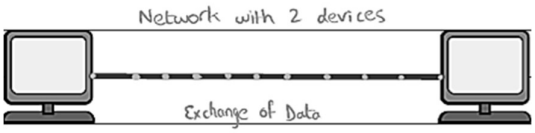
CHAPTER-2 Communication And Networking Technologies

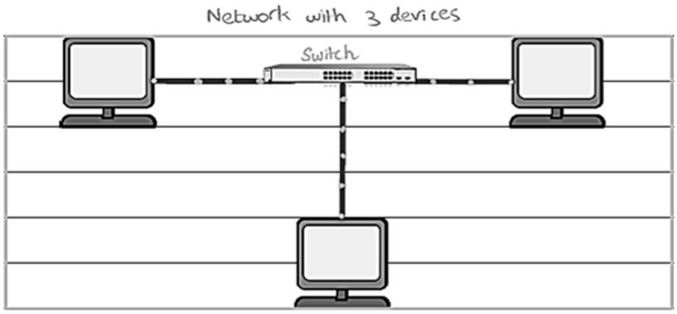
Internet:

A global network providing communication facilities.

Network:

When two or more systems are connected through wire or wireless.





Advantages of using network:

File Sharing: Users can share files with other users.

Hardware Sharing: Users can share hardware such as printers.

Software Sharing: User can share software applications.

Communication: User can send email or chat.

Disadvantages of using network:

Cost: Addition equipment would be required.

Management: Network required technical staff.

Malware: Virus can easily spread in improperly secured network.

Hacking: Once a device is connected to another device, it is easier to hack.

Local Area Network

In Local Area Network PCs are connected in one room or in one building or on one site.

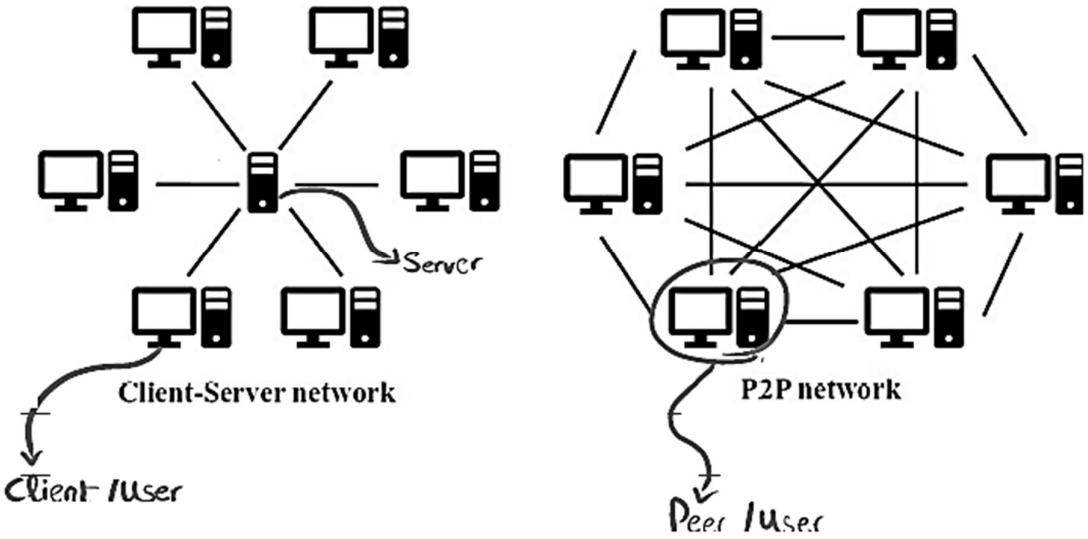
Wide Area Network

In a WAN, the networked computers could be thousands of kilometers apart on different sites.

CLIENT-SERVER MODEL AND PEER-TO-PEER

Network can be designed in two different ways:

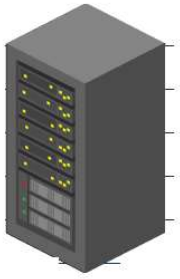
1. Client-server Model
2. Peer-to-peer Model



Server:

A server is a computer or system that provides resources, data to other computers know as client.

- File Server
- Print Server
- Proxy Server
- Web Server
- Application Server



Client-Server Model

In client-server model at least one computer is used to serve and other computers are referred to as clients. The server provides an application and the client uses the application.

Benefits of client-server Model

- Files and resources are centralized
- Security management is easy
- Centralized backup
- Clients are less powerful machines, therefore less expensive to buy
- Saving resources on server reduces the burden on the client
- Internet monitory

Thin Client:

A device or software which is heavily dependent on having access to a server. Thin client will not work unless it is connected all the time to server. e.g web browser, Google Docs

Thick Client:
A device or software that can work offline. It still able to do some processing whether it is connected with server or not. e.g Laptop, Microsoft Excel

Advantages and Disadvantages of Thin Client
Advantages:
- Less expensive to expand as low powered and cheap devices can be used.
- Data updates and new software installation done centrally on server.
- More secure as server can offer protection against hacking and malware.

Disadvantages
- Dependent on server, if the server goes down then the device cannot work.
- More downtime

Advantages and Disadvantages of Thick Client
Advantages:
- More robust as device can carry out processing even when not connected to server
- Better uptime
- Reduce server demand
- Clients have more control

Disadvantages
- Less resource
- Each client need to update data and software individually
- Data integrity issue, since many clients access the same data which can lead to inconsistent data.

Integrity means reliability and accuracy of data.

Consistency states that only valid data will be entered to the database.

Differences between Thin client and Thick client

Thin client	**Thick client**
It relies on server.	It can work without server.
It relies on faster internet.	It can work on slow network connection.
It requires few local resources such as SSD, HDD and RAM.	It relies heavily on resources.
It store data on server.	Data store on device itself.
More downtime	Better uptime
e.g web browser, Google Docs	e.g Laptop, Microsoft Excel

Peer-to-peer Model
In peer-to-peer model, data is shared directly between systems without requiring a central server. Each peer can therefore act as a client and request a file from another peer or it can act as a server when another peer requests the download of a file.

Key features of peer-to-peer network

- All computers are of equal status.
- Each computer provides access to resource and data.
- Computers can communicate and share resources.
- Each computer is responsible for its own security.

Benefits of Peer-to-peer network

- It avoids possibility of congestion when more clients are simultaneously requesting to download a file.
- It allow user to download different parts of files separately.
- The parts are available on more than one host.

Drawbacks of Peer-to-peer network

- Reduced security, so each computer is at risk from viruses from other computer
- No central management of backup, if the data from one computer is not backup it is lost to all of them.
- No central management of file, consistency may be difficult to maintain.
- Individual computers may responds slower because they are being accessed by other computers.

Scenario Based Questions

Q Downloading a file from a website is an example of client-server application. What is meant by term client-server?

- File is made available from web server.
- The user's browser is the client software.
- The client (software browser) requests the file from the server.
- The desired file is returned to the client computer.

Q Describe using the banks as an example of the key features of client-server model.

- The bank's server holds the customer's account data and performs the requested tasks.
- Computers used by the customers are the clients that send request to the server which returns the results of the request.
  e,g A customer asks for a list of recent transactions on their account.

Q How client-server model enables the employee to access files from different computers?

- The employee computers are the clients.
- The server hosts the shared file.
- An employee can request the file from any of client computer.
- Several employee can access the same file from server at the same time.

Network Topology

There are five requirements for a data communications system: a sender, a receiver, a transmission medium, a message and a protocol. A transmission medium can be air (e.g. for WiFi) or cables (e.g. for Ethernet). Data can be sent through the medium in different modes:

- **Simplex mode** where data flow is one-way only
- **Half duplex** where data can flow either way but not simultaneously
- **Full duplex** where simultaneous both-ways data flow is possible.

A 'message' is any type of data, which can be sent as either:

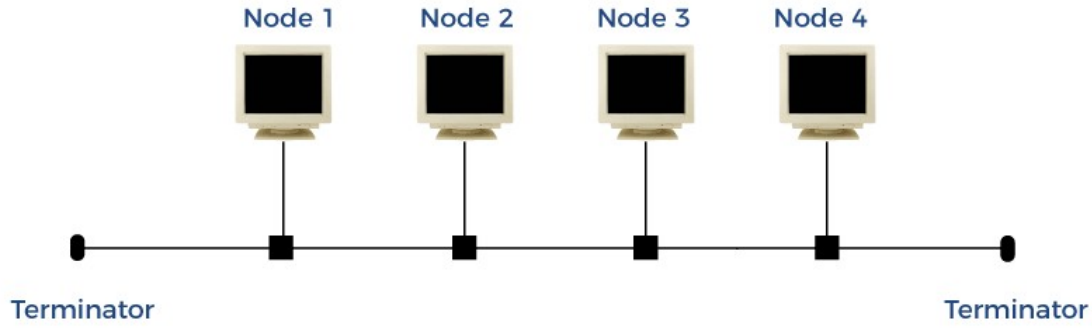
- **Broadcast**, which is a one-to-all communication (as used traditionally for radio and television)
- **Multicast**, which is from one source to many destinations
- **Unicast**, which is a one-to-one communication.

Network topology

A network's topology is the arrangement, or pattern, in which all nodes on a network are connected together. Bus topology, star topology, mesh topology are common examples.

Bus topology

Bus topology uses a single central cable to connect computers and devices.



Advantages

- Easy to setup
- Less cable required
- Less expensive

Disadvantages

- If main cable breaks, the whole network stops.
- Efficiency reduces as the number of devices increase.
- Difficult to detect fault at an individual station.
- Collisions are not suitable for heavy traffic.
- Security is fewer because several computers send and receive signal from source.

Data collisions occur in bus topology networks when two devices try to send data simultaneously.

Q Where can we use bus topology?

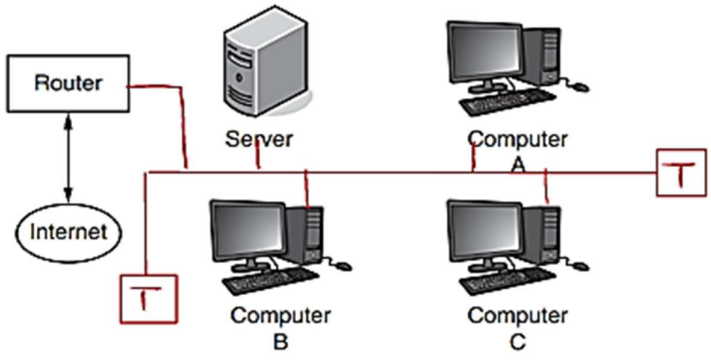
- When small and temporary network is needed.
- Networks which does not rely on high data transfer speed.
- Used in office or school.

Q How packets are transmitted between two computers in bus topology?

- Packets have address of recipient
- Sender transmit data through the bus.
- The bus carries data along the central cable.
- As the data arrives at each computer, the system compares the address to see if it matches.

1 A Local Area Network (LAN) consists of three computers, one server and a router connected to the Internet. The LAN uses a bus topology.

(a) Complete the following diagram to show how the computers, the server and the router could be connected.



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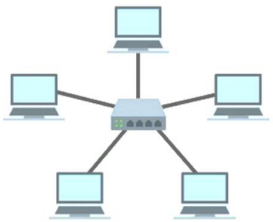
Star Topology

Every computer is linked with central device.



Advantages

- Easy to connect / remove node.
- Centralized management helps in monitoring the network.
- Failure of one node does not affect the rest of the network.
- Fewer collisions.
- Signals only go to destination so it is secure.

Disadvantages

- If the central device fails then the whole network goes down.
- Performance is dependent on capacity of central device.

Q Where will we use star topology?

- Large organization
- Educational establishment
- Where high performance is must
- Found in home as well, where router acts as server.

Q Why star topology is the usual way to configure a network?

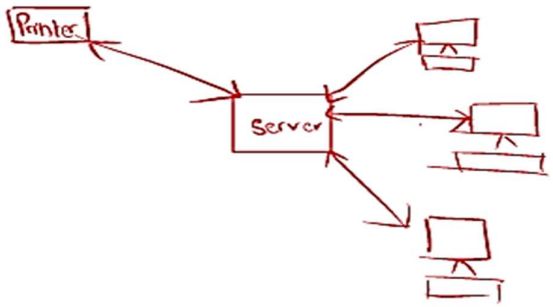
Because central device can be used to connect the network to other networks and, in particular, to the Internet.

How packets are transmitted between star topology?

- Packets have address of recipients
- Sender sends data to central device
- Server reads address and find where recipient is.
- Server directly send data to recipient.
- Server transmit packet only to recipient.

2 Cables connect the computers in a university admissions department in a star topology. The server room contains the server and printer for the employees to use. The department has three employees. Each employee has a computer connected to the star network.

(a) (i) Draw a diagram to show this topology.



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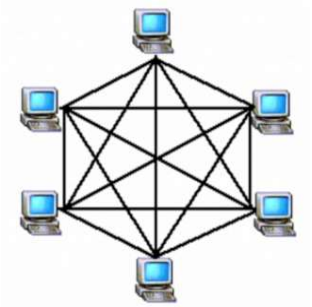
Mesh Topology

All devices are interconnected to each other.



Advantages

- Failure of one node does not affect the rest of the network.
- Good privacy and security, since packets travel along dedicated routes.

Disadvantages

Large amount of cabling is needed which is expensive and time consuming.
Setup and maintenance is difficult and complex.

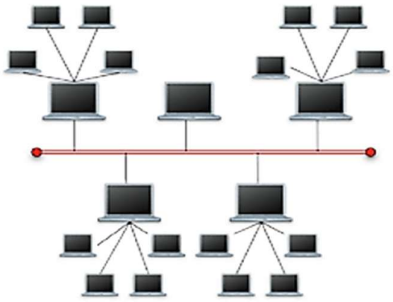
How packets are transmitted between mesh topology?

- Packets have address of recipient
- Sender transmit packets directly to node as each node is connected to at least one another node.

Q Where will we use mesh topology?

- Where establishment of communication is important.
- Military organization
- Emergency service

Hybrid Topology
It is a combination of two or more topologies.



Advantages
- Highly reliable as in case of failure there are many sub networks.
- Easy to troubleshoot and fix errors.

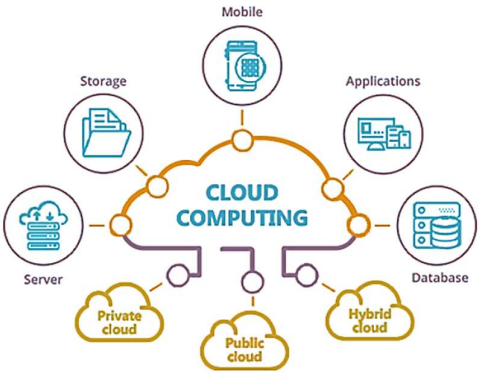
Disadvantages
- It is expensive to setup.
- Difficult to manage
- Complex network

Q Where will we use hybrid topology?
Large organization with different topologies in each building.

Cloud Computing

Cloud computing refers to data and applications being stored and run on cloud so less storage is occupied and less processing is done on local device. It is a big building which contains servers.

Advantages
- Files stored on cloud can be accessed at any time from any device anywhere in the world with internet.
- No need to carry external storage device.
- Cloud storage can be free.
- Most cloud service providers have inbuilt backup.
- Storage could be better.
- Can easily increase capacity.
- Data can be easily shared.



Disadvantages
- Can only access the cloud with internet.
- No control over security
- It can take a long time to upload / download the data.
- It can be more expensive in long term.
- There could be a limit to amount of storage unless paid for.

Private Cloud
Owned by and only accessed by an organization.
Application: Highly regulated industries and government agencies would use private cloud.

Public Cloud
Own by cloud service provider.
Application: It is for general use.

Transmission Media

Cable

A network cable can be twisted pair, coaxial or fibre-optic. The twisted pair and coaxial cables both use copper for the transmission medium. Cables are often referred to as 'guided media'

Twisted pair

It is copper cable used for connecting telephone to telephone lines, one cable for four twisted pairs.

Coaxial Cable

It is copper cable used in long distance telephone cabling by cable television companies.

Fibre Optic cable

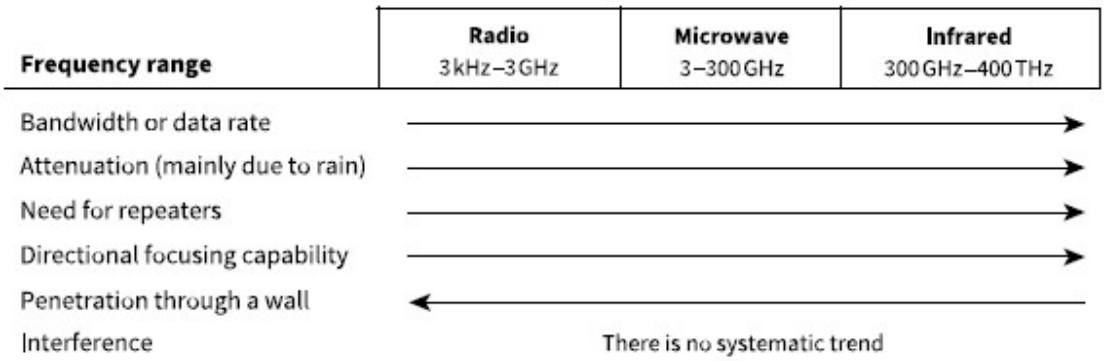
Light is transferred by using concept of total internal reflection. Pulses of lights are sent, those pulses have values 0 or 1.

Trained people are needed to install and maintain because it breaks when bend. It is difficult to terminate.

	Twisted pair	Coaxial	Fibre-optic
Cost	Lowest	Higher	Highest
Bandwidth or data rate	Lowest	Higher	Much higher
Attenuation at high frequency	Affected	Most affected	Least affected
Interference	Worst affected	Less affected	Least affected
Need for repeaters	More often	More often	Less often

Wireless

The alternative to cable is wireless transmission. The three options here are radio, microwave or infrared. These are all examples of electromagnetic radiation. Wireless is often referred to as 'unguided media'



Radio Waves

These are electromagnetic waves, used in Wi-Fi, frequency range is 3 kHz-3Ghz. Radio waves carry data back and forth from wireless adapter and router.

Microwave

These are electromagnetic waves, frequency range is 3 GHz-300 GHz. These are used in TV and MRI (Magnetic Resonance Imaging)

Infrared

Electromagnetic waves with frequency range 300 GHz -400 THz and used in TV remote.

Benefits of wireless network compared to wired network

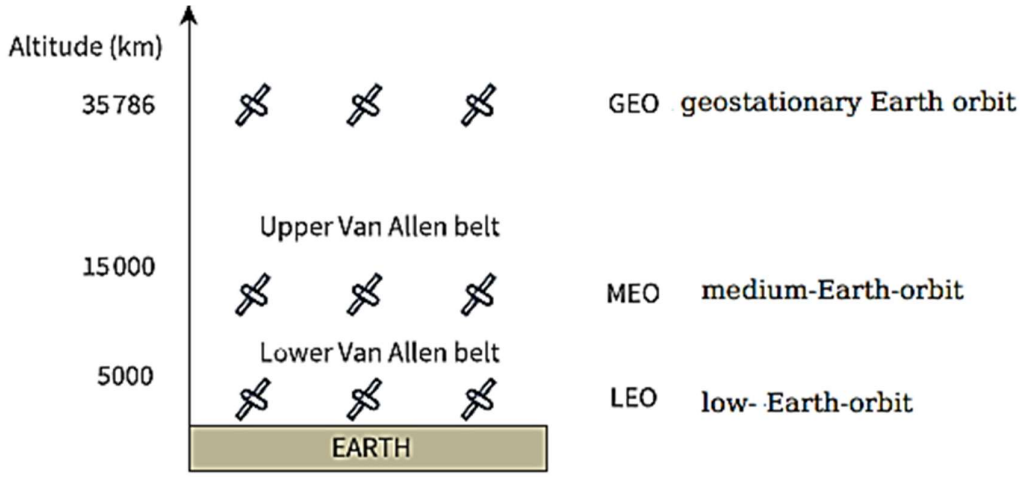
- Devices can be more mobile as they do not have to be connected to cables.
- Easier to setup as no cables needs to be installed.
- Additional devices can easily be added.
- Many different types of devices can be easily connected at the same time.

Drawbacks of wireless network compared to wired network

- Easier to hack
- Interference
- Signals degrades quickly

Satellite

A satellite can act as a component in a network and can directly connect with ground-based components.



GEO

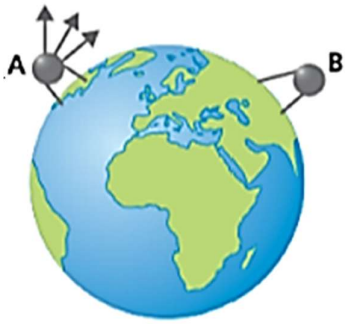
Provides long-distance telephone and computer network communication. Only three GEO satellites are needed for full global coverage.

MEO

Closer to Earth are a group of medium-Earth-orbit (MEO) satellites some of which provide the global positioning system (GPS). Ten MEO satellites are needed for global coverage.

LEO

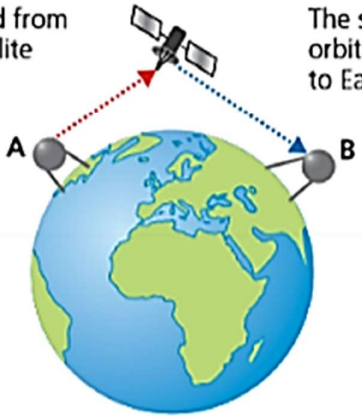
Low-Earth-orbit (LEO) satellites work in 'constellations' to supplement the mobile phone networks. Fifty LEO satellites are needed for full global coverage but currently there are several hundred LEO satellites in orbit.



The electromagnetic radiation from antenna A is transmitted but is unable to reach antenna B due to the Earth's curvature.

To overcome this problem, we need to adopt satellite technology:

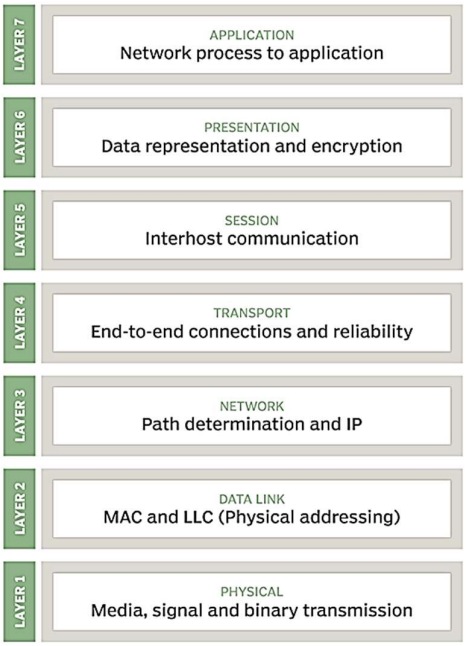
The signal is beamed from antenna A to a satellite orbiting Earth.



The signal is boosted by the satellite orbiting Earth and is then beamed back to Earth and picked up by antenna B.

Hardware Used in Network

Open Systems Interconnection (OSI) model



Switch

A connecting device that can direct a communication to a specific end-system. This is Data Link Layer network device.

NIC (Network Interface Card)

- Provide device with a mac address to uniquely identify it on the network.
- Allows each individual device to connect to the network.

WNIC (Wireless Network Interface Card)

- Provide device with a mac address to uniquely identify it on the network.
- Allows each individual device to connect to the network wirelessly.
- They use antenna to communicate with network via electromagnetic waves.

Bridge

Bridge connects two different LANs. It divides a single LAN to two to reduce traffic.

How bridge works?

P1 wants to send data to P2, data will go to each and every node which will increase traffic.

Bridge has mac address of each device and identify if data should stay on left or right, this will reduce traffic.

WAP (Wireless Access Point)

- Allowing devices to connect to LAN instead of using cables.
- Easy to move a device to different location.

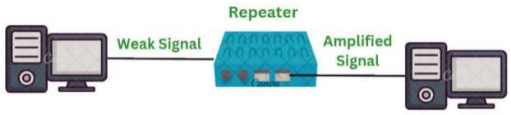
Router

- Connects two or more networks
- Can connect network to WAN.
- Receive packets and forward towards destination.
- Using IP address of destination.
- Assign private IP address.
- Connects similar network.
- They works in Network Layer of ISO.

Gateway

- Connects two or more networks
- Can connect network to WAN.
- Receive packets and forward towards destination.
- Using IP address of destination.
- Assign private IP address.
- Connects dissimilar network.

Repeater



Repeater is used to boost the signals.

Used when data needs to travel **long distances** without losing quality

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Bit Streaming

How video is sent using bit streaming?

- Data is compressed before transmitting.
- Video is transmitted continuously as a series of bits.
- Video is hosted on media server.
- On download, the server sends data to buffer on client's computer.
- The buffer stores the data from the server.
- The user's stream software receives bit stream from the buffer.

Define on-demand bit streaming.

- Digital video tapes are converted to bit streaming format for broadcasting on net, this is called encoding.
- These encoded streaming videos are then uploaded to the dedicated server.
- A link for the encoded video is placed on a website.
- A user clicks on the link to download the encoded stream video.
- The streamed video is broadcasted to the user when they require it.
- Can be paused / can go back and re-watch fast-forward.

Define real time bit streaming.

- An event is captured live with video camera.
- The video camera is connected to a computer.
- The video signal is converted to streaming media file, encoded on computer.
- The encoded file is then uploaded from computer to a dedicated streaming server via cable or high speed internet connection.
- Server sends the live images to all users requesting it as real time video streaming.
- Cannot be paused.

Importance of bit rate / broadband speed on bit streaming

- Bitrate determines how quickly the data is sent over the internet to the viewers.
- Higher the bitrate or broadband speed, better the quality of bit streaming and there will be no buffering.

Benefits of Bit Streaming

- No need to wait for a whole file to be downloaded
- No need to store large files on user's computer
- Allows on demand payback
- No specialist software is required for playback in browser

Drawbacks of Bit Streaming

- Video hangs, if internet speed slow or inadequate buffering capacity
- Loss of internet mean we cannot access video
- May required specific software to run the file.
- Viruses can be downloaded from the website

Difference between World Wide Web (WWW) and internet

Internet

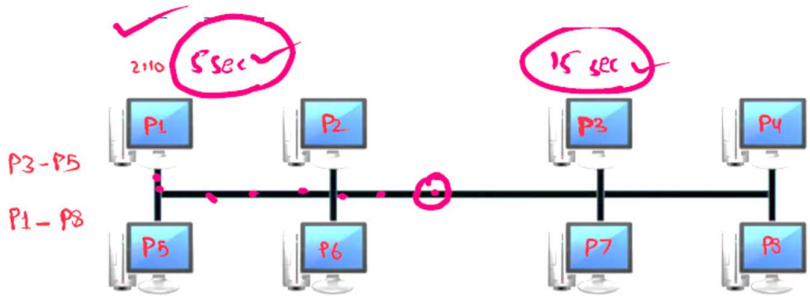
- It is massive network of network
- Internet stands for Interconnected Networks
- Internet uses TCP/IP protocol

World Wide Web (WWW)

- It is a collection of web pages / documents stored on website
- http protocols are used to transmit data
- Web pages are written in HTML.
- URLs specify the location of web pages.
- Web documents are accessed using browsers.

CSMA / CD

Carrier Sense Multiple Access – Collision Detection



Collision of data prevents it from reaching its destination

Explain what is meant by CSMA / CD?

- CSMA / CD stands for Carrier Sense Multiple Access / Collision Detection
- Before transmitting the data, a device checks if the channel is busy.
- If channel is free data is sent.
- When transmission begin, it listens to other device.
- If there is a collision, transmission is stopped.
- Both devices wait a different random time, then they try again.

Functions of CSMA / CD

- Monitor traffic
- Only allow data to be sent when the line is idle
- Detects collision on the network
- Halt transmissions when a collision occurs
- Calculate random wait time
- Allow re-transmission after a random amount of time.

How collision is detected?

Due to voltage change, the collision is detected.

HARDWARE DEVICES TO SUPPORT THE INTERNET

Modem

It connects router to internet.

Describe the transmission of data using PSTN?

- PSTN stands for Public Switched Telephone Network
- It consists of many different types of communication line.
- Data is transmitted in both directions at the same time.
- The communication passes through different switching centers.

Description	Conventional telephone using PSTN	Internet-based system
connection only in use whilst sound is being transmitted		✓
dedicated channel used between two points for the duration of the call	✓	
connection maintained throughout the telephone call	✓	
encoding schemes and compression technology used		✓
lines remain active even during a power outage	✓	

Benefits and Drawbacks of dedicated lines

Benefits

- Faster transmission of data
- More consistent transmission speed
- Improved speed

Drawbacks

- Expensive to setup / maintain
- Disruption to the dedicated line would leave no alternative.

Modem

It connects a device to internet over a telephone line.

IP ADDRESSING

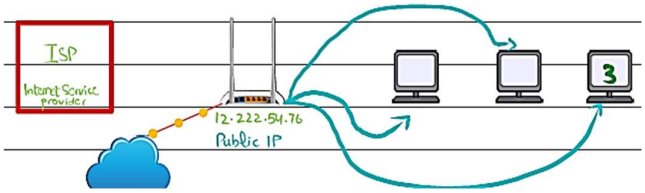
What is IP stands for?

Internet Protocol

What is the purpose of IP address?

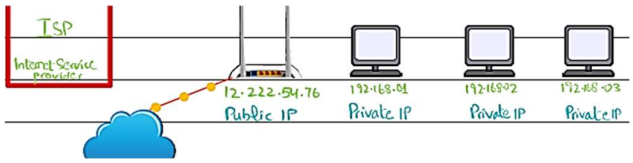
- It is used to locate a device on a network and gives identifier to each device.
- Each address is unique within the network.
- It allows a device to send data to the correct destination.

Public IP addresses



- Public IP addresses are registered on the internet.
- It gives access to internet.
- These are unique
- These are assigned by ISP.
- These are not secure as Private IP.

Private IP addresses



- Private IP addresses are not registered on the internet.
- You cannot access internet by just private IP.
- These are assigned by router.
- These are unique within their network but can be duplicated within other network.
- It is secure.

Static IP Addresses

- Address is assigned by ISP
- When a computer disconnects and rejoins a network, the address does not change.

Dynamic IP Addresses

- Address is assigned by the network OS.
- When a computer disconnects and rejoins a network, the address changes.

Use of Subnetting

Subnetting is the process of dividing a larger network into smaller, more manageable parts, called subnets. Benefits of subnetting are:

- Split a large network into a grouping of smaller network.
- It helps to minimize the traffic so improves speed and performance.
- It ensures that the traffic remains within its designated subnet.

Subnet Mask

Subnet mark is used to identify how many octets are used as Network or Host.

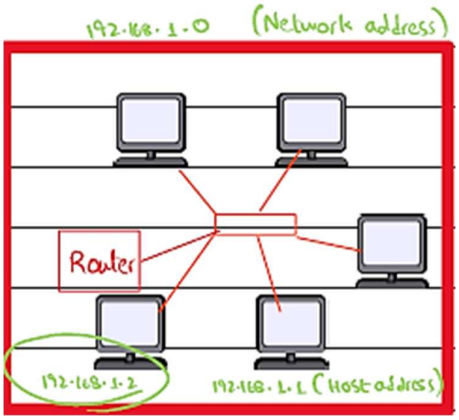
255.0.0.0
255.255.0.0
255.255.255.0

```
Connection-specific DNS Suffix  . :
Link-local IPv6 Address . . . . . : fe80::a469:b9bb:507b:3d9e%7
IPv4 Address. . . . . . . . . . . : 192.168.100.10
Subnet Mask . . . . . . . . . . . : 255.255.255.0
Default Gateway . . . . . . . . . : fe80::1%7
                                    192.168.100.1
```

IP Address contains two things:

1. Network Address
2. Host Address

Octet = 0 – 255



Class A	First octet contains 0-127	1.0.0.1
Class B	First octet contains 128-191	128.1.0.1
Class C	First octet contains 192-223	192.168.100.1
Class D	First octet contains 224-239	224.0.0.0

IPv4 AND IPv6 Addresses

IPv4

- Each IP address contains 4 octets.
- Each octet should be in range of 0-255
- IP address is separated by dot “.”
- It is 32 bits length address.
  192.168.0.1

IPv6

- Valid hexadecimal number
- 8 octet separated by colon ":"
- Each octet is 4 hexadecimal digit
- It is 128 bits length address
  2001:0B00:0000:0000: 0000:0000:0000:0000

The following are examples of valid IPv6 (normal) addresses:

- 2001:db8:3333:4444:5555:6666:7777:8888
- 2001:db8:3333:4444:CCCC:DDDD:EEEE:FFFF
- :: (implies all 8 segments are zero)
- 2001:db8:: (implies that the last six segments are zero)
- ::1234:5678 (implies that the first six segments are zero)
- 2001:db8::1234:5678 (implies that the middle four segments are zero)

Explain why there is a need for IPv6?

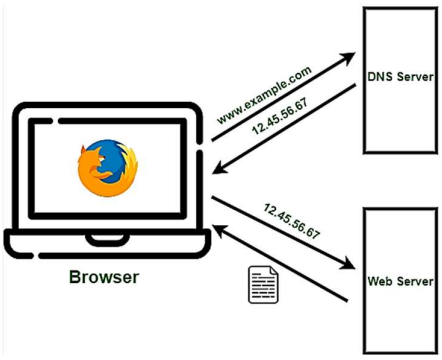
The number of IP addresses needed will exceed the number available using IPv4.

DNS (Domain Name System)

The **DNS** is like the **Internet's phone book.** It **translates domain names** (like www.google.com) into **IP addresses** (like 142.250.180.68) So domain name is an identifier of a website.

How a URL is converted to matching IP?

- URL is parsed to obtain the domain name.
- Domain name is sent to nearest DNS server.
- DNS holds a list of domain name and matching IP address.
- Domain name resolver searches its database for the domain name.
- If DNS does not find the domain name, the request is forwarded to higher level DNS.
- If domain name is found, the IP address is returned.
- If not found, it show an error message.



URL (Uniform Resource Locator)

(b) Consider the URL:

http://cie.org.uk/computerscience.html

(I) Give the meaning of the following parts of the URL.

http enables browser to know what protocol is being used to access information in the domain

cie.org.uk is the domain name

computerscience.html file name which is being viewed.

[3]

%20

It is the coding for space as <space> are not allowed to URL.

https://www.google.com/search?q=computer%20science

?

It acts as separator, separates URL from all parameters.

https://www.google.com/search?q=computer

Working Example

Complete the following paragraph that describes the sequence of events when a user requests a page from a website.

1. The user enters the Uniform Resource Locator (URL) into the address bar of the .....
2. The domain name is taken from the URL and sent to a Domain Name Service (DNS). This stores ..... of domain names and their matching IP addresses.
3. If it finds the domain name, it sends the IP address to the .....
4. If it does not find the domain name, it sends the request to .....

Answer

1. Web browser [1 mark]
2. An index/a list/a table [1 mark]
3. Web browser [1 mark]
4. A higher-level DNS [1 mark]