unix system.

Introduction to computer networks

A computer network is a group of devices connected with each other through a transmission medium such as wires, cables etc. These devices can be computers, printers, scanners, Fax machines etc.

The purpose of having computer network is to send and receive data stored in other devices over the network. These devices are often referred as nodes.



There are five basic components of a computer network

Network components

Message: It is the data or information which needs to be transferred from one device to another device over a computer network.

Sender: Sender is the device that has the data and needs to send the data to other device connected to the network.

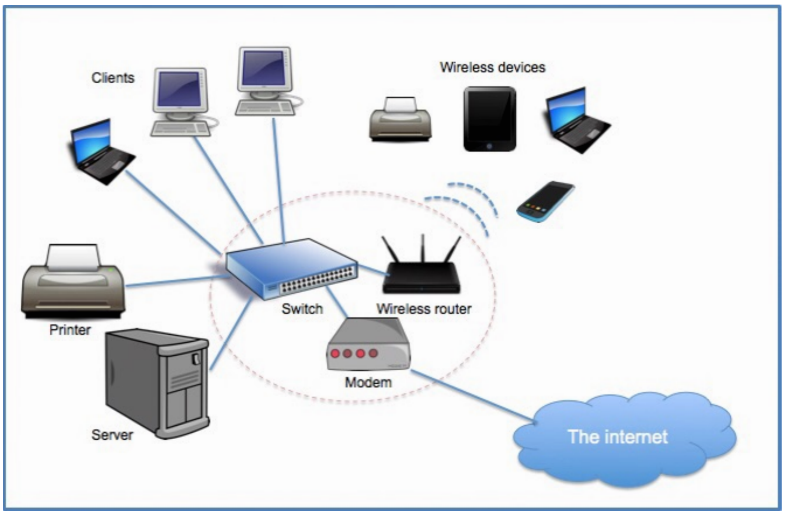
Protocol: A protocol is a set of rules that are agreed by both sender and receiver, without a protocol two devices can be connected to each other but they cannot communicate.

Transmission media: In order to transfer data from one device to another device we need a transmission media such as wires, cables, radio waves etc.

Receiver: A receiver is the device which is expecting the data from other device on the network.

What is a computer network?

Computer network is a collection of computing devices (computers, mobiles, routers etc.) are connected to each other by a link (wired like optical fiber, coaxial cable etc. Or wireless like radio, satellite, etc.) and are agreed to share information and resources.



Features of computer network

Cost effectiveness

Resources sharing enable user to use costly software and hardware without owning them

Sharing

CN enable resources like file, software, hardware to be shared among devices

Speed

The data sharing speed has increased significantly due to the computer networks.

Security

Gives user nights to restrict or allow sharing of information and resources

Integration

Computer network devices can seamlessly coordinate to give user an experience of having large resources

Scalability

Size of computer network can dynamically increase with time

Some uses of computer network

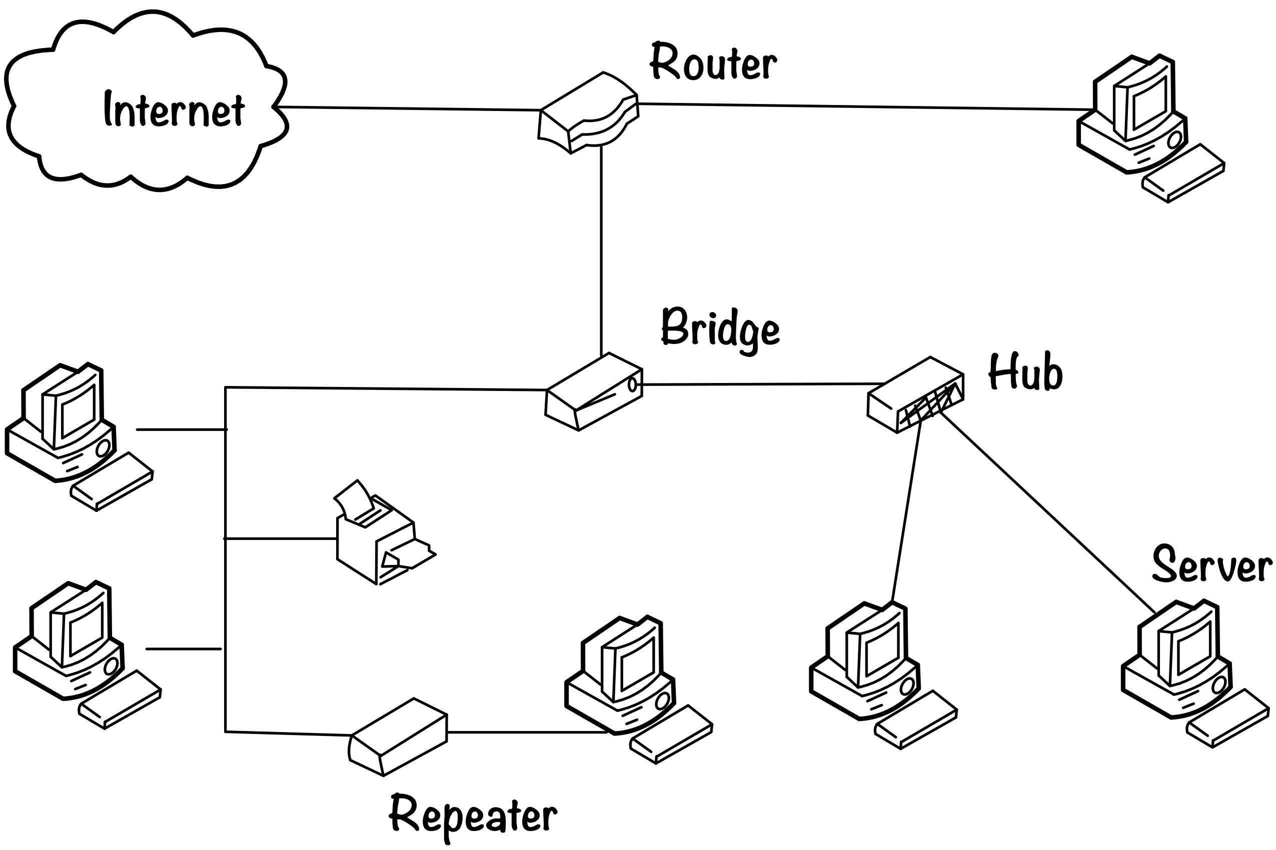
Computer networks have become invaluable to organizations as well as individuals. Some of its main uses are as follows –

- Information and Resource Sharing – Computer networks allow organizations having units which are placed apart from each other, to share information in a very effective manner. Programs and software in any computer can be accessed by other computers linked to the network. It also allows sharing of hardware equipment, like printers and scanners among varied users.
- Retrieving Remote Information – Through computer networks, users can retrieve remote information on a variety of topics. The information is stored in remote databases to which the user gains access through information systems like the World Wide Web.
- Speedy Interpersonal Communication – Computer networks have increased the speed and volume of communication like never before. Electronic Mail (email) is extensively used for sending texts, documents, images, and videos across the globe. Online communications have increased by manifold times through social networking services.
- E-Commerce – Computer networks have paved way for a variety of business and commercial transactions online, popularly called e-commerce. Users and organizations can pool funds, buy or sell items, pay bills, manage bank accounts, pay taxes, transfer funds and handle investments electronically.
- Highly Reliable Systems – Computer networks allow systems to be distributed in nature, by the virtue of which data is stored in multiple sources. This makes the system highly reliable. If a failure occurs in one source, then the system will still continue to function and data will still be available from the other sources.
- Cost–Effective Systems – Computer networks have reduced the cost of establishment of computer systems in organizations. Previously, it was imperative for organizations to set up expensive mainframes for computation and storage. With the advent of networks, it is sufficient to set up interconnected personal computers (PCs) for the same purpose.

Network hardware, and network software

Computer networks components comprise both physical parts as well as the software required for installing computer networks, both at organizations and at home. The hardware components are the server, client, peer, transmission medium, and connecting devices. The software components are operating system and protocols.

The following figure shows a network along with its components –



Hardware Components

- Servers –Servers are high-configuration computers that manage the resources of the network. The network operating system is typically installed in the server and so they give user accesses to the network resources. Servers can be of various kinds: file servers, database servers, print servers etc.
- Clients – Clients are computers that request and receive service from the servers to access and use the network resources.
- Peers – Peers are computers that provide as well as receive services from other peers in a workgroup network.

- Transmission Media – Transmission media are the channels through which data is transferred from one device to another in a network. Transmission media may be guided media like coaxial cable, fibre optic cables etc; or maybe unguided media like microwaves, infra-red waves etc.
- Connecting Devices – Connecting devices act as middleware between networks or computers, by binding the network media together. Some of the common connecting devices are:
    a. Routers
    b. Bridges
    c. Hubs
    d. Repeaters
    e. Gateways
    f. Switches

Software Components

- Networking Operating System – Network Operating Systems is typically installed in the server and facilitate workstations in a network to share files, database, applications, printers etc.
- Protocol Suite – A protocol is a rule or guideline followed by each computer for data communication. Protocol suite is a set of related protocols that are laid down for computer networks. The two popular protocol suites are –
    - a. OSI Model (Open System Interconnections)
    - b. TCP / IP Model

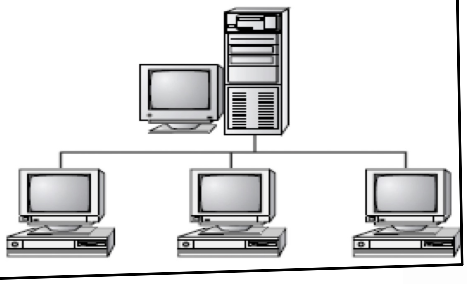
What is a topologies?

Topology is a way of arranging network elements and link.

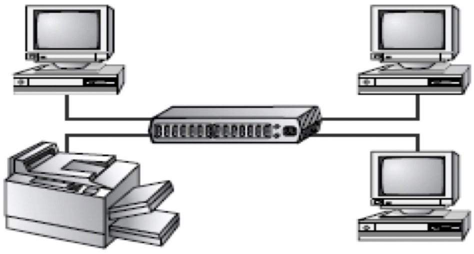
Each computer shares the same data and address path. With a logical bus topology, messages pass through the trunk, and each workstation checks to see if the message is addressed to itself. If the address of the message matches the workstation's address, the network adapter copies the message to the card's on-board memory.

A single BUS connects all computer components

Bus topology



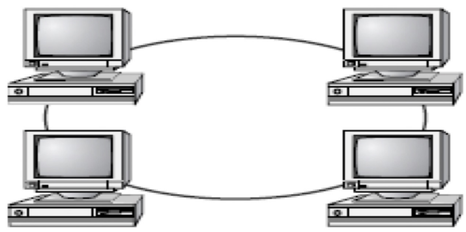
Star Topology



A physical star topology branches each network device off a central device called a hub, making it very easy to add a new workstation.

Also, if any workstation goes down it does not affect the entire network. (But, as you might expect, if the central device goes down, the entire network goes down.)

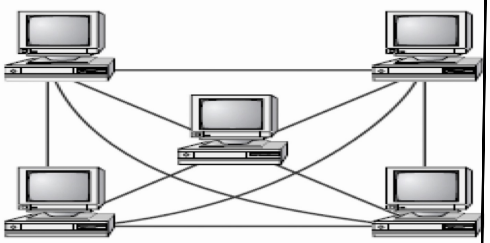
Ring Topology



Each computer connects to two other computers, joining them in a circle creating a unidirectional path where messages move workstation to workstation.

Each entity participating in the ring reads a message, then regenerates it and hands it to its neighbor on a different network cable.

Mesh Topology



The mesh topology is the simplest logical topology in terms of data flow, but it is the most complex in terms of physical design.

In this physical topology, each device is connected to every other device

This topology is rarely found in LANs, mainly because of the complexity of the cabling.

Topology	Advantage	Disadvantage
Bus	Cheap & easy to install	Difficult to reconfigure , Break in the bus stop network,
Star	Cheap & easy to install, reconfigured easily, fault tolerant	More expensive than Bus
Ring	Efficient easy to install	Reconfiguration difficult Very expensive
Mesh	Simplest most fault tolerant	Reconsitiguration difficult Extremely expensive, very complex

Metric units

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

Normally, "m" is used for milli and "μ" (the Greek letter mu) is used for micro.

Network performance metrics

Transmission time. It is the expected time taken by the message to move in a medium. i.e. the time 1st bit leaving the source and last bit arriving at destination.

$$\text{Transmission time} = \frac{\text{Message size}}{\text{Bandwidth}}$$

Propagation Time Propagation time measures the time required for a bit to travel from the source to the destination.

$$\text{Propagation time} = \frac{\text{Distance}}{\text{Speed in medium}}$$

What are the propagation time and the transmission time for a 2.5-kbyte message (an e-mail) if the bandwidth of the network is 1 Gbps? Assume that the distance between the sender and the receiver is 12,000 km and that light travels at 2.4×10^8 m/s.

$$\text{Propagation time} = \frac{12{,}000 \times 1000}{2.4 \times 10^8} = 50 \text{ ms}$$

$$\text{Transmission time} = \frac{2.5 \times 10^3 \times 8}{1 \times 10^9} = 0.020 \text{ ms}$$

Latency The latency or delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out from the source.

$$\boxed{\text{Latency} = \text{propagation time} + \text{transmission time} + \text{queuing time} + \text{processing delay}}$$

Bandwidth: The range of frequencies contained in a composite signal is its bandwidth.

$$\boxed{\text{Bandwidth} = \text{maximum frequency} - \text{minimum frequency}}$$

Unit is in hertz

Capacity The maximum number of bits that can be transmitted in second over a channel.

$$\underbrace{C}_{\text{Capcity}} = \underbrace{B}_{\text{Bandwidth}} \times \log_2\left(\overbrace{\frac{S}{N}}^{\text{Signal to noise ratio}}\right)$$

Not in dB

$$SNR\ in\ dB = 10\log_{10}\left(\frac{S}{N}\right)$$

Throughput: Number bits actually reaching the destination in second.

Imagine a highway designed to transmit 1000 cars per minute from one point to another. However, if there is congestion on the road, this figure may be reduced to 100 cars per minute. The bandwidth is 1000 cars per minute; the throughput is 100 cars per minute.

What is the theoretical capacity of a channel if the bandwidth is 20 KHz and SNR is 40dB?

$$SNR = 40dB$$

$$\frac{S}{N} = 10^{SNR/10}$$

$$= 10^{40/10}$$

$$= 10^4$$

$$C = B \times \log_2\left(\frac{S}{N}\right)$$

$$C = 20 \times 10^3 \times \log_2\left(10^4\right)$$

$$= 265.754\ kbps$$

What is the total delay (latency) for a frame of size 5 million bits that is being sent on a link with 10 routers each having a queuing time of 2 μs and a processing time of 1 μs. The length of the link is 2000 Km. The speed of light inside the link is 2×10^8 m/s. The link has a bandwidth of 5 Mbps. Which component of the total delay is dominant?

We have,

Latency = processing time + queuing time + transmission time + propagation time

Processing time = 10 × 1 μs = 10 μs = 0.000010 s

Queuing time = 10 × 2 μs = 20 μs = 0.000020 s

Transmission time = 5,000,000 / (5 Mbps) = 1 s

Propagation time = (2000 Km) / (2×10^8) = 0.01 s

Latency = 0.000010 + 0.000020 + 1 + 0.01 = 1.01000030 s

The transmission time is dominant here because the packet size is huge.

What is the length of a bit in a channel with a propagation speed of 2×10^8 m/s if the channel bandwidth is 1 Mbps?

(bit length) = (propagation speed) x (bit duration)

The bit duration is the inverse of the bandwidth.

Hence,

Bit length = $(2 \times 10^8$ m/s) × [(1 / (1 Mbps)] = 200 m. This means a bit occupies 200 meters on a transmission medium.